Identifying areas where coal seam gas development may assist agricultural intensification

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Abstract

The coal seam gas (CSG) industry has suffered criticism on numerous agriculture related issues. However, despite potential costs associated with CSG development, landholders could have opportunities from additional farm income from CSG contracts. Whilst there are initial studies on the macro level impacts of CSG on the economy, environment and community, there is limited information on the geographical extent of the overlap between agriculture and CSG and its impact on the physical and economic components of farms. This study aims to evaluate the inherent agricultural potential of the areas under CSG petroleum leases in the Surat Basin by identifying areas where aspects of CSG development may help facilitate farm intensification. This initial assessment and site selection process is part of a further research undertaking on the evaluation of the agricultural productivity and financial performance of the farm enterprises in CSG tenements.

Biophysical attributes (e.g. slope, pH, plant available water, and climate) were used to classify areas within the CSG tenements that share related biophysical characteristics. The comparison of the biophysical production environment of the CSG tenements and its existing land uses was used to provide a simplified indication of areas perhaps not currently supporting its potential land use and where CSG payment therefore could prove beneficial in farm improvement and assist in agricultural intensification and development. . Future work will now focus on these areas and on what opportunities may exist within them.

Key words

Coexistence, Fuzzy membership, GIS, raster input

Introduction

Agricultural expansion and intensification is being constrained by land use competition from other land developments (Fischer, Byerlee *et al*. 2011). While there are areas in Australia that are non-arable and can be devoted to other profitable industries such as mining and energy (i.e. CSG), these industries also thrive in fertile and agriculturally productive areas. Because of this, concerns have been raised regarding the threat of CSG to agricultural production.

However, given the diversity of the physical and agro-socio-economic characteristics of the farms in the Surat Basin, a common effect of CSG cannot be assumed. In some circumstances, despite potential reductions in farm income and increased farming costs associated with CSG development, landholders could gain benefits through significant inflow to net farm income from effective negotiations with energy companies. These financial opportunities could support agricultural intensification, especially when cash flow is highly variable.

This site (area) selection process provides information on the geographical extent of the overlap between agriculture and CSG and is being used to determine case studies for further research on determining whether co-existence between these industry sectors may either increase or decrease farm enterprise wealth based on the level of current and potential farm productivity. These areas within the CSG tenements in the Surat Basin are classified according to their current and potential land use in order to highlight areas where it may be most likely for CSG payment to facilitate agricultural intensification. Subsequent studies can target these areas for further investigation.

Methods

Study area

The study area includes the CSG petroleum leases or tenements within the Surat Basin region in Queensland, comprising 26,534.79 km^2 or 15 percent of the entire basin. The majority of this area is used for agriculture covering 88% of the total tenement area.

Spatial data preparation and analysis

Four biophysical characteristics were used in the study–slope, plant available water capacity (PAWC), soil pH, and aridity index. Percent slope was derived using the hole-filled Shuttle Radar Topography Mission (SRTM) (Jarvis, Reuter *et al*. 2008) Digital Elevation Model (DEM) data with spatial resolution of 3 arc-seconds (approximately 90m) . The Australian Soils Resource Information System (ASRIS) (CSIRO 2013) provided information for both the PAWC (0-100 cm) and soil pH (1:5 soil: C_aCl_2 solution extract) at a map scale of 1:250,000 having a raster resolution of 0.0025 degrees or approximately 250metres. The aridity index (annual rainfall: annual evaporation) represents the climatic environment with a raster resolution of 0.05 degrees (approximately 5km) obtained from the Bureau of Meteorology.

All spatial data were resampled to a 30m spatial resolution and converted into the Geocentric Datum of Australia (GDA) 1994 and projected using Map Grid of Australia (1994), Zone 55. The raster input data were subjected to fuzzification according to its strength of membership based on ASRIS, United Nations Environmental Programme (UNEP), and the Strategic Cropping Land (SCL) criteria.

