

EXPLORING THE RELATIONSHIP BETWEEN URBAN FORM AND SUSTAINABLE HOUSEHOLD BEHAVIOUR

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INTRODUCTION

“The way cities are planned, built and function can promote more efficient use of resources, including water, energy and land, minimise the production of waste and encourage more reuse and recycling, reduce greenhouse gas emissions, and support biodiversity in and around urban areas through better management of open and green space.” (Commonwealth of Australia, 2010 pp. 3)

This quote, from the 2010 State of the Cities Report, advances the Australian government view that urban design and planning are important factors towards achieving sustainable outcomes. The current policy position can be traced back to the United Nations (UN) World Commission on Environment and Development's seminal 1987 document “Our Common Future: The Brundtland Report” (Brundtland Commission, 1987). The Brundtland Report was the first far-reaching UN report of its type to consider the impacts of global development on the environmental health of the Planet. It also introduced the concept of sustainable development, defined as the “social and economic advance to ensure human beings a healthy and productive life, but one that did not compromise the ability of future generations to meet their own needs” (Centre for a World in Balance, 2010). The Report was a trigger for government agencies around the world, including Australia, to move away from a period of uncoordinated and parochial urban planning policies to reassert support for environmental planning objectives (Gleeson, Darbas et al 2004; Anderson, Dobson et al 2006).

The sustainability discussion generated by the Brundtland Report led to an increase in the number of metropolitan planning strategies developed in Australia, with many promoting an “urban consolidation” and “compact city” approach to ensure the sustainability of Australian cities. At the same time, there was an emergence of new urban social movements in several cities highlighting the shortcomings of urban consolidation (Gleeson, Darbas et al 2004). The anti-urban consolidation position was strongest in the mid to late 1990s led by leading urban commentators Hugh Stretton and Patrick Troy, who lamented that “government urban policy has been developed with seemingly little understanding of the origins of urban planning or why Australian cities take their present form and structure” (Troy, 1996 pp2).

Today, urban consolidation continues to be the cornerstone of most sustainable urban development policy positions yet the tension around what constitutes sustainable urban development remains, especially within academia. Compact city proponents continue to suggest that higher density urban forms are the most sustainable because they facilitate lower energy outputs, especially those generated by transport, whereas dispersed city proponents suggest that there is little data to support this position and that most Australians aspire to live in a detached home in suburbia.

This paper will argue that there are two areas where sustainable urban form research could be improved – namely the measurement and identification of different urban form types in different contexts, and the use of more relevant sustainability indices to compare the sustainability merit of different urban form types. Undertaking research that addresses these two issues may provide planners and policy makers with a better understanding of the relationship between some urban form types and certain sustainability outcomes.

Firstly, many researchers use density calculations to represent urban form differentiation (eg high density versus low density). Although density measures allow easier statistical analysis by allowing urban form to be quantified, critics of the density measure suggest that a more accurate urban form typology is required that considers the different structural components (dwellings, transport corridors, accessibility, open space etc) that exists across metropolitan areas. Density calculations may provide a broad overview of the structure of an urban area, but does it provide an accurate one for research purposes?

Secondly, only a small number of researchers have utilised household behavioural indices as the basis for comparing different urban form types. It is argued by those researchers that have used them that only by looking at the behaviour of the inhabitants of different urban form contexts can conclusions about sustainable urban form be made.

Using Australia's largest city, Sydney, as a case study, our research utilises and maps an urban form typology relevant to Australian cities before applying household behaviour indices to compare the relative sustainability merits of different urban form types. This paper will outline the methodology being used for this research before presenting some preliminary findings from the secondary data collected and analysed so far.

RESEARCH FRAMEWORK

There has been an ongoing and plentiful supply of urban form research from a variety of disciplines since the release of the Brundtland Report. The literature review undertaken for this research has helped highlight issues and gaps that exist with previous research, particularly in the urban planning area. There are several key texts that provide the theoretical framework for the methodology proposed in this research project, particularly with regard to the conceptualisation of sustainability (Jenks et al, 2010); the identification and measurement of different urban form types (Pressman, 1985; Minnery, 1992; Newton et al, 2000; and Neuman, 2005) and the use of household behavioural indices to represent the sustainable characteristics of different urban form types (Neuman, 2005 and Williams and Dair, 2010).

What is Urban Form and how is it Measured?

A simple definition of urban form is provided by Anderson et al (1996): "the spatial configuration of fixed elements". Dempsey (2010, pp 21) states that such a definition applies mostly to the broad city or regional scale, which would include urban settlement type, layout of suburbs and the relative position of the central business district. Dempsey sees urban form as closely related to scale. Using Williams et al's (2010) definition: "the morphological attributes of an urban area at all scales", Dempsey states that urban form may range from localised aspects such as building materials, façades and fenestration, to, at a broader scale, housing type, street type and their spatial arrangement, or layout (Dempsey 2010 pp 21-22). This is supported by Ghosh and Vale's definition: "Urban form refers to the spatial distributions of different land uses connected together with physical infrastructures and associated transport networks. The land use characteristics, site layout, designs of built-up structures, development potentials, related legislation and planning policies and resident community preferences generate varied capabilities and qualities in different urban forms." (Ghosh and Vale, 2009 pp 507).

