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Table of Contents

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Exploring local food sustainability potential and 'Agrarian Urbanism' in the regional city of Dubbo

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Exploring local food sustainability potential and 'Agrarian Urbanism' in the regional city of Dubbo

ABSTRACT

Rapid urbanisation as a consequence of population growth is likely to reduce the availability of valuable agricultural land areas for food production. Two-thirds of the world's population will be living in urban areas by 2030. Cities around the world are integrating local food production capabilities within built environments to create food secure and environmentally sustainable habitats. Regional cities with comparatively less population have a significant potential and distinct advantage to incorporate these measures early on in planning for the urban areas. In this paper, a review is conducted on local food production policies and practices in relevant cities. 'Agrarian Urbanism' approach to the master planning of new developments can protect valuable agricultural land and natural areas. A real-world case study that applies 'Agrarian Urbanism' principles is analysed. Dubbo, one of the most important regional cities of Orana region in New South Wales in Australia is selected as a case study for research analysis. Using Australian Bureau of Statistics (ABS) data and Geographic Information Systems (GIS) methods, current local food production potential, and its capacity to meet the annual food (vegetable) demand of Dubbo City are estimated and examined through four scenarios. The local food production typologies that could be embedded in the urban fabric are explored, and recommendations are formulated. Research outcomes suggest that Dubbo city has a reasonable prospect to grow into a sustainable regional city of future. Collaborative efforts of governments, private, non-profit and farming organisations, industries and residents would be important for the uptake.

Keywords: *local food; sustainability; agrarian urbanism; regional city; food security*

Introduction

Human settlements grow spatially over a temporal scale through dynamic processes of growth consuming valuable agricultural land areas essential for supplying food demand. Two-thirds of the world's population will be living in urban areas by 2030 (Population Reference Bureau, 2011). Fifty percent more food would be required to be produced to feed nine billion people on earth by 2050 (World Bank 2016). Regional cities would have an important role to play in this urbanisation process. Therefore, building an efficient and secured food system in regional cities should be critical priorities for future. Cities around the world are integrating local food production capabilities within built environments to create food secure and environmentally sustainable habitats.

Local food production potential within built environments is noteworthy in many cities of the world. In London, the UK, allotment gardens produced 232,000 tonnes of fruit and vegetables in 1999 capable of supplying 18% of the population's daily intake as per World Health Organisations (WHO) recommendations (Garnett 1999). Food and Agricultural Organisation of United Nations (FAO) reported that urban growers in the Republic of Congo produced annually a total of 330,000 tonnes of vegetables, equivalent to a market value of over $400 million dollars (FAO 2011). Local food production in Congo supplied nutritional food to 11.5

million people and improved enormously the food security (FAO 2011). A significant amount of open spaces is locked within millions of private and public outdoor spaces in the cities and suburbs of the world. If these land areas could be put to productive uses, cumulatively these spaces could work as an alternative local food production network and supply a considerable share of population's food demand (Ghosh 2014).

In this paper, Dubbo, the largest city of Orana region in New South Wales, is the focus of this research. Dubbo City is strategically placed at a location conveniently accessed from Sydney and on the route from Brisbane to Melbourne. The larger Dubbo Local Government Area (LGA) covers an area of 3426 square kilometres (sq. km) and contains two Statistical Local Areas (SLAs): Dubbo SLA Point A and Dubbo SLA Point B. Dubbo SLA Point A, covers 330 sq. km. with a population of 36,184 people (ABS 2011a). This paper focuses on Dubbo SLA Point A (Fig 1) and mainly the built up areas of the Dubbo City is located within this SLA.

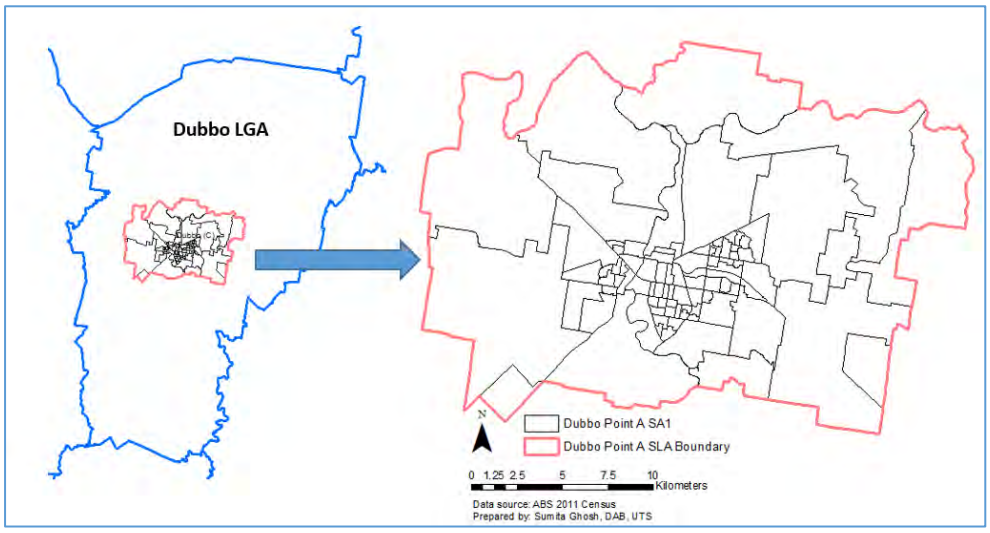

Fig 1: Dubbo Statistical Local Area (SLA) Point A
(Data Sources: ABS 2011 Census; Prepared by: Sumita Ghosh)

Aims and objectives of the research

The main aims of this research are to: estimate the total available productive land within built environments of a small regional city Dubbo and local food production potential of these productive land areas to supply the annual food demand of the City for self-sufficiency. This research focuses only on calculating the total vegetable demand of the population considering vegetables as an important part of the total dietary requirement of the population. The five objectives of this research study follow.

