Queensland technical methods - Cropping (grains)

Australian Biomass for Bioenergy Assessment

May 2018

This document is part of a series describing the technical methods used to publish the Queensland based data for the Australian Biomass for Bioenergy Assessment (ABBA) <arena.gov.au/projects/the-australian-biomass-for-bioenergy-assessment-project>. All documents in the series are available to view and download at <publications.qld.gov.au>.

What is the Australian Biomass for Bioenergy Assessment?

ABBA provides detailed information about biomass resources across Australia. This information will assist project developers make decisions for new bioenergy projects, and provide linkages between potential biomass feedstocks—through the supply chain—to end users. To achieve this, ABBA collects datasets, on a state- by-state basis, about the location, volumes and availability of biomass, and publishes them on the Australian Renewable Energy Mapping Infrastructure (AREMI) platform <nationalmap.gov.au/renewables>. ABBA is managed by AgriFutures Australia with funding support from the Australian Renewable Energy Agency (ARENA).

Why grains industries?

Agricultural crop residues have been flagged as a potential resource for the production of bioenergy (Stuckley et al 2012). Cereal straw or the residue or stubble left over from grains industries in Queensland has been identified as a potential source of lignocellulosic material. Lignocellulosic biomass has a relatively low energy content, however the use of crop residues helps reduce the competition between biomass production and food production (Herr et al 2012).

Factors to be considered when looking at the use of cereal crop residues and their use in bioenergy include:

- Sustainability– retaining residues in the field has a large benefit to soil conservation and health.
- Economics and feasibility of harvesting cereal straw residues – ie is more energy potentially expended to gather cereal straw than would be generated as bioenergy.

Resources of the Queensland cereal crop industry

Cereal crops in Queensland are predominantly grown in the northern grains region, from the NSW/QLD border near Goondiwindi, to Kingaroy in the east and Emerald in the north. Wheat and sorghum are the top two cereal crops grown in Queensland by area (Figure 1) and the focus of this assessment. Wheat is one of Australia's main agricultural export commodities and sorghum is the main dryland summer crop produced in north eastern Australia's subtropical region.

Typically in the northern grains region there is a winter growing season followed by a summer fallow. This is different from the southern regions where it is possible to have continuous cropping systems regions (Fairne and Filmer 2008). The summer fallow in the northern regions allows for soil moisture to be replenished for the next season's crop (Markly and Littler 1989, Scott et al 2010).

Cereal crop residues were estimated for wheat and sorghum across Queensland. Residues in this context are considered to be straw that may be available for collection and use in bioenergy industries.

What data about grains industries is published by ABBA?

ABBA has published data about the volume of straw residues produced (for both wheat and sorghum) in an aggregated form at a local government area (LGA) level. This data is produced at a broad scale and is therefore not suitable for use at a local scale.

Data is estimated using modelled district yield data (for both wheat and sorghum) and the ratio of grain to total above ground biomass or the Harvesting Index (HI). The process for deriving cereal crop residues is outlined briefly in Figure 2 and discussed in detailed through the following steps.

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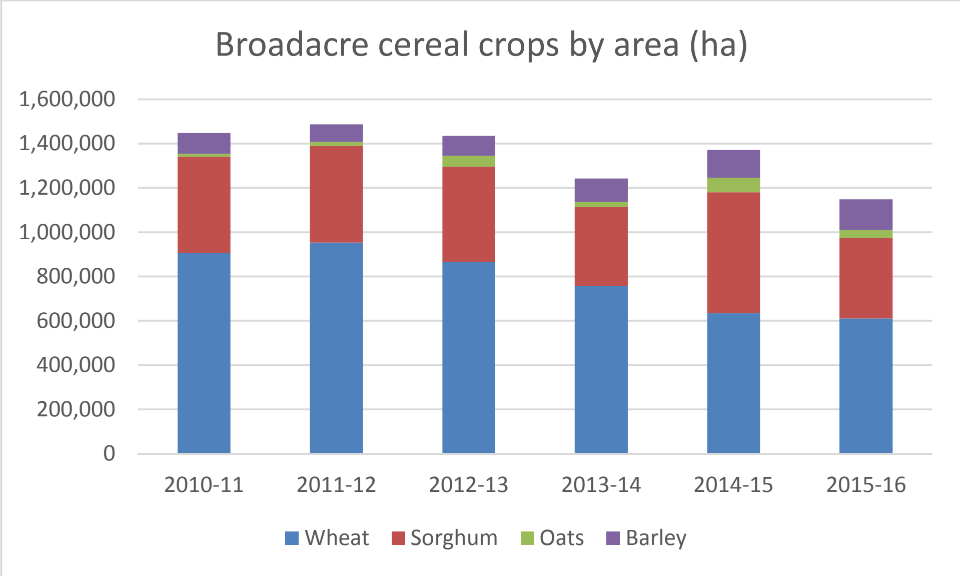