Whatever the definition and scale, historical concern for the most desirable urban form has been focused on quality of life improvements and the aesthetics of urbanity (Breheny, 1996), primarily as a reaction to the evils of the 19th century industrial city (Hall, 1998). Breheny divides most of the major utopian urban theories – whether historical or contemporary – as either centrist (promoting a compact urban form) or decentrist (promoting a dispersed urban landscape of low density residential areas).

More recently, the debate post-Brundtland Report has been whether compact urban forms help to address global issues such as climate change. In countries like Australia, the debate is whether increasing residential densities as part of an urban consolidation agenda actually achieves the sustainable benefits it is supposed to deliver compared to the distinctive home-ownership, single dwelling model that has dominated the Australian urban landscape in the post-World War II period. Breheny might call this a classic centrist versus decentrist debate.

The reason why compact cities are favoured as the most sustainable option is summarized well by Peter Hall: "There has developed a conventional wisdom that the idea urban form is represented by the traditional compact European city, dependent on short distances to work and to shop and supported by generous investment in public transport, which uses fewer non-renewable resources and creates less pollution than the scattered Anglo-American urban form" (Hall, 1997 pp 214). Hall adds, however, "That like most fixed ideas, this one has a small element of truth and a much larger element of myth".

The "myth" may relate to the methods used by some urban form researchers to make conclusions about the most sustainable urban form. Researchers such as Newman and Kenworthy (1996) have compared different cities using average density calculations to characterize the whole of the city as either compact/dense or dispersed. A common criticism of such an approach is the use of density calculations (measured as either population per area or residential dwellings per area) to represent different urban form types. Such large scale density calculations do not address the variations in density or form that exists within the large aggregated areas being calculated. There are also differences in land use patterns, physical design, social characteristics, and ecological conditions among places with the same overall density (Neuman, 2005 pp 21). Examples of this in the Sydney case study context might be tracts of similar lot-sized detached dwellings calculated to be lower than 10 dwellings per hectare being situated in different parts of the metropolitan area with different urban characteristics (see **Fig. 1** below). For example, 10 dwellings per hectare are calculated

to exist on the fringe of the urban area, with its limited accessibility to urban services, but also exist along some stretches of railway corridors, which generally have good accessibility to urban services. The environmental and social differences between fringe areas and railway corridor areas might appear obvious, yet the density calculations for the two are exactly the same.

Although density calculations continue to be used to enable easier statistical comparison, an increasing number of researchers are developing unique typologies (to the city or country being investigated) based on variables such as residential type (using density as a guide rather than a proxy), public transport accessibility and land use mix (Newton 2000, Holden and Norland, 2005; Ghosh and Vale 2009; Jenks and Jones, 2010).