- To review briefly local food production approaches in selected cities of the world;
- To comprehend emerging theories and approaches on 'Agrarian Urbanism' and 'The Transect;
- To calculate total vegetable demand of the Dubbo City;
- To estimate total available productive land within built environments of the Dubbo City;
- To calculate to what extent this available productive land area could supply the annual vegetable demand of the resident population;

Research methodology

This paper focuses on determining the local food production potential of the Dubbo City to supply the total vegetable demand as an important part of daily diet of a healthy population. The vegetable production could be easily integrated within new and existing built areas. The research methodology consists the following six main steps to achieving the objectives of this research.

(a) To conduct a review of selected cities; an analysis on an 'Agrarian Urbanism' case study and to investigate 'The Transect' concept in the context of the Dubbo City;
(b) To determine and measure areas under urban developments in the Dubbo city that could integrate local food production;
(c) To estimate annual vegetable demand of the total population in the Dubbo SLA Point A;
(d) To calculate total available productive land within the urban areas of the Dubbo City using a scenario-based approach;
(e) To calculate annual local vegetable production potential of available productive land within built environments to supply the total annual vegetable demand using four scenarios;
(f) To formulate recommendations based on the outcomes from the above analyses;

A review of selected cities, an Agrarian Urbanism case study and 'The Transect' in Dubbo

A brief review was conducted in selected cities that have incorporated local food production within built environments and have formulated relevant planning policies and practices. 'Agrarian Urbanism' as an emerging food urbanism theory (Duany, A and Duany Plater-Zyberk & Company (DPZ) 2010; DPZ 2016) is discussed. A real-world 'Agrarian Urbanism' case study: Prairie Crossing that applies 'Agrarian Urbanism' principles of master planning was analysed. This case study showcases how urban growth could protect agricultural and natural areas effectively in new urban developments in peri-urban and rural zones of the city through 'Agrarian Urbanism' approach to master planning. These strategies are significantly important in Dubbo context. 'The Transect' is a broader concept of systematically exploring varying physical or natural of human environments along a cross section through the settlement (City of Miami 2016). Using 'The Transect' approach (Duany, 2002; Duany et al. 2010; City of Miami 2016), land uses/land cover patterns, Dubbo City Transect land use zones, typical morphological characteristics of these zones were examined from the aerial imagery. The food typologies such as home gardens and farms, etc. that could be integrated along the different transect zones were investigated.

Determining urban areas for integrating local food production within built environments

Data on basic community profile such as population, average household size, total family households and dwelling types, numbers, and the number of bed rooms in the dwellings and spatial boundaries at the SLA and SA1 levels under Australian Statistical Geography Standard (ASGS) classification were collected from Australian Bureau of Statistics (ABS) 2011 Census. ASGS is the new geographical framework for ABS data from ABS 2011 Census onwards. The SLAs are defined as Local Government Areas (LGAs) or part thereof (ABS 2011b) and SA1 as the smallest data release unit built from whole mesh blocks and contains a population of

approximately 200 to 800 persons according to the ABS 2011 Census (ABS 2011c). Data was also collected from relevant reports and academic literature. There are altogether eighty-nine SA1s within Dubbo SLA Point A boundary. Dwelling density and building footprints are indicators of available productive spaces within neighbourhoods. The number of bedrooms in the separate houses assisted in estimating the built up footprints of dwellings. Dwelling density, population density, percentages of dwelling types such as separate houses, townhouses and apartments, and total land areas in hectares under separate houses for each of the total eighty-nine SA1s were calculated using GIS methods. The morphologies of areas are cross checked using the Dubbo Transect. The SA1boundaries that have very low population densities and dwelling densities were excluded as these SA1s represent the areas where land may already have been allocated to crop and livestock farming. A total of sixty-three SA1s selected which could be categorised as urban development areas within Dubbo SLA Point A boundary.

Estimating total annual vegetable demand the Dubbo SLA Point A population

The Department of Health and Ageing, Australian Government (2006) recommends daily on average five servings of vegetables from three different groups of vegetables: starchy, deep green and legumes and other vegetables. It is calculated that the average energy required daily from the vegetables approximately ranges from 12% to 20% of the recommended daily average food energy intake per person of 2150 kcal (Haug et al. 2007). According to Australian Government's 'Healthy Eating' recommendations on daily vegetable servings and intake distribution in the three groups of vegetables, 425 kcal to 255 kcal energy from vegetables is required daily for an average person. The total vegetable demand is calculated to be equal to an average value of 330 kcal of the total daily diet for an average person in Australia (Ghosh 2011). This value is multiplied by the total population Dubbo SLA Point A to calculate the total annual vegetable demand.

Estimating available productive land and annual local vegetables production potential

The percentages of separate houses are significantly higher than the other dwelling types in Dubbo and this dwelling type has opportunities to integrate localised production in home and community gardens. Therefore, it is assumed that mainly the local food production would be integrated into the neighbourhoods where these separate houses are located. The total building footprints of separate houses in hectares for each of the sixty-three selected SA1s were calculated considering approximate ground coverage of standard one bedroom, two bedrooms, three bedrooms, four bedrooms and five and more bedrooms houses. It is assumed that 20% of the area would be devoted to impervious uses such as roads and paved surfaces. The total available productive land was calculated by subtracting total building footprints of separate houses, impervious surfaces and land areas under other dwelling types and other uses for the selected area of Dubbo City. Four productive land utilisation scenarios were examined. Scenario 1 (Maximum) includes 100% utilisation of available productive land while Scenario 2 (High) focuses on 80% utilisation of total available productive land. Scenario 3 (Medium) includes 50% utilisation of total available productive land and in Scenario 4 (Low) only 25% utilisation of total available productive land were done. All the four scenarios were spatially mapped and available productive land areas for sixty-three selected SA1s were calculated.