Figure 1. Area harvested (ha) of broad acre cereal crops in Queensland 2010-2016 (ABARES)

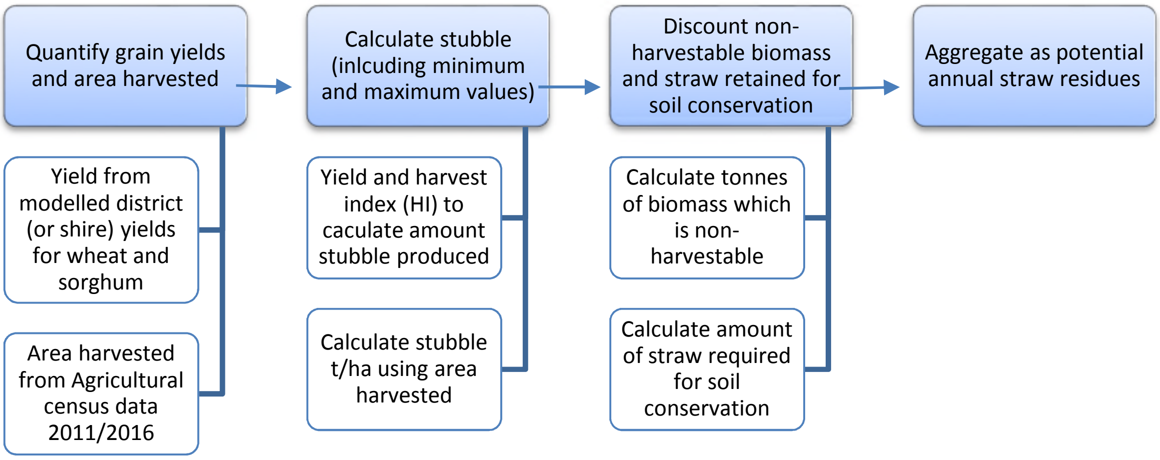

Figure 2. Process for estimating cereal straw residues in Queensland

Methods

Step 1: Calculate yield

District (or shire) yield data was sourced from the Agricultural Land Audit <daf.qld.gov.au/environment/ag-land-audit> produced by the Department of Agriculture and Fisheries. These shires are equivalent to local government areas in Queensland in 2008 (before amalgamation). This data indicates modelled wheat and sorghum yields using 100 years of climate data. Modelled yields of el Niño and la Nina years are also included in order to indicate the minimum and maximum yields that could be expected in these areas. Wheat and sorghum production is highly variable from year-to-year mainly because the climate in Australia is extremely variable. These shire yields were developed using an agro-climatic modelling approach (Potgieter et al. 2005, Potgieter et al. 2006).

There is a difference in the shire boundaries (of 2008) and the boundaries of the current LGAs at which this data is being reported. Yield data from shires was allocated to current LGAs by the following rules:

- where the boundaries of the current LGA were the same as the shire boundary in 2008 the yield was allocated directly, or
- where multiple shires (from 2008) were present within the one current LGA - the yields were averaged and a single value was allocated to the entire LGA

Step 2: Calculate area harvested

Cereal crops are largely confined to the northern grains region of Queensland and so the calculations for residues are confined to the LGAs of this northern grains region only. All other LGAs in Queensland have not been assessed.

The area harvested (in hectares for both wheat and sorghum) was obtained from the 2011 and 2016 Agricultural Census (Australian Bureau of statistics 2017). The agricultural census information is the only data set that indicate the area harvested for individual crops at a SA2 statistical area level.

The area harvested for each crop in each SA2 was averaged between the 2011 and 2016 years in order to smooth some of the variation which is experienced between years.

The averaged areas were then allocated to an LGA by the following rules:

- where the SA2 was entirely within a LGA (this was the majority of cases) the area was added directly to that LGA, or
- where an SA2 boundary crossed a LGA boundary the area harvested was allocated to the LGA with the majority of the SA2.