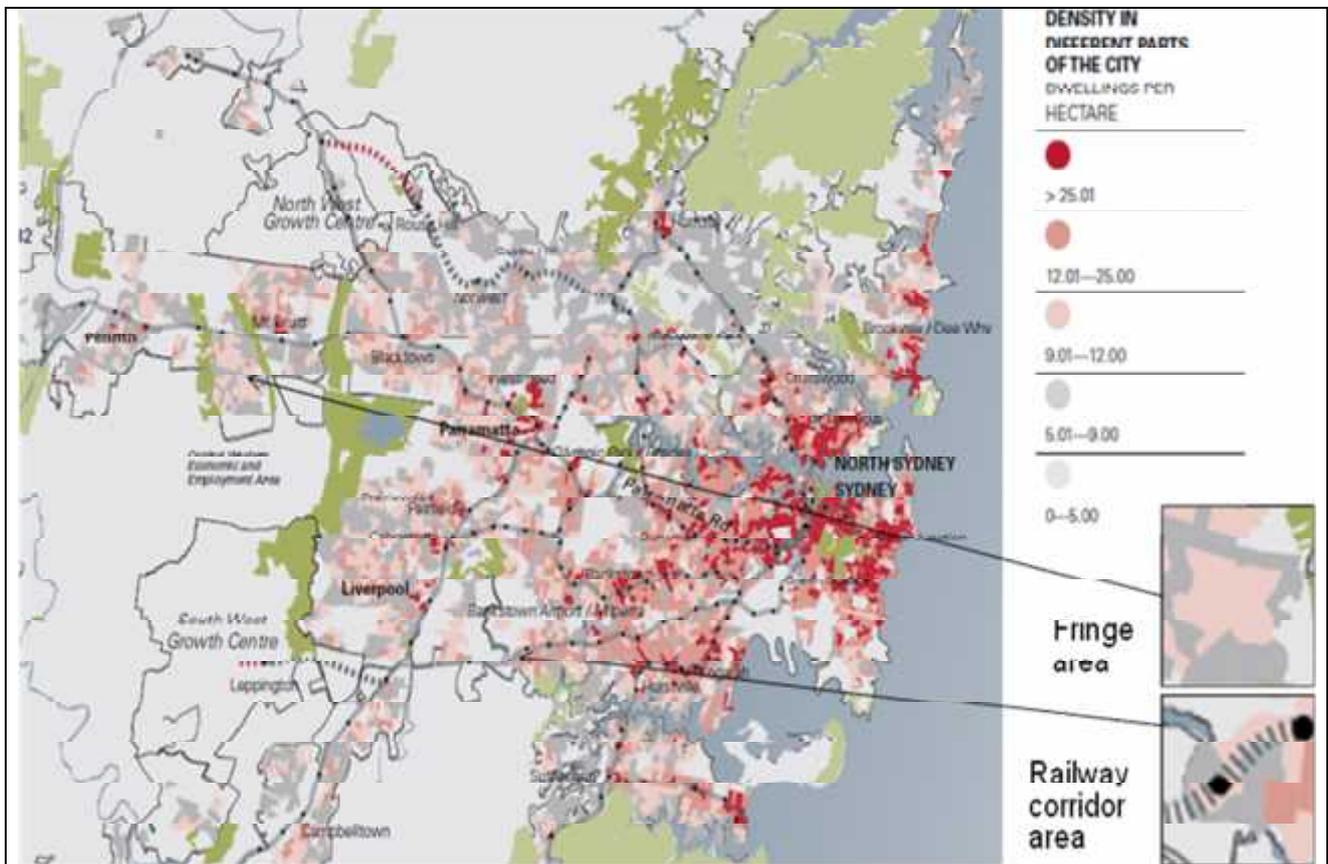


Figure 1 – Density Calculations for Residential and Commercial Zoned Land in Sydney (NSW Department of Planning, 2005)

At the “large aggregated” or metropolitan scale, there are now several well understood urban form contexts that can be applied to the type of large metropolises that exist in North America and Australia (Pressman, 1995). For example, Los Angeles and Dallas represent two common types in the North American context. A city like Los Angeles has its dispersed grid pattern and cities like Dallas and Atlanta have spider web forms consisting of a vital central area ringed by major transport arterials and dispersed development. Australia’s largest city Sydney has a modified spider web form like Dallas, especially with its central core, but with prominent linear radials spreading from the central core.

Within this global context, several researchers have developed a broad metropolitan scale typology to describe current and future patterns of urban growth (Pressman, 1985; Minnerly, 1992). One researcher who has then used this typology to test the energy and greenhouse gas emission implications of different urban form types in the Melbourne context is Peter Newton (2000). The typology categories he used to describe Melbourne’s current and potential future form are:

- Dispersed city — outward expansion at relatively low densities, random infill and remaining dominated by a central city as the key economic node. At present Australia’s large cities are more closely aligned to this urban form than to any of those below;
- Compact city — increased population and density of inner group of suburbs;

- Multi-node city — increased population, housing densities and employment in selected nodes across the city; increased investment in orbital rail links or freeways linking the nodes;
- Corridor city — a focusing of growth along linear corridors emanating from the CBD and supported by upgraded public transit infrastructure;
- Fringe city — where additional growth is accommodated predominantly on the fringe of the city; and
- Ultra city — where additional growth is accommodated primarily in provincial cities within 100 km of the principal (capital) city and linked by high speed rail transport.

It is apparent that rather than one or two of these forms dominating the metropolitan area like they may do in other international contexts (such as the compact city and fringe city in Europe or the corridor city in some Asian contexts) there is a mixture of these urban form types within large Australian cities like Sydney and Melbourne (Minnery, 1992). It is also apparent that although density calculations could be used to quantitatively describe each category, the categories themselves have not been developed after a density calculation has taken place – they are developed on visualizing how the city looks, forms, and operates from a land use and accessibility perspective at a particular point in time.

Testing each urban form type in relation to indicators such as energy consumption, self-containment of sub-urban regions and vehicle kilometres travelled, Newton concluded that urban form – when described like this - does matter. He stated that a trend to a more compact city, however defined, will lead to significant environmental improvements compared to the business-as-usual dispersed city model (Australian Academy of Technological Sciences and Engineering, 1997 pp170; Newton, 2000). “Although no one form can provide all the environmental, social justice, liveability and economic efficiency conditions required for Australia, it is clear that the increasingly dominant dispersed urban form is unsatisfactory” (Minnery 1992, pp106).

Measuring the Sustainability of Urban Form

Since the release of the Brundtland Report, there has been “competing and conflicting views over what the term (sustainability) means, what is to be sustained, by whom, for whom, and what is the most desirable means of achieving this goal” (Agyeman and Evans, 2004 pp 156).

When attempting to measure sustainability in relation to urban form, researchers have tended to adopt the UN’s 1987 definition and develop measurable indices that is represented by its environmental, social, and economic dimensions (Jenks and Jones, 2010). Such an approach, however, does not enable researchers to easily answer the question as to which urban form type is the most sustainable. In reality, “sustainability is a broad, vague term that has many meanings – there is no single accepted image of how to specify it exactly and put it to work” (Neuman, 2006 pp 17). As such, although the work and research undertaken to better understand the relationship between urban form and sustainability has been valuable, both “centrists” and “decentrists” can find ample evidence to support their argument regarding which urban form provides better sustainability outcomes (Gray, Gleeson et al, 2008 and Rickwood, 2009a).

The question then is whether this inability to pin sustainability down to one distinct measure is a problem for urban form researchers. It may be problematic if researchers are attempting to determine the most sustainable urban form. It may not be problematic, however, if researchers are attempting to understand the extent to which urban form contributes to the three elements of sustainability.