Ghosh (2014) developed a local food energy model that assessed local food production potential of low to medium density residential urban form case studies at a community scale in Australia and New Zealand. The annual vegetable productive capacity of land is calculated to be equal to 5.94 kg/m^2. The vegetable productivity in energy units is calculated to be equal to 0.007 GJ/m2 or 70 GJ/ha considering New Zealand and Australian case studies (Ghosh 2014). The energy unit makes a useful connection and a calculation between dietary energy intake and local food production was done. Total vegetable productivity in energy units for the selected SA1 were calculated for these four scenarios. Four local production potential scenarios were compared to understand to what extent local production of vegetables could supply the vegetable demand of the city. Recommendations were developed considering outcomes form the above analyses for the Dubbo City.

Research analysis and results

A brief review of local food planning policies and practices in selected cities

The City of Vancouver in Canada promotes urban agriculture through its public policy initiatives, such as 'Food Policy Council' and planning policy connecting the regional scale to local planning policies. Metro Vancouver's 'Regional Growth Strategy', and the 'Agricultural Land Reserve' (Mullinix, Fallick and Henderson 2009) regional policies show an excellent policy alignment with city and local scale policies such as 'Vancouver Food Strategy', 'Greenest City Action Plan', 'Urban agriculture design guidelines for the private realm' and 'Edible Landscaping Guide' (City of Vancouver 2016; City of Vancouver 2013; NYC Global Partners 2012). 'Toward a Bright Green Future' aims to create Vancouver as a globally leading city in urban food systems by 2020 (NYC Global Partners 2012). The initiatives '2010 Garden Plots by 2010', and 'Tree Keepers Program' provide significant supports to creating community gardens in neighbourhoods and parks and home gardens for local food production within built environments. An increase in community participation up to 21,750 people was achieved in 2014-2015 (City of Vancouver 2016). Vancouver takes a holistic approach to the development of a complete sustainable food system.

In the low-density City of Detroit in the USA, integrating local food production methods include adaptive reuse of vacant lands, establishing rooftops, home and community gardens for local food production using traditional and new gardening practices. Keep Growing Detroit (KGD) has a strategic mission of re-creating Detroit as a 'food sovereign' city and emphasises a 'production-focused model' of local food production (KGD 2011). Under Garden Resource Program (GRP) program, up to 20.000 Detroit residents have decided to grow food in the home, community and schools gardens and urban farms and have received resources and assistance with gardening (KGD 2011). Institutional environments for local food production are noteworthy in the post-industrial city of Detroit as significant progress has been made in establishing collaborative partnerships between public and private companies and developing new economic practices around urban agriculture. Local food production practices and approaches within built environments of Detroit provide exemplary evidence on how growing local food within urban areas could shape and revive a shrinking city's economy, culture, community engagement to offer a new way life for its residents.

Singapore is a very high density, and 100% urbanised wealthy island country or city–state in southeast Asia (Lee and Tan 2011). Due to lack of productive land, Singapore's integration of local food production within built environments is focussed on innovation and technology adoption for hi-tech, and hi-yield methods of local food production. 'Sky Greens' is a vertical farm in a multi-storied building grows high-quality vegetables hydroponically in rotating tiers of growing racks mounted on 'A' shaped vertical frames (Sky Greens 2014). The social importance of growing food locally promotes social networking and community engagement. 'Community In Bloom (CIB)' program to facilitate a socially networked community with a gardening culture, civic ownership and community participation in Singapore. Up to 20.000 residents have participated in the CIB program; 1000 community gardens have been added and 60 hectares of skyrise greenery at rooftop level have been added (Chiew 2013; National Parks, Singapore 2016).

In Australia, City of Sydney and City of Melbourne have recognised importance local food production. These two cities have adopted community garden policies to establish the frameworks for managing new and existing community gardens to provide social, cultural, economic and environmental benefits to residents. The City of Sydney has thirteen community gardens within its Local Government Area (LGA) and numbers are significantly on the rise to support and achieve the goals of the major policy 'Sustainable Sydney 2030' (City of Sydney 2014). The City of Melbourne's Community Garden Policy address two goals: a city for people and an eco-city from the City of Melbourne Council Plan 2013–2017. 'Street Gardens Policy', 'Growing green guide for Melbourne', 'We Need To Talk About Food – a Sustainable Food Information Tool' and 'Sustainable gardening in the City of Melbourne' documents establish the importance of local food production within the City of Melbourne (City of Melbourne 2016). Many other Australian cities are already recognising the importance of local food production.

The examples of cities presented above provide evidence that cities at different development stages and with different densities are making provisions for improved food security for future. Regional cities with comparatively less population have a significant potential and distinct advantage to incorporate these measures early on in planning for their urban areas. 'Agrarian Urbanism' principles for master planning of new developments to protect agricultural land and natural areas are explained later in this paper. These aspects could improve sustainability and public health and wellbeing; increase property values and create a thriving local economy. The regional cities could evolve as innovative food efficient larger cities of future considering these sustainability aspects of urban planning.