LGAs with less than 1000 ha were excluded from the analysis.

Step 3: Calculate the remaining stubble after harvest

Harvest Indexes (HI) for each crop (Table 1) were used along with yield data (step 1) and area harvested figures (step 2) to calculate the amount of stubble left over after harvest at a LGA level. This was done using the following equation:

[1]Amount of stubble (tonnes per hectare) = grain yield (tonnes per hectare) x (1-HI)/HI.

Table 1. Mean harvest index of wheat and sorghum (Unkovich et al 2010)

Crops	Mean Harvest Index
Wheat	0.36
Sorghum	0.46

Step 3: Calculate the non-harvestable biomass

A proportion of the stubble is considered to be non-harvestable biomass. This is the proportion of the plant including the chaff and leaf material. Herr et al (2011) reports that 18% of the non-grain biomass is non-harvestable (8% leaf and 10% chaff). This figure has been applied in this assessment.

Step 4: Calculate the amount of stubble to be retained for sustainability and soil conservation

A sustainability factor of 2t/ha was used as an estimate of straw to be retained in the paddock for soil conservation and sustainability. This figured was sourced from the study by Herr et al (2012) and applies specifically to the cereal crops of the Northern Grains region.

Retaining trash residues provide benefits of environmental stewardship and sustainability to reduce sediment, nutrient and pesticide losses, while enhancing moisture retention, weed management and soil health.

Step 5: Calculate remaining straw and convert to calculate dry weight

Step 3 - (Step 4 + Step 5) = potentially available straw

Cereal straw was calculated as having a moisture content of 12.5% (Wheat Harvesting 2017).

Step 6: Calculate minimum and maximum cereal residues

The minimum and maximum residue totals were calculated to understand the potential fluctuation between years. The district yield data by Potgieter et al. (2005 and 2006) also included district average yields for el Nino and la Nina years. These yields were applied to indicate the potential minimum and maximum cereal straw values for each LGA.

The figures for non-harvestable biomass and sustainability were kept the same in these calculations.

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1 Grains and Research Development Corporation – managing stubble

In some instances where the yields did not produce enough to factor in both 2t/ha for sustainability and 18% non-harvestable biomass these areas were given a straw production value of zero.

The final data is rounded to the nearest 10 by the following rules:

- Data at the midpoint is rounded up (e.g. 35 has been rounded to 40)
- Data less than five is given a value of zero
- Data five or larger (but less than 10) is given a value of 10.

Outputs

- A table of estimated average annual wheat straw (dry tonnes) by LGA
- A table of estimated average annual sorghum straw (dry tonnes) by LGA

Assumptions

The assumptions made when calculating cereal straw residues include:

- Calculations do not take into account the different technologies employed by individual farms and the variable harvesting operations (harvesters, machinery etc). Management techniques and harvesting may change significantly from year to year and between districts.
- The area harvested is represented by averaging the 2011 and 2016 figures from the agricultural census (Australian Bureau of Statistics 2017), to account for variation in area harvested between years. The area harvested can vary significantly between years and the calculated area harvested does not represent a long term average.
- All residues are calculated as a dry weight. Cereal straw was calculated as having a moisture content of 12.5% although this may vary across seasons and districts. Grain in Queensland is usually harvested at around 12.5% moisture and so it is assumed that the non-grain biomass was also around 12.5% moisture.
- The 2t/ha for sustainability for the northern grains region (Herr et al 2011) is based on Queensland having a higher temperatures and summer rainfall which promote increased decomposition rates. Thus, a higher stubble load needs be retained to maintain cover in the northern region than in other regions with winter dominant rainfall. Herr states:

  > "In northern systems higher amounts are required with 1.5 to 2.0 t/ha recommended. In some summer/autumn rainfall areas stubble retention will need to exceed these minimum values to account for losses that will occur due to decomposition over the non-crop period. Hence, regional stubble retention rates need to be adjusted according to local conditions".

  2t/ha was applied as the upper most limit and calculations have not been adjusted according to local conditions as the data is not appropriate to use at a local scale.
- The calculations do not include an assessment of the economics and feasibility of harvesting cereal straw residues – ie is more energy potentially expended to gather cereal straw than would be generated as bioenergy.

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