A group of measures that may provide a more accurate insight into the relative sustainability credentials of different urban form types are those related to household behaviour. Some researchers suggest that the sustainable credentials of a building or an area can only really be answered once “behavioural” sustainability is understood (Holden and Norland, 2005; Williams and Dair, 2010). This is supported by examples from around the world that show that up to 75 percent of greenhouse gas emissions are directly or indirectly influenced by consumers (UK Sustainable Consumption Institute, 2009). This position is best encapsulated by Michael Neuman (2005, pp 23):

“Form, as biologists and geologists understand it, is an outcome of evolution. Form is a snapshot of process. It is a fixed condition at any point in time. Form, in and of itself, is not measurable in terms of sustainability. Asking whether a compact city, or any other form of the city, is sustainable is like asking whether the body is sustainable. The proper question is not if the body is sustainable, but rather, does the being that inhabits the body live sustainably? “

When attempting to build “sustainable communities”, designers, planners and developers have tended to focus on the design of the household structure itself. This is based on the theory that the “home” has the potential to greatly influence sustainable behaviour, particularly with regard to energy and water use and waste outputs (van der Wal et al, 1998 pp 36). Yet, recent research from the UK (Williams, Dair et al, 2010) questions the extent to which “technical” sustainability efforts (the technologies, materials or design features used in a development that contribute to sustainability in their own right) can enable a building or a precinct with groups of sustainably designed buildings to be called sustainable. Their study comparing the behaviours of those living in sustainability designed housing against the rest of the population showed that only energy and water use behaviours were greater in sustainably designed housing. Other behaviours such as car travel, social participation, and composting were actually less sustainable than the population in general. Such results show that variables other than housing design are influencing overall behaviour. The key for urban form researchers is to determine the extent to which the household structure, the surrounding neighbourhood and the urban form this takes combines to be an influence.

Measuring the relationship between urban form and household behaviour needs to be considered in context. There are a range of other factors that have the potential to influence a household’s propensity to behave sustainably (Barr, 2003). These include prior knowledge and education, the political and social values of household members, psychological variables (for example, the influence of other people’s behaviour) and several situational variables, including the ability for one’s neighbourhood to provide households access to environmentally-friendly services (Barr, 2003: pp229-230). The extent to which these variables are intertwined with urban form is something this research project also hopes to untangle.

METHODS

The following methodological steps underpin this research project.

1. Defining, compiling and measuring Sydney’s unique urban form.

Sydney has been chosen as an urban form case study metropolis because it typifies the urban form and built form characteristics of Australian cities; is an internationally significant city that is well understood by national and international research and policy professionals; and is conveniently located for this research project. In considering the complexity of Sydney’s urban form (especially relating to location, housing structure and accessibility) the different urban form categories identified earlier have been applied using ABS CCD level data and GIS mapping software.

The urban form categories were mapped in the following way (see **Fig. 2** on the next page):

- **Compact City:** all CCD’s located within Sydney’s inner urban LGA’s - City of Sydney, Leichhardt, Waverley, Marrickville and Randwick (north of Gardener’s Road). These LGA’s are generally considered to be highly accessible to public transport, employment, retail and essential services with a mixture of housing choice.
- **Multi-Node City:** CCD’s located within 800m of railway stations (proxy for centroid) located within designated (by Planning NSW) high-order centres: North Sydney, Chatswood, Parramatta, Hornsby, Liverpool and Campbelltown. As highly accessible to public transport, employment, retail and essential services as the Compact City but dominated by apartments.
- **Sub-regional Centres:** CCD’s located within 800m of railway stations (proxy for centroid) located within designated (by Planning NSW, 2005) secondary centres: Bankstown, Ashfield, Burwood, Blacktown, Penrith, Sutherland, Dee Why, Kogarah and Hurstville. In the case of Dee Why, it is all CCD’s within 800m of Pittwater Rd and Dee Why Parade intersection. Sub-regional centres have similar characteristics to the Multi-Node City on a smaller scale with less employment opportunities.
- **Corridor City:** Any CCD’s outside the previous categories that are located within 800m walking distance of a railway station within the rest of the metropolitan area or 400m of a high-order bus corridor (Anzac Pde and Pittwater Rd). Characterised by good accessibility to local shopping precincts with a mixture of housing choice (other than four-storey and above apartments).
- **Dispersed City:** any other areas left within what is considered the traditional Sydney suburban environment. Generally comprises a mixture of old and contemporary detached dwellings dominated by car access and local bus services.
- **Fringe City:** designated areas beyond traditional suburban environments (primarily contemporary build) with poor public transport and local service accessibility.

2. Selecting key sustainability performance data as it relates to household behaviour.

An initial set of key consumption data related to household sustainability has been attained from secondary sources:

- 2006 aggregate household water consumption data (quarterly) at the ABS Census Collection District (CCD) level from SydneyWater.
- 2006 aggregate household electricity consumption data (yearly) at the ABS CCD level from Energy Australia.
- 2006 car ownership data at the ABS CCD level from the ABS 2006 Census.

These three areas (energy, water and transport) are considered by some researchers to comprise the key behaviours contributing to household related greenhouse gas emissions (Holden and Norland, 2005). These aggregated indices have been made available for this research at the ABS Census Collection District (CCD) level.

Each of the indices has been processed in the UWS Urban Research Centre's GIS to align the data to the different urban form categories outlined above. As well, where a CCD contains 100% of one particular dwelling type (either detached dwellings; semi-detached, villa or terrace dwellings; up to three storey walk-up apartments; or four storey and above apartments), it has been singled out to enable assessment of different combinations of urban form and dwelling type.