Fuzzy Membership

In the study, the raster data of biophysical attributes comprising PAWC, slope, soil pH, aridity has been assigned to its appropriate set using a specific fuzzification process in ArcGIS (ESRI 2014). The following fuzzy membership functions for each biophysical variable were used:

- For the PAWC, fuzzy 'large' was chosen as the membership type. According to ASRIS, areas with soils that have PAWC of 20 to 40mm are considered to have low water holding. Values used in this criteria are indicative of the range of soil properties within the ASRIS dataset, though it should be noted that these are lower than reported by others (Dalgleish and Foale 1998) working in this region.
- In the western cropping zone, a slope of less than or equal to 3 % is considered suitable for cropping, while for other zones, a slope up to 5 percent is acceptable (Shaw 2011). The type of membership set for slope variable is called fuzzy 'small', slope > 5% would mean that its membership is approaching a value of 0, or having low suitability membership.
- Strategic Cropping Land guidelines suggest a suitable soil pH range of > 5 at 300mm and 600mm soil depth for all soils, but ≤ 8.9 for rigid soils (Shaw 2011). In order to capture these critical points, the fuzzy 'Gaussian' membership was adopted. This type of membership function transforms the input values into a normal distribution, with the crossover point (approximately set at pH 6.7) having the value of 1.
- Aridity index criteria for the study used the UNEP classification. This index indicates degree of dryness of the climate in a particular area. Those areas considered arid have an index of 0.03 to 0.2 while semi arid regions are between 0.2-0.5 index (UNEP 1997). A critical crossover point of 0.27 was chosen to arbitrarily cover the range of values in categorising aridity. Similar to PAWC, aridity variable adopted the fuzzy 'large' as membership type.

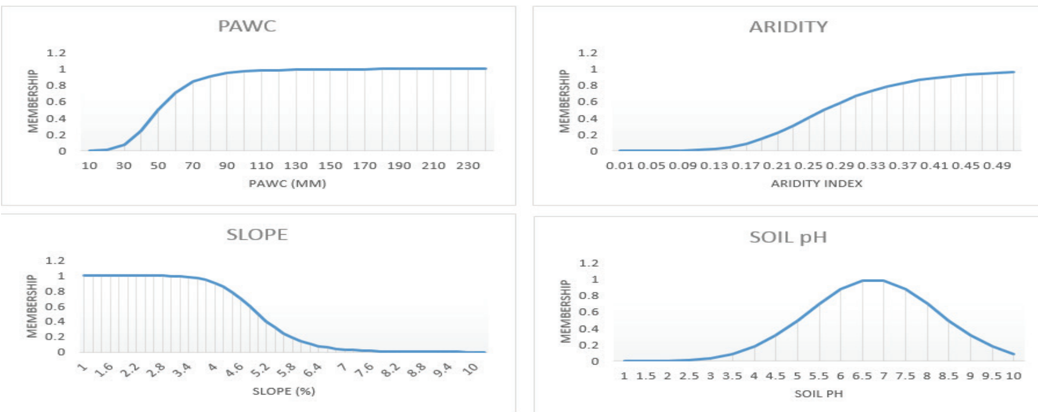


Figure 1. Fuzzy membership of biophysical variables

An overlay type method was adopted in which input fuzzy rasters were combined according to the least common denominator for the membership of all the input criteria, or the Fuzzy 'And'. The fuzzy overlay rule was executed by classifying the membership value as:

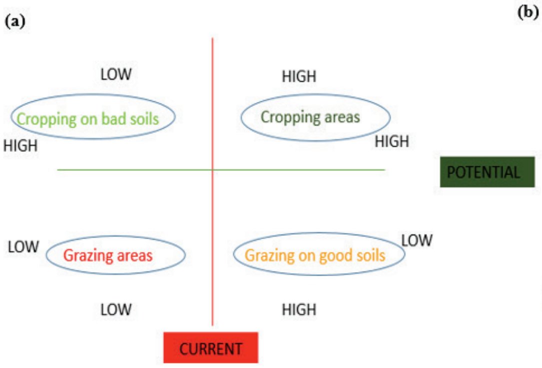
- 0 to 0.39 = low suitability for intensification
- 0.40 to 1 = high suitability for intensification

The fuzzification of the raster inputs was compared to the land use data derived from the 2006 National Land use map and Australian Land use and Management updated as of 2010 obtained from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) (ABARES 2010). This allows the identification of areas with potential agricultural intensification and high productive value, and those in which additional source of funding could support agricultural improvement and development.