'The Transect' of the Dubbo City and Agrarian Urbanism international case study

Duany et al. (2010) conceptualised that four models of food urbanism: 'Agricultural Retention', 'Urban Agriculture', 'Agricultural Urbanism' and 'Agrarian Urbanism' could be integrated within cities and towns. 'Agricultural Retention' relates to the protection of farmlands at regional and macroeconomic scales and 'green belts' protecting farmlands is an example of this. 'Urban Agriculture' model refers to local food production within built environments on any available land such as vacant land, community and home gardens, rooftops and planter boxes etc. The 'Agricultural Urbanism' model links to a working farm on

which the community may be economically associated (such as buying from the farm or managing through Community Supported Agriculture (CSA)) but not socially connected to the farm (Duany et al. 2010). Developing food based societies and designing the liveable places are fundamental to 'Agrarian Urbanism' model and links to new urbanism principles of planning and designing places (DPZ, 2016).

Prairie Crossing, Illinois in the USA is selected as the Agrarian Urbanism case study. It is developed by Vicky and George Ranney and is built on 270 hectares of land area (Ranney, Kirley, and Sands 2010). The design and planning process of this development provide prime importance to the protection of agricultural or productive land; preservation of natural areas and creating a sustainable community and society around farming as the primary activity following 'Agrarian Urbanism' principles of design and planning. In this development, a total of 40.5 hectares are devoted to organic farming for three separate farming organisations and 67 hectares of land have been restored as native prairies. Altogether 60% of the total site is open space consisting of lakes and ponds, natural areas and farming land areas. Environmental and ecological benefits are achieved through carbon and stormwater benefits of natural vegetation (Prairie Crossing 2014; Ranney et al. 2010). New urbanist planning is reflected through the diversity of different dwelling and mixed use building types, transit-oriented development, communal gathering spaces, sixteen kilometres of walking and cycling trails promoting active transport through natural prairies and food farms. Food production and nature conservation become the fundamental basis for structuring the places. All these successfully create better public health and social wellbeing through working and living in a food based community. This spatial planning allows continuation of life style patterns of communities in peri-urban and rural locations. The property values are increased to a greater extent due to the proximity of dwellings to nature and availability of options for preferred life style choices. This pattern of development is highly relevant for Dubbo context as still most of its peripheral areas are under rural or peri-urban uses. Future urban growth in Dubbo following 'Agrarian Urbanism principles could accommodate the urbanisation more sustainably.

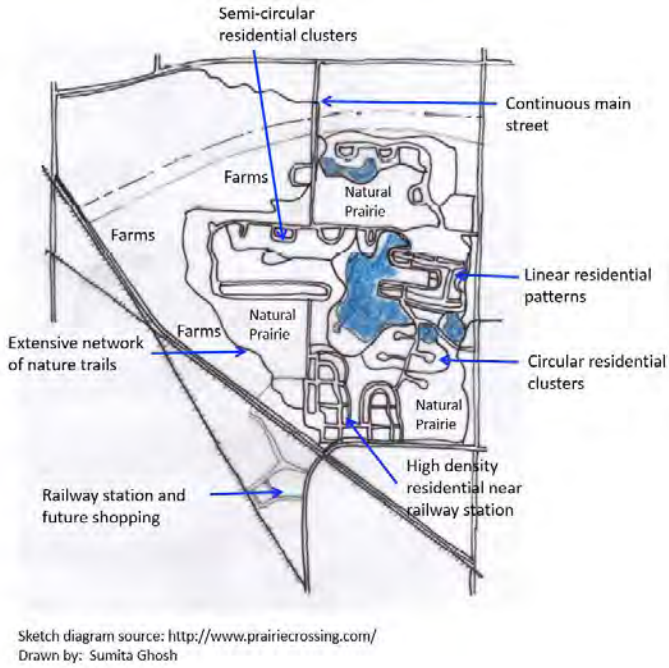

Fig 2: Master Plan of Prairie Crossing, Illinois, USA

‘Agrarian Urbanism’ approach to designing developments is intrinsically linked to ‘The Transect’ concept. In this paper, ‘The Transect’ is defined to contain varying morphological characteristics human environments along an urban to rural continuum; ‘an index of diversity’ (Duany, 2002: 257) and ‘contemporary ways of envisioning’ (Bohl and Plater-Zyberk, 2006: 5) the development patterns. Emerging theory in food urbanism and planning recognises its importance as a planning strategy (Talen 2002). ‘The Transect’ has six broadly classified land use zones: Natural (T1), Rural (T2), Sub-urban (T3), General Urban (T4), Urban Centre (T5) and Urban Core (T6) including districts (Duany et al. 2010; City of Miami 2016). Following this concept a form-based zoning code Miami 21 developed and is adopted and operative since April 2012 in the City of Miami (City of Miami 2016). ‘The Transect’ characteristics of a city vary with different cities depending on their population, spatial extent, activities, morphologies and many other interrelated factors.

A transect passes through the central section of the Dubbo City. Four land use zones: T1 Natural, T2 Rural, T3 Sub-urban, and T4 General Urban are identified in the Dubbo City. According to City of Miami (2016) in ‘T1 Natural zone’ natural areas or conservation areas are included while the ‘T2 Rural zone’ land areas include both open and cultivated land areas such as woodland, grassland, and agricultural land. ‘T3 Sub-urban zone’ is the low density transition zone between urban and rural zones with predominant residential land use patterns. ‘T4 General Urban zone’ includes primarily residential land use although could include mixed-use developments. The main purpose of this analysis to identify the morphological characteristics and food typologies for the Dubbo City. The Dubbo City Transect is dominated by the ‘T2 Rural zone’ and urban areas still maintain suburban morphologies. Agrarian Urbanism planning applications are possible in rural agriculture and peri-urban areas where communities are transitioning or still continuing with their lifestyles rural or agrarian societies. As discussed in the case study, master planning of the communities could be done in a way that it accommodates urbanisation with minimal impacts on the existing communities’ lifestyles. This analysis reinforces that there are significant areas within Dubbo that could apply ‘Agrarian Urbanism’ principles of planning. Different food typologies such as community gardens, home gardens, small and large urban farms could be integrated within the area linking to the residential density patterns. Dubbo community garden is already operating within the city as shown in Fig 3. Dubbo City Transect, local food typologies and ‘Agrarian Urbanism’ application areas are detailed in Fig 4.