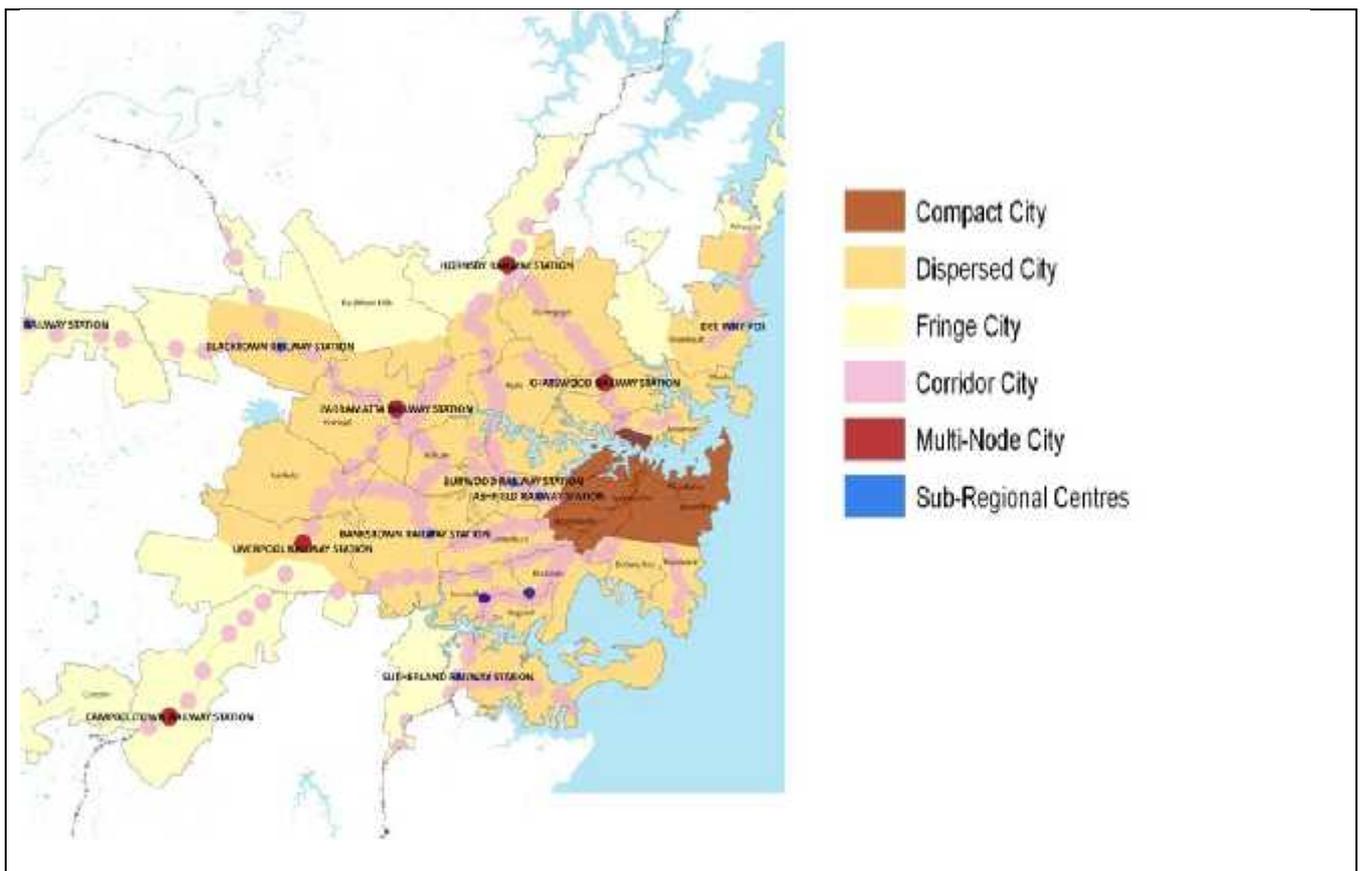


Figure 2 – Sydney's Urban Form Categories (UWS Urban Research Centre)

3. Statistical analysis to better understand potential relationships between the sustainability indices and different urban form and dwelling types.

Secondary data collected have been statistically assessed using GIS and PASW (SPSS) to determine the extent of variation that exists across the different urban form types for the three sustainability indices. The results of this assessment is summarised in the following section.

4. Primary Research.

The patterns that have emerged for two of the indices (electricity consumption and car ownership rates, which will be explored in the next section) – enable case study areas to be selected to explore whether any potential patterns exist between other sustainable behaviours and urban form/dwelling type. Case study areas have been chosen from those CCDs within Energy Australia's catchment area containing 100 per cent of a certain dwelling type (EA's catchment area is the smallest of the three secondary data catchment areas being investigated so selecting case study areas from here guarantees all indices are being assessed). Case study areas have been selected from the group of CCDs that are calculated to be within the 95 percent confidence level of the mean for electricity consumption.

Within each urban form/dwelling type category, two case study areas are likely to be surveyed – those considered to have a relatively high and relatively low socio-economic rating (based on the ABS SEIFA Index, 2011) so as to compare results against an acceptable, measureable and widely understood socio-economic variable. Questionnaires have been developed to explore a range of sustainable behaviours in order to obtain a richer database from the case study areas selected. This will enable further statistical analysis to better understand potential relationships that may exist between urban form/dwelling type and the different indices that will exist in the expanded sustainability data suite. The range of sustainability categories from which behavioural data will be surveyed include:

- Waste recycling and composting (environmental);
- Non- journey to work travel behaviour (social and environmental)
- Social and local community participation (social)
- Access to and use of local services (social)
- Consumption habits and cost of living (economic)

DISCUSSION – SOME PRELIMINARY RESULTS

Analysis of the secondary data suggests a pattern developing between urban form type and both energy (electricity) consumption and cars owned per household (see **Fig. 3** and **5** below). On the other hand, no obvious pattern is apparent between water use and most urban form types (**Fig. 4**) – similar averages exist except for Compact City, which has higher mean consumption rate than others.