Results

Land use was used as a surrogate for agricultural production: cropping areas represent higher intensification of production, while grazing/pasture represent a lower level of intensification. In order to identify areas of interest, land use data were intersected with the fuzzy overlay of the biophysical areas and sorted according to their current and potential land use (Figure 2a). The boundaries of each group are the result of the overlay procedure and maybe subject to limitations, which thus provides this study with an initial and aggregate estimate.

Figure 2b shows the distribution of the areas of interest. The 'dark green' areas are grouped as HH or those cropping areas that have high current and potential intensification (top right of the matrix, Figure 2a). These areas depict the most suitable environment, based on the inherent biophysical parameters (slope, soil pH, PAWC, aridity). Further, being a cropping zone, it is has the highest potential for farm productivity and returns based on current input and farming management. These areas comprise nine (9) percent (209,848 hectares) of the total agricultural tenement of the study area. CSG payment would be used here to improve an already intensive agricultural system, possibly through increased efficiency or management intensity.



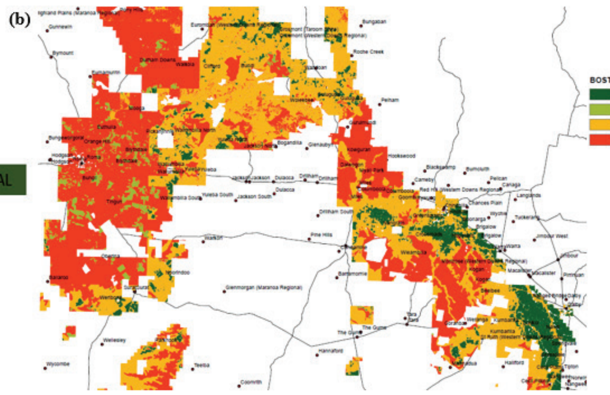


Figure 2a. Quadrant of level of intensification **Figure 2b. Level of intensification map**

The LL areas where current and potential intensification is low. These are grazing areas on marginal cropping land, less suitable for high value production (i.e. due to poor soil quality, low water availability). These 'red' zones (Figure 2b), constitute the largest portion of the agricultural tenements having 49 percent or a total of 1,140,872 hectares. CSG payment may be of use in improving existing land use rather than in changing it to something more intensive.

In between are the mixed classification of LH and HL. The LH are the 'yellow' regions in the map (Figure 2b) that have high potential due to the environmental conditions, but are currently grazed. This region (902,052 hectares or 39%) is inherently suitable for agricultural production according to the biophysical characteristics and the fuzzification process. While this land use is presently devoted to grazing, there may be scope to improve its returns through additional investment for its transition into cropping. It may be that CSG payment could be used in these regions to move toward a more intensive land use. On the other hand, HL are the 'light green' areas (73,477 hectares) that indicate current cropping in areas categorised as less suitable for high value land use using the methodology described. CSG payment may assist in providing a more stable cash flow in these environments where current efforts for intensification may have risk.

It should be noted that only four biophysical attributes have been used in site classification yet,other local factors would also likely impact any future land use. Furthermore, all potential benefits from intensification would need to be weighed against the possible losses incurred due to CSG operations on the farm, and these are likely to be highest in the HH zones.

Conclusion

This study on the biophysical attributes of the CSG tenements as input to the site selection process of case study areas is a simplified indication into where CSG could have potential impact on agricultural productivity and financial performance of the farm enterprises. While some farmers may regard CSG operations as unnecessary to their farm enterprise, exploration of the level of productive potential of agricultural tenement reveals areas that could possibly increase their farm returns with more intensive agriculture or alternative farming system. It may be that farmers in these areas could utilise the financial support or compensation from gas companies as capital to develop and improve their farm by re investing in infrastructure and inputs. There are notable examples related to this, where farmers have chosen to use CSG payment or on-farm investment to improve their enterprise. Investigations into how this can be achieved will be undertaken in subsequent effort in this area. This study is a preliminary step in investigating this issue for the coexistence of agriculture and CSG. A series of case studies for the different regions highlighted in this analysis will be undertaken in future work to illustrate the benefit of CSG income in farm improvement.

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