Fig 3: Dubbo Community Garden producing vegetables and herbs (Photos by Sumita Ghosh)

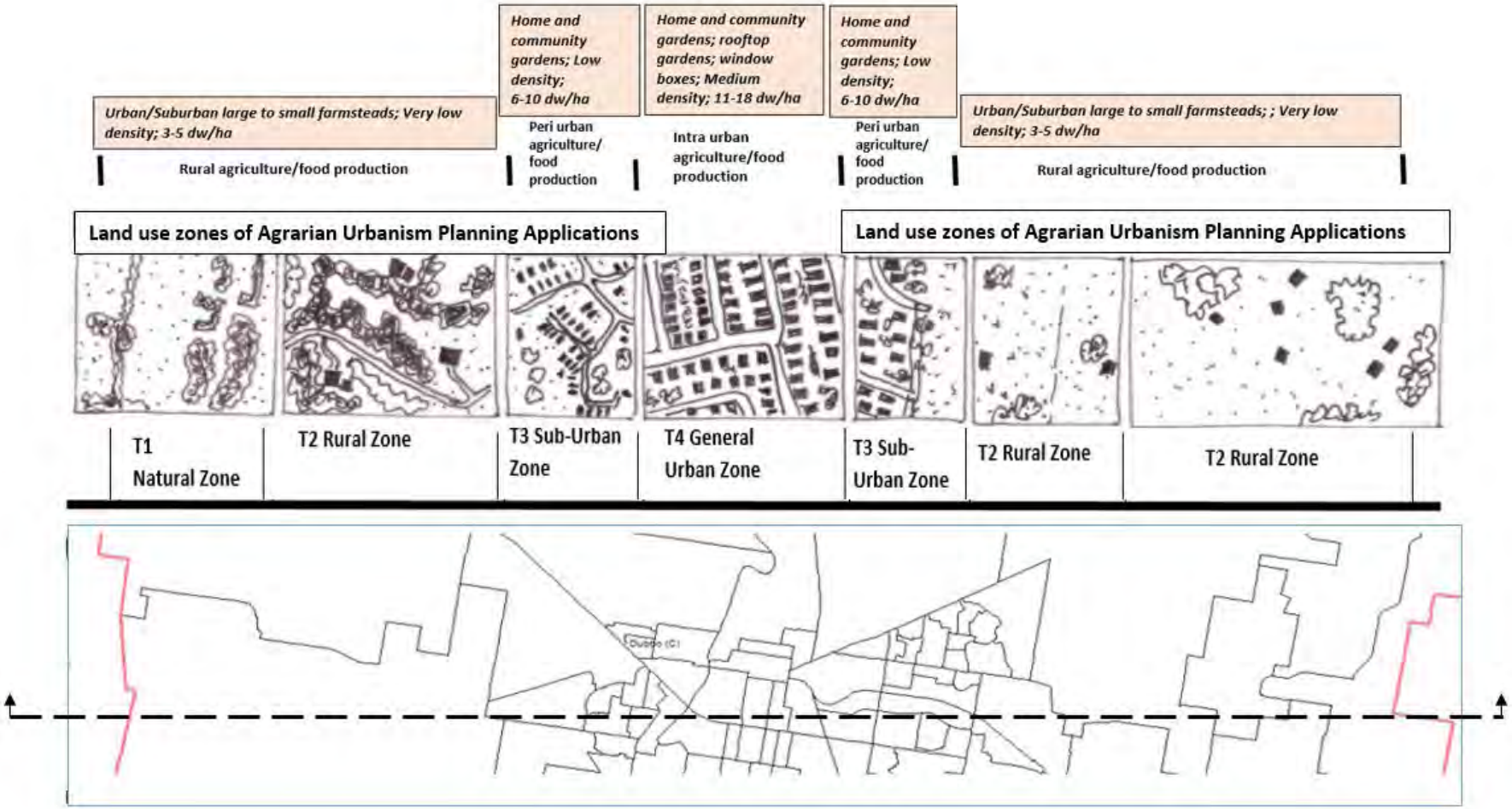

Fig 4: Dubbo City Transect, Local food production typologies and Agrarian Urbanism Planning Application areas
(Data Sources: Google maps 2016; ABS 2011 Census; Drawn by: Sumita Ghosh)

Basic community profile and density analysis on the Dubbo City

The Dubbo City has a traditional Australian suburban society with a median age 36 years, and 62.5% of the population are employed full time. The highest number of people are employed in health care and social assistance followed by retail trade. The other employment is administrative and support services, public administration and safety and construction and manufacturing. 89.6% of the population is born in Australia. The household car ownership is high, and a higher share of people travel to work by car. Dubbo has a total population of 36,184 people in ABS 2011 Census. Dubbo is the centre of grain production and livestock farming although data on production of vegetables in the region are not available. The following Table 1 presents basic community profile data for the Dubbo SLA Point A.