Whereas car ownership rates per dwelling may, on the surface, make some sense given the extent of previous research that suggests that dispersed urban form exhibits higher rates of car ownership and use, it is the differences in energy consumption between more compact forms and the dispersed forms that raises some questions. Is the pattern a result of the influence of a type of dwelling that predominantly exists in these urban form types or is it the urban form “environment” people live within that is influencing the result? Or are there some other socio economic variables affecting the trend?

To understand the role that different dwelling types play in different urban form contexts is difficult considering the consumption and car ownership data has been aggregated to the CCD level (for privacy reasons). However, there are enough cases of CCDs with 100 per cent of one type of dwelling in them to make some assessment of the impact of dwelling on behaviour within different urban form types. **Fig. 6** below brings in to play dwelling type within each urban form category. **Table 1** that follows also shows how many of these cases exist for the different dwelling types across the urban form types mapped.

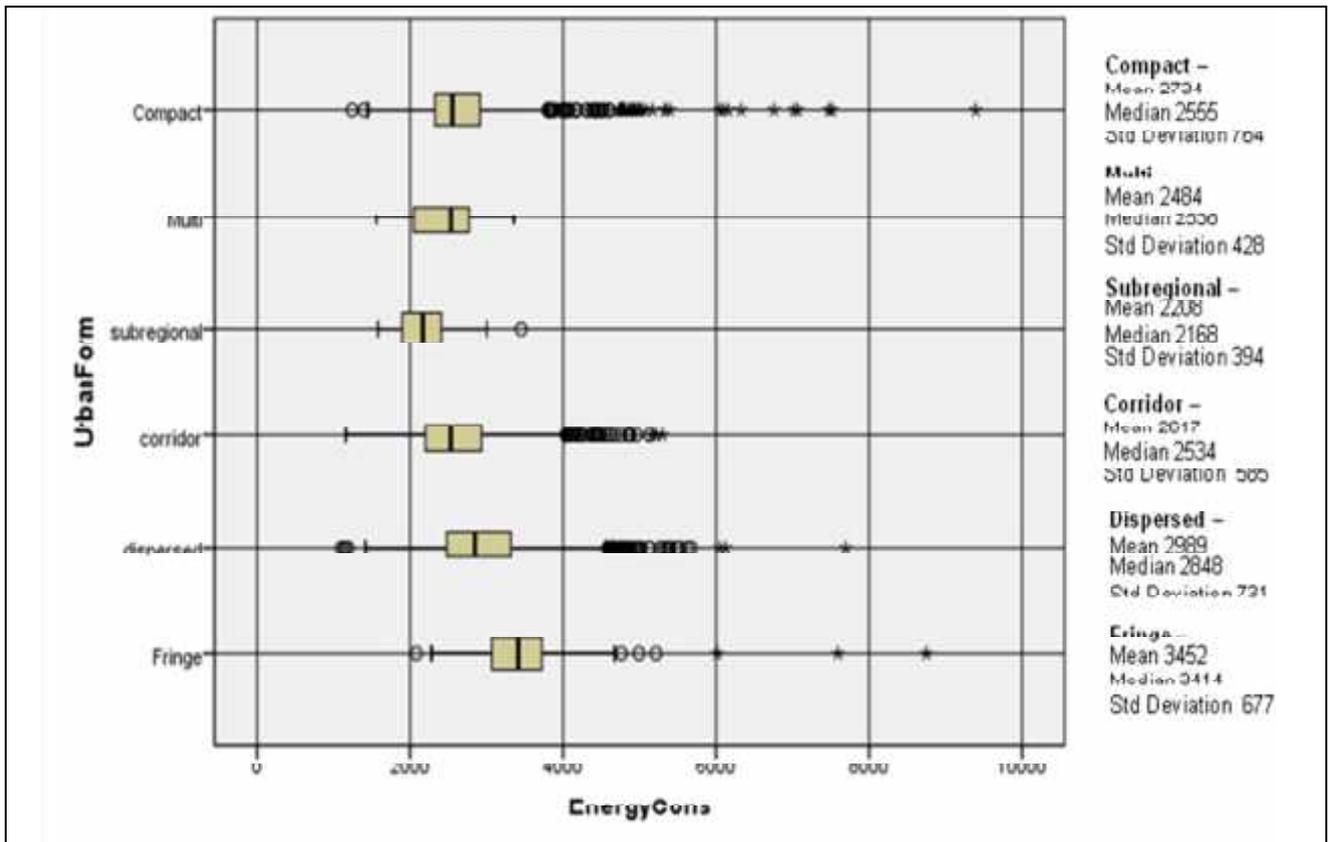


Figure 3 – Electricity Consumption per person (kw consumed/year)

