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Feeding and housing the urban population: Environmental impacts at the peri-urban interface under different land-use scenarios

Alison Rothwell[a,*], Brad Ridoutt[b], Girija Page[a], William Bellotti[a]

[a] School of Science and Health, University of Western Sydney, Locked Bag 1797, Penrith, NSW 2751, Australia
[b] Commonwealth Scientific and Industrial Research Organisation (CSIRO), Private Bag 10, Clayton South, Victoria 3169, Australia

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ABSTRACT

The environmental consequences of the decision to urbanise and displace peri-urban (PU) food production are not typically evaluated within a comprehensive, cross-sectoral approach. Using a novel application of life cycle assessment (LCA) within exploratory scenarios, a method for integrating housing and food production land uses in PU regions is proposed, based on relative environmental impacts. Using two housing types (greenfield and infill) and two types of food production (field and high-technology greenhouse (HTG) lettuce production), environmental impacts for five exploratory land-use scenarios are compared for PU land in a developed and growing city. Each scenario is able to house an equivalent residential population whilst delivering equal quantities of fresh food to a city market. The results clearly indicate that infill housing and food production has less environmental impact than greenfield development. The environmental impact categories of climate change, freshwater eutrophication, photochemical oxidant formation, particulate matter formation and human toxicity are reduced by 25–43 percent under infill scenarios. Sparing PU land through infill housing development combined with sustainable food intensification using HTG production, enabled multifunctional PU land-use including food production, housing and afforestation while delivering lower relative environmental impacts. Urban afforestation on PU land made available by these measures reduces the effect of climate change by up to 5 percent per hectare per year.

1. Introduction

Urban areas have a substantial environmental impact in relation to their small absolute land area. Anthropogenic emissions from urban areas range upwards of 30 percent of the global total. Building-related greenhouse gas (GHG) emissions are predicted to rise a further 50–150 percent by the middle of the 21st century as urban populations expand (IPCC, 2014). The expansion of urban areas and the consequent direct changes in land use may contribute to environmental burdens in other sectors, including the agriculture sector — for example, when housing is allowed to extend onto peri-urban (PU) cropland, displacing food production to more remote locations (Low Choy and Buxton, 2013). Since the agriculture sector contributes a further 14 percent of total global anthropogenic emissions (United Nations Human Settlements Programme, 2011), the combined environmental impact of urban expansion replacing PU farms may be significant. Typically, however, these consequences are not evaluated comprehensively using a cross-sectoral approach. Few environmental studies have attempted to analyse the continued provision of fresh perishable food following displacement of PU agriculture.

Furthermore, the potential trade-offs between different environmental impacts that may occur have seldom been analysed. For example, reductions in GHG emissions may coincide with increases in other environmental effects associated with urban systems: increased particulate matter (Brochu et al., 2011); declining water quality (Tong and Chen, 2002); increased ozone concentration (Sicard et al., 2013); human toxicity; and water scarcity. Inhaled particulate matter may contribute to human ill health; declining water quality affects urban ecosystems. Increased ozone levels may adversely affect certain materials as well as human and plant health. Human toxicity results from the persistence of harmful chemicals leading to toxicity in the environment and in the food chain. Various chemicals are known to affect cognitive development, with research indicating that children may be more at risk in urban areas than in rural regions (Calderón-Garcidueñas et al., 2008; Liu and Lewis, 2014). A growing awareness of the need

* Corresponding author.
E-mail address: alison.rothwell@uws.edu.au (A. Rothwell).

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for efficient use of water resources in urban areas is reflected in measures to secure water supplies and water-scarcity pricing is beginning to appear on government agendas (Frontier Economics, 2011). Comparisons within a suite of environmental impacts permit trade-offs to be examined, together with a clearer appreciation of regional relevance.

The present study describes an approach for integrating housing and food-production land usage in PU regions, based on their relative environmental impacts. Using combinations of two housing types with two types of lettuce production, the environmental impacts of five exploratory PU land-use scenarios were analysed using a life cycle assessment (LCA) approach. Primary data was applied wherever possible. All scenarios accommodate equal residential populations and deliver equal quantities of fresh food to a city market. The possibility of further PU land use, such as afforestation, was also explored. By incorporating both housing and food system changes, the cross-sectoral approach adopted in the study has produced a novel and comprehensive assessment of the environmental consequences of urban expansion displacing PU food production.