Table 1: Basic community Profile of Dubbo SLA Point A

Variables	Data	Percentages
Total population	36,184	-
Occupied private dwellings	12,886	91.9%
Unoccupied private dwelling	1,137	8.1%
Average people per household	2.5	-
Couple family with children	3850	41.6%
Couple family without children	3403	36.8%
Median Age	36	-
Median weekly rent	$200	-
Median weekly household income	$1,086	-
Worked full time (15 years or over)	10,954	62.5%
Worked part-time (15 years or over)	4,792	27.3%
Country of Birth (Australia)	32,421	89.6%
Average motor vehicles per dwelling	1.7	-
Travel to work by car as driver	11,701	70.3%
Aboriginal and Torres strait Islander population	4,817	13.3%

Data source: ABS 2011Census

Table 2 presents spatial distribution, and areas and SA1s in each of the five categories of dwelling density distribution. Using the ABS 2011 Census data, population density (Fig 5) and dwelling density (Fig 6) for the Dubbo City are mapped.

Table 2: Spatial distribution of residential dwellings in Dubbo Point A - SLA

Dwelling density per hectare (dw/ha)	**No. Of SA1s (nos.)**	**Total area (ha)**	**Total population (people)**
0-1	26	31108	9931
2-5	22	1135	8966
6-8	22	511	9031
9-11	17	315	7454
12-16	2	31	802

Note: Dwellings include all residential dwelling types such as separate houses, townhouses and apartments etc.

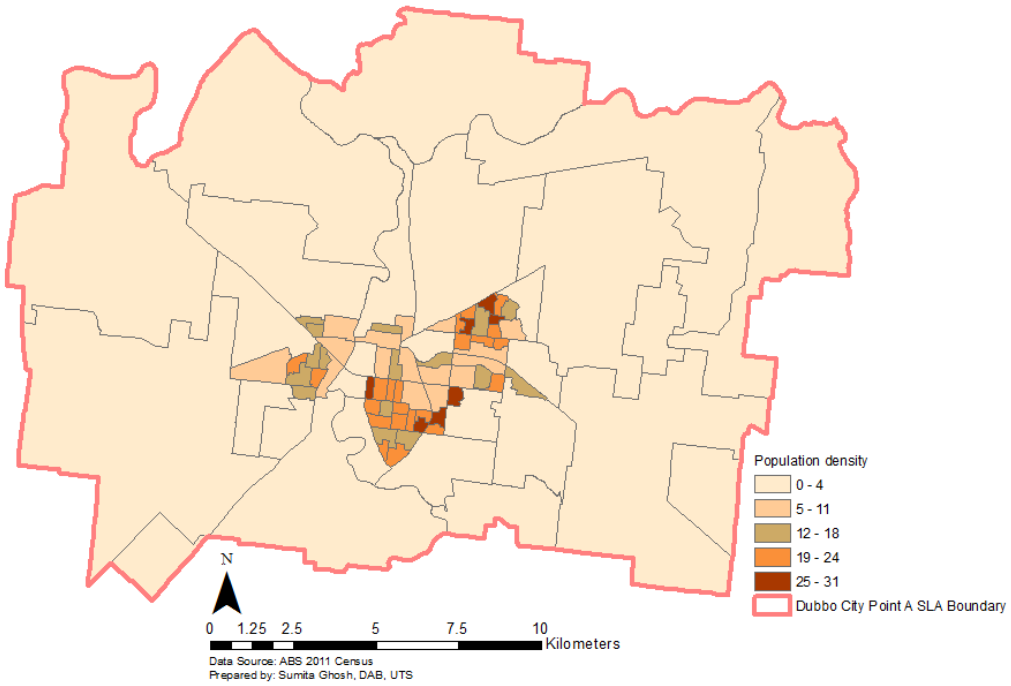

Fig 5: Dubbo SLA Point A - population density per hectare

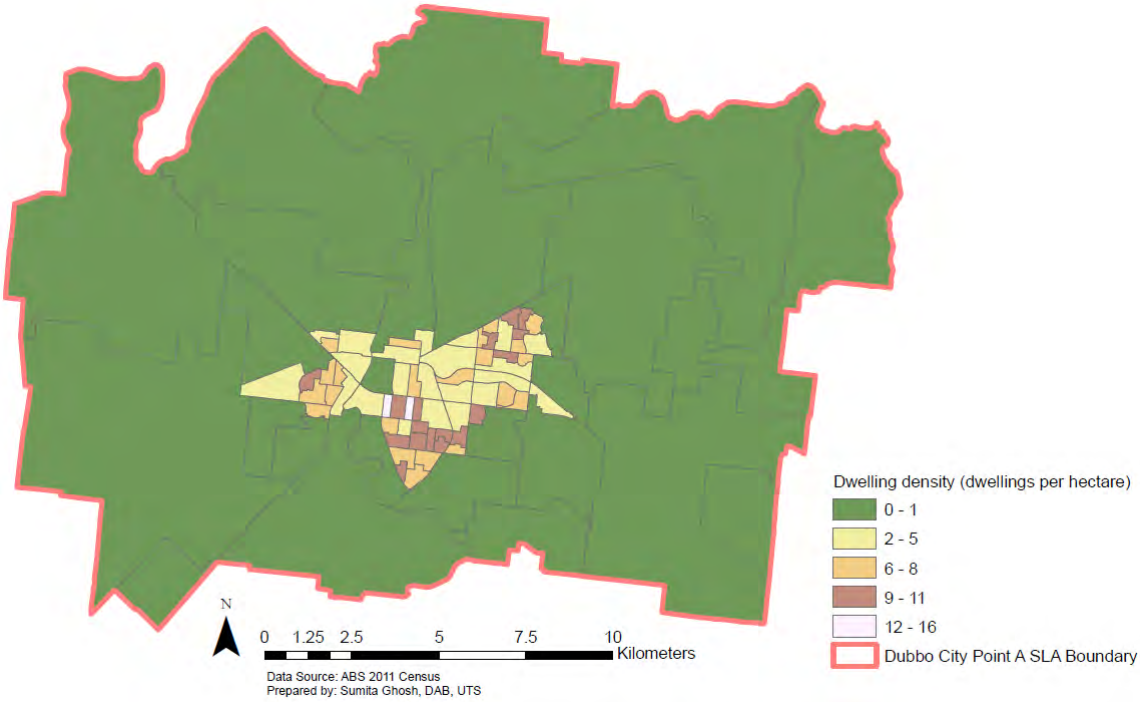

Fig 6: Dubbo SLA Point A - dwelling density per hectare
(Note: Dwellings include all residential dwelling types such as separate houses, townhouses and apartments etc.)