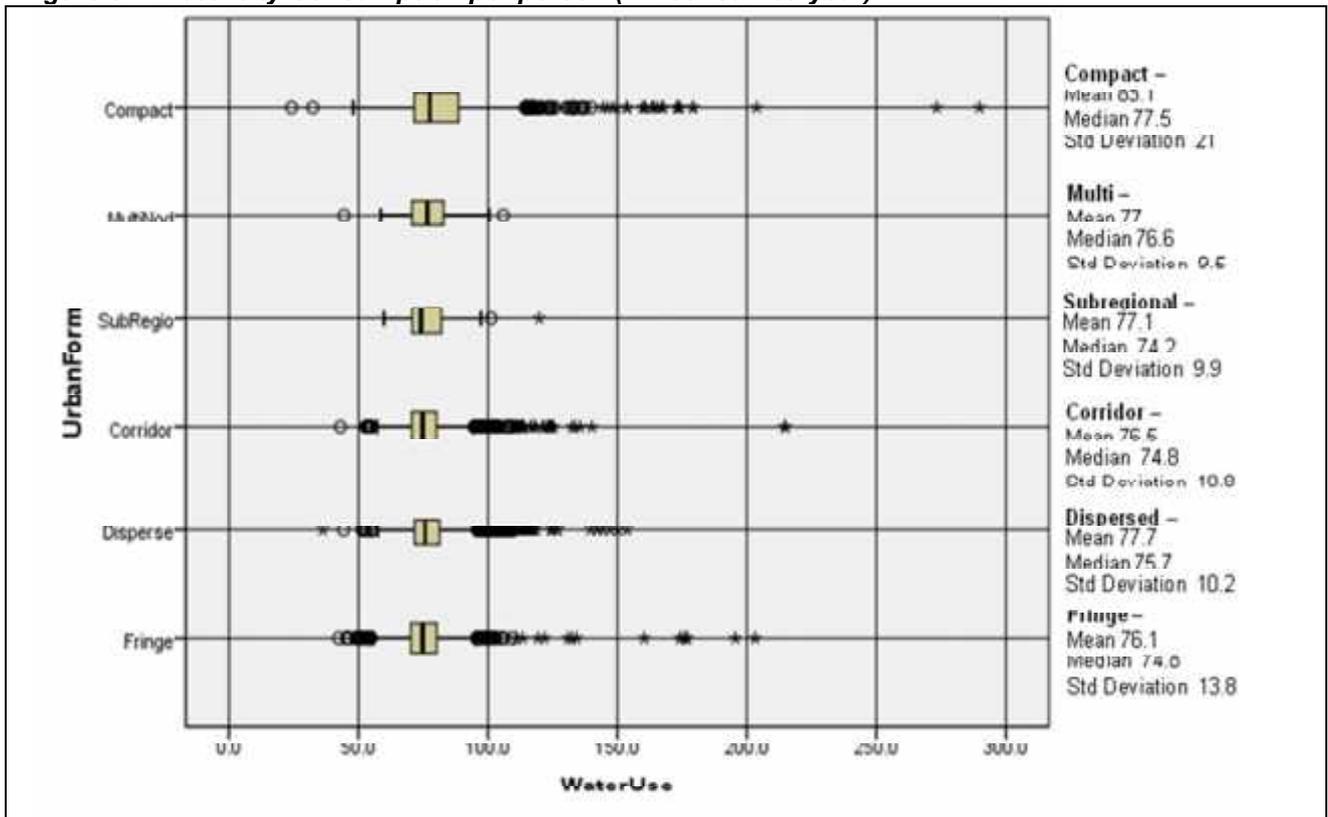


Figure 4 – Water Consumption per person (kl consumed/year)