1.1. Peri-urban landscapes and food provision

PU regions are transitional zones between urban and rural districts. Land in PU regions may be used for a multitude of purposes — housing, recreation, ecosystem preservation, commercial food production and other primary industries. Spatially, there is no consistent worldwide definition of how far from a metropolitan centre a PU region might extend. For example, they may range from tens to more than a hundred kilometres from a major centre. Population densities are defined in some contexts, as in the European PLUREL project (Piorr et al., 2011) but, more typically, densities remain undefined due to inter-country variation, with the focus continuing to be on the competition for resources in PU regions (FAO, 1999). PU regions are often highly contested. Conflict is manifested at the level of governance: land-use planning is typically based on an urban–rural dichotomy that exhibits poor integration of the demands of each. This may extend to the level of residents, with newer residents often possessing lifestyles that are opposed to production values. In Australia, as in other developed nations, PU agricultural regions have changed rapidly, historically succumbing to urban development and sprawl (Piorr et al., 2011; Millar and Roots, 2012; Low Choy and Buxton, 2013). It is paradoxical that the commercial fresh food production capacity to support an increasing urban population is therefore lost (Martin et al., 2008). In a developed and growing city such as Sydney, for example, expected population trajectories to 2061 will entail providing food for an additional 200 persons each day (ABS, 2013)[1].

The opportunity to improve environmental outcomes for PU development by incorporating food provision into planning is often not recognised internationally (APA, 2007; Lovell, 2010; Zasada, 2011; van der Schans and Wiskerke, 2012; Pires and Burton, 2013; Russo et al., 2014). Conventional commercial PU agriculture is often missing from discussions about urban agriculture and its place in urban planning. Metropolitan strategies in Australia, for example, have yet to proactively consider the continuing provision of fresh food from surrounding agricultural land. This is in contrast to the progress evident in cities such as Chicago, London and Vancouver (Budge, 2013). Such inattention to commercial PU agriculture in urban planning is evident despite its significant contribution to local (and regional) markets. For example, in the USA, urban-influenced regions have been reported to produce most of the fruit and vegetables, at 91 and 78 percent respectively (American Farmland Trust, 2013). In Sydney, PU vegetable production was recently valued at 27 percent of the value of production for the state of New South Wales. The contribution of PU agriculture is larger for specific crops, such as for lettuce at 53 percent (ABS, 2014)[2]. Commercial PU agriculture performs a more vital role than other forms of urban agriculture (e.g. community gardens and rooftop gardens) whose output quantity is typically dramatically lower in developed cities in the USA, for example (Brown, 2002). Direct-to-consumer urban agriculture in the San Francisco foodshed, such as community-supported agriculture, has been reported to contribute only 0.75 percent of overall production value (Thompson et al., 2008). Similarly, recent figures indicate that intra-urban vegetable production in the Sydney metropolitan region contributes only 0.6 percent of the value of PU vegetable production (ABS, 2014).

Planning approaches that consider only the immediate impact of urban development, yet ignore the displacement of commercial food producers, remain incomplete and potentially flawed. Comprehensive environmental assessment of any decision to urbanise PU horticultural lands requires that more than the urban system alone be taken into account. The consequences of such decisions cannot be fully understood unless the system is expanded to include the impact both of housing and of horticultural systems. Such an awareness must include consideration of food production displacement if the necessary food production to supply local retail markets is to continue. Informed decisions about long-term, sustainable urban development are possible only if the decision-makers have access to environmental data to complement economic and social considerations. (Economic and social factors are outside the scope of this study.)

1.2. Land-use integration in peri-urban settlements

If the interrelation of urban and agricultural systems is recognised, the opportunity then arises for PU regions to support environmental impact mitigation by integrating different land uses. Policy instruments that encourage such strategies have been recommended for minimising the lock-in risks associated with urban land use and infrastructure life spans (IPCC, 2014). Since PU regions are already typified by a wide range of land uses, it would appear reasonable to assess their ability to incorporate several functions, rather than limit them merely to the single function of conversion to greenfield housing. Such functions may include productive, cultural and ecological land use, which form three dimensions of landscape multifunctionality (Lovell and Taylor, 2013). Multifunctionality in urban landscapes is emerging as a necessity, since an obvious consequence of urbanisation is loss of agricultural and natural land. Benefits associated with effective multifunctional landscape planning include support and regulating services (e.g. carbon sequestration and afforestation) that flow on to increased biodiversity and reduced urban heat-island effects; however, despite the increasing application of the multifunctional landscape concept to agro-ecosystems, there are few examples in urban ecosystem planning (Lovell and Taylor, 2013).

Multifunctional combinations of land uses in PU regions will generate different environmental impacts to monofunctional housing use. The extent of any difference between such environmental impacts is not clear. Few studies of the environmental trade-offs for alternative PU land-use scenarios have been reported, in which housing, food production and co-benefits such as afforestation may be integrated. To fill this gap, several of the scenarios compared in the present study comprise the elements of housing, fresh food

[1] Series B medium growth data for Greater Sydney.

[2] Data representative of the Hawkesbury–Nepean region, a PU area of Greater Sydney.