The analysis clearly indicates that the city is still in its formative stage with the urban areas concentrated at its centre with green areas surrounding the urban areas which have natural and rural zones. 'The Transect' analysis also confirmed these aspects. There is significant potential to protect natural areas and agricultural land in these areas. Approximately 94% or 31108 hectares of land areas cover these areas while the built up urban area at the centre covers only 6% or 1991 hectares of land.

Estimating total vegetable demand, available productive land and local food potential

Considering the total population of Dubbo SLA Point A equal to 36,184 people, total annual vegetable demand of the population was calculated to be equal to 18,248 gigajoules or GJ per year. The building footprint was estimated for each SA1s within the selected areas of Dubbo considering the number of bedrooms in the separate houses. Except other dwellings types, separate houses cover approximately 1501 hectares of land, and total building footprint was equal to 85 hectares within the selected areas. It is assumed that up to 20% or 300 ha of land was devoted to impervious uses such as paved surfaces, roads, and others. The total available productive land for vegetable production is 1116 ha.

Four scenarios were assessed for their abilities to supply the total annual vegetable demand. The Scenario 1 (100% use of the available productive land), Scenario 2 (80% use of the available productive land) and Scenario 3 (50% use of the available productive land) when put to cultivation and production of vegetables, then surplus vegetables would be produced in these three scenarios compared to total vegetable demand of the population. Scenario 1 would produce four times the required demand while the Scenario 2 and the Scenario 3 would produce three and two times of the required demand respectively. In Scenario 4 with 25% use of the available productive land would be just able to meet the total vegetable demand of the population with a minimal surplus amount of vegetables. With the increase in the population of City of Dubbo, the total vegetable demand would also escalate. If the urban morphologies or structure of the City remains same, Dubbo would be able to grow all its vegetable demand within the city. Fig 7 presents the maps for four scenarios showing the spatial distributions of available productive land areas in SA1s within the built environments of the Dubbo City. Table 3 presents the local vegetable production potential of the Dubbo City to meet the total vegetable demand of the population in four scenarios.

Table 3: Vegetables production potential of Dubbo within built developments (separate houses) for Dubbo SLA population

	Scenario 1: 100% utilisation of available productive land	**Scenario 2:** 80% utilisation of available productive land	**Scenario 3:** 50% utilisation of available productive land	**Scenario 4:** 25% utilisation of available productive land
Available productive land in the selected Dubbo SA1s (ha)	1116	893	558	278
Energy equivalent of vegetable production potential from available productive land in the selected SA1s (GJ)	78120	62510	39060	19460
Vegetable production potential surplus/deficient/sufficient of Dubbo Pt. A SLA population (GJ)	59872	44248	20812	1282
Dubbo Pt. A SLA vegetables demand supplied (times of required vegetables demand)	4	3	2	1

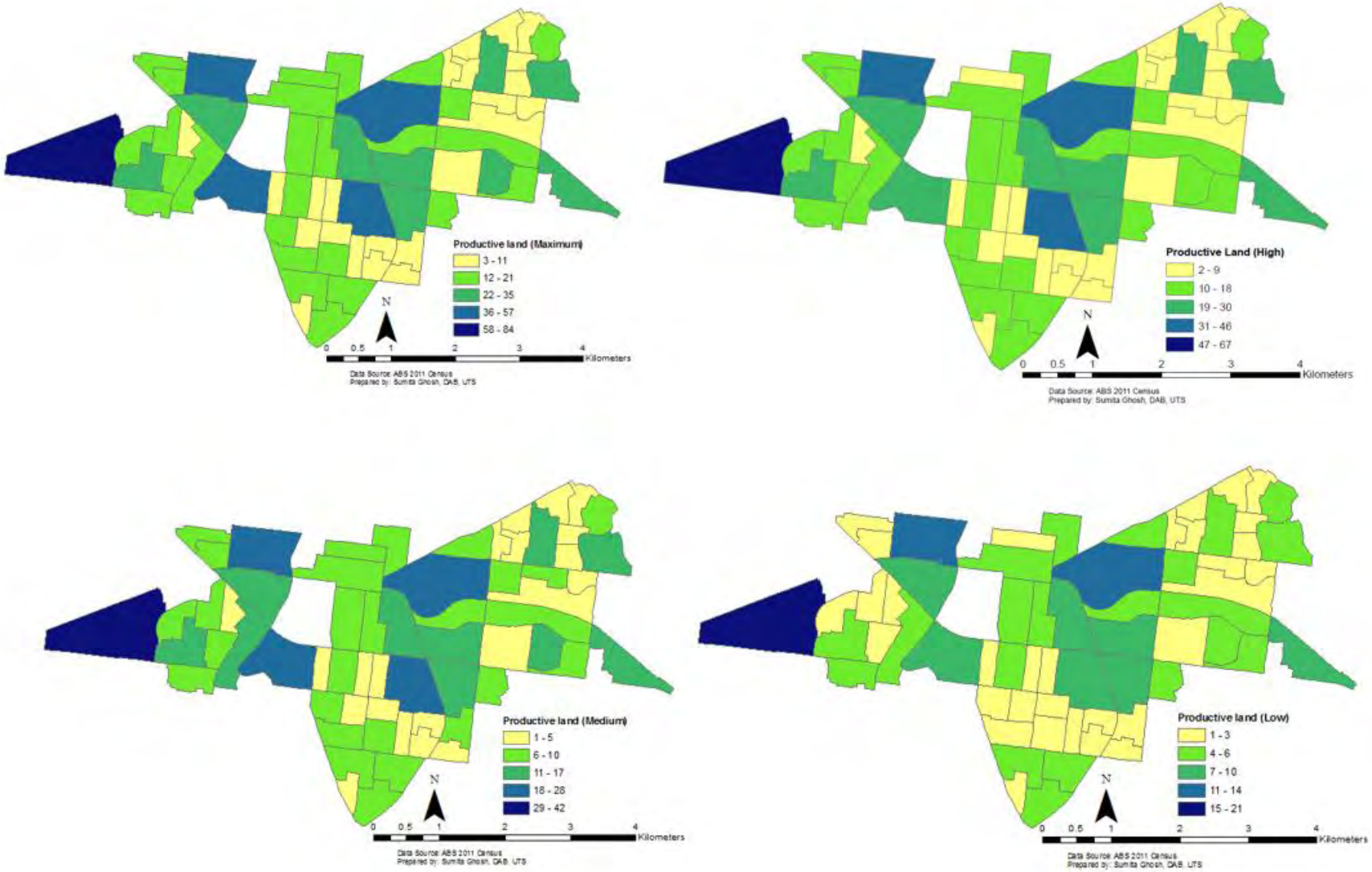

Fig 7: Available Productive Land in hectares in four scenarios: maximum, high, medium and low

Currently, the Local Environmental Plan (LEP) in Dubbo City permits horticulture under Agricultural activities only in Primary Production (RU1), Rural Landscape (RU2), Primary Production Small Lots (RU4), Village (RU5) and Large Lot Residential (R5). Horticulture is prohibited in General Residential (R1) and Low Density Residential (R2) and Recreational and Business zones (Dubbo City Council 2011). Significant work needs to be done in Dubbo to align the food and planning policies. As an important regional city of NSW, this City will be accommodating more population in future. Generating community awareness, and skills and establishing collaborative partnerships would be most important for the uptake of local food.

Recommendations and Conclusion

An ABS household survey conducted in 1992 on backyard production of vegetables in New South Wales (NSW). Households in NSW grew 28% of their total home production of vegetables which included tomatoes, potatoes, cabbages, capsicum, cauliflower, carrots and beetroots, lettuce and peas (ABS 1992). According to this survey, an Australian backyard grew, 70.4 kg vegetables on average, and tomatoes were the most popular vegetable (ABS 1992). The outcomes of the research support that the Dubbo City has a significant area of productive land available within its existing built environments that could potentially grow the significant surplus amount of vegetables, up to four times more than the required annual vegetable demand of the resident population. Current estimation shows that only the 25% of this available productive land area could supply the vegetable demand of the city. These productive areas could be fitted with appropriate food production typologies such as front and backyard gardens, community and allotment gardens and small urban farms for producing local food. The surpluses could be supplied to the surrounding smaller towns and cities to create a thriving local economy.

As the city grows, its structure could change, and densities could increase. As seen in the City of Vancouver, Detroit, and Singapore, these cities have evolved over time and require to accommodate different local food production typologies to become food secure. For example, food production typologies in Singapore is technically driven, and hi-tech hydroponic vegetable production due its high-density development pattern but Detroit could accommodate urban farm, community garden and home gardens typologies due its low-density development pattern. The Dubbo Transect and analysis of ABS data confirmed that built/urban environments located at the centre of the Dubbo SLA Point A. These areas are surrounded by very low density primarily green spaces. The morphology of the Dubbo City demonstrates that it is in that life stage of a city where hinterland and primarily suburban development patterns are currently retained. Future urban growth processes in the Dubbo City could be accommodated in a sustainable manner through appropriate planning policy formulation and informed decision making. Urban food production policies should be aligned well with planning policies similar to the City of Vancouver in Canada. Long term planning horizon for the policies and regional influences on the city must be considered. The conventional lifestyles of people could be protected using an appropriate method of designing and planning such as 'Agrarian Urbanism' approach in peri-urban and rural locations. Incorporating these aspects would lead to sustainable food system planning and a resilient food secure city and a self-sufficient community development. Onsite production of food would also generate co-benefits of reduced

carbon emissions by reducing transport distances of vegetables from offsite locations and carbon storage and sequestration and stormwater benefits of vegetation.

Generating community awareness and developing skills are important for the uptake of local food production. For example, 'Community In Bloom (CIB)' program in Singapore, Garden Resource Program (GRP)' in Detroit and the initiatives such as '2010 Garden Plots by 2010', and 'Tree Keepers Program' in the City of Vancouver generated increased community participation and also established notable numbers of new food producing gardens. Grants, incentives and training programmes and skill development workshops would be essential to provide knowledge and understanding on the importance of local food production to the city residents. Establishing useful partnerships between local council, farming organisations, government and private organisations and communities could generate new enterprises and successes in implementing local food production initiatives.

Dubbo City has a reasonable prospect to grow into a sustainable regional city of future. This research highlighted the important roles of regional cities to consider local food production as an important aspect of sustainable urban development. Regional cities with comparatively less population have a significant potential and distinct advantage to incorporate these measures in planning policies for these urban areas.

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