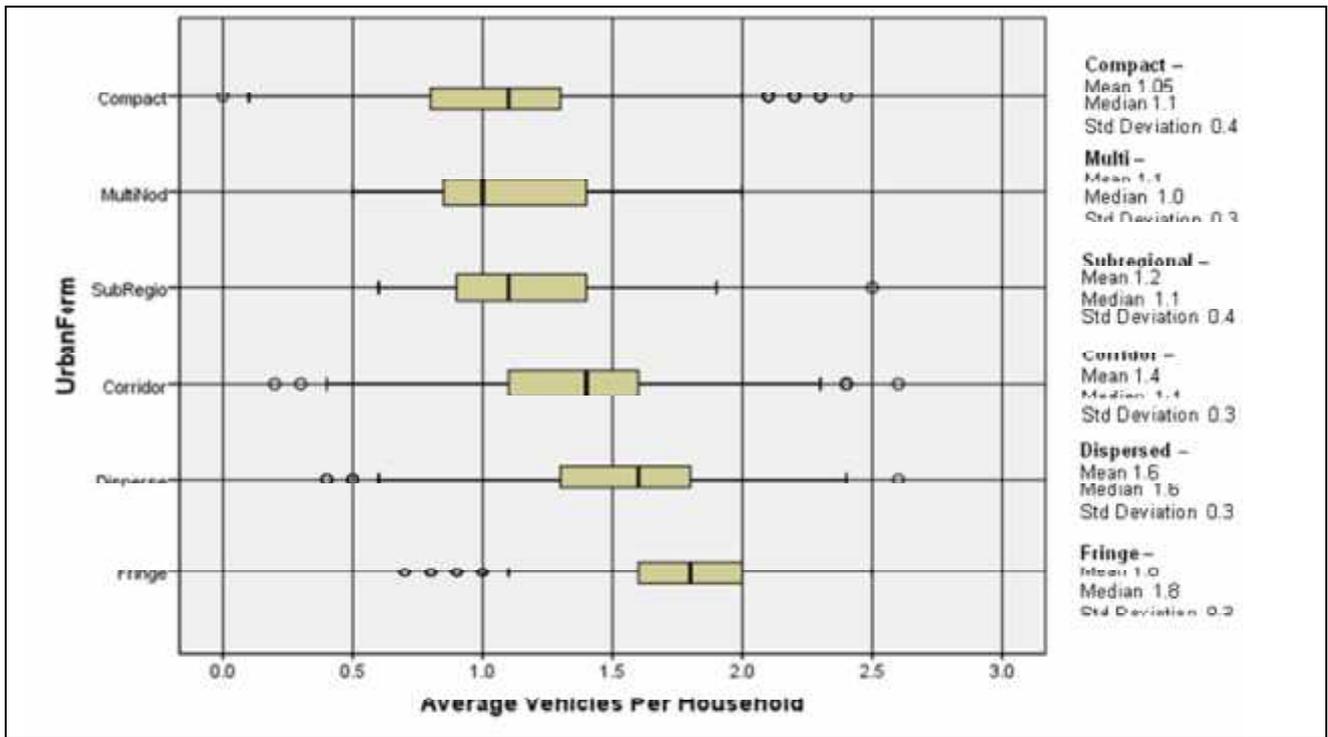


Figure 5 – Cars Owned per Household

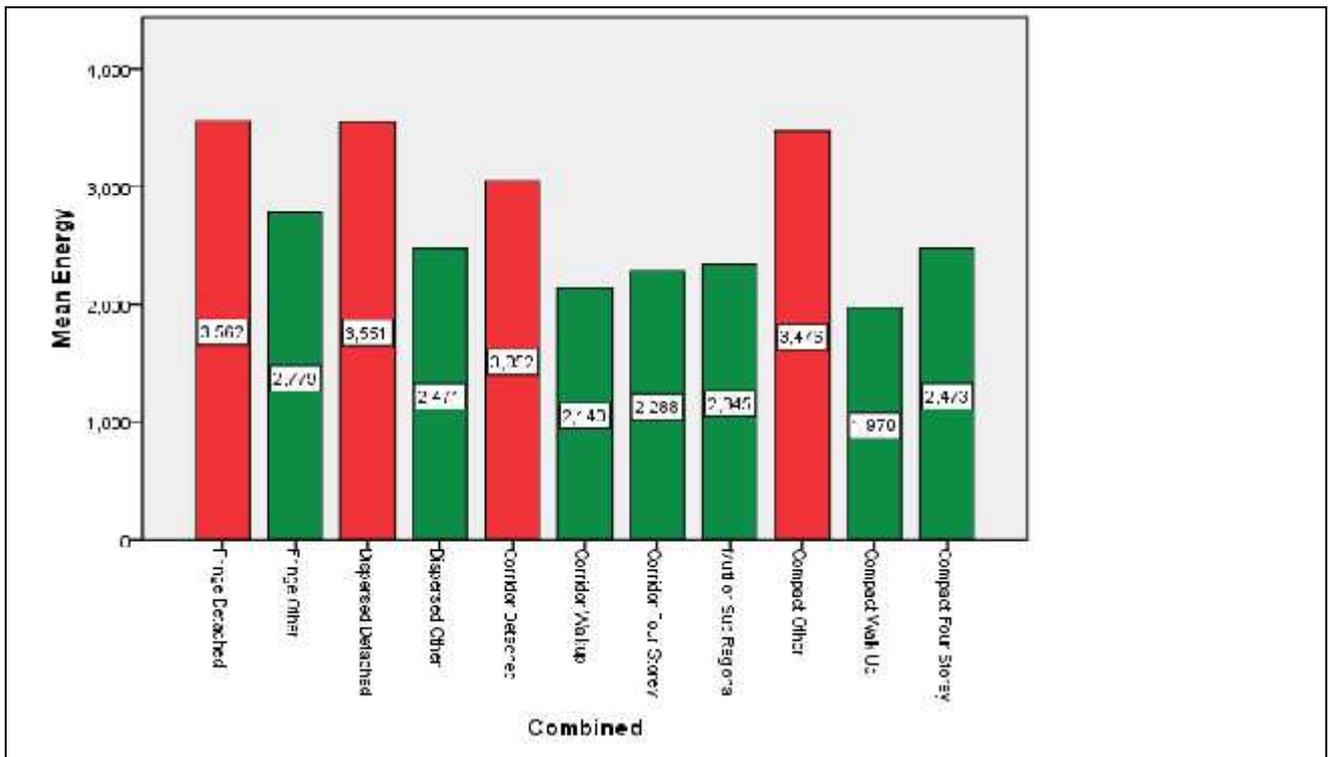


Figure 6 – Urban form with Dwelling Type Variations – Electricity use per person per year

Table 1a and b – Summary of CCD cases containing 100 per cent dwelling types (copied from PASW/SPSS)

Case Processing Summary – Energy Consumption

Combined		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Energy	Fringe Detached	66	100.0%	0	.0%	66	100.0%
	Compact Walk Up	4	100.0%	0	.0%	4	100.0%
	Compact Other	10	100.0%	0	.0%	10	100.0%
	Fringe Other	1	100.0%	0	.0%	1	100.0%
	Dispersed Detached	161	100.0%	0	.0%	161	100.0%
	Dispersed Other	15	100.0%	0	.0%	15	100.0%
	Multi or Sub Regional	11	100.0%	0	.0%	11	100.0%
	Corridor Detached	78	100.0%	0	.0%	78	100.0%
	Corridor Walkup	7	100.0%	0	.0%	7	100.0%
	Corridor Four Storey	14	100.0%	0	.0%	14	100.0%
	Compact Four Storey	40	100.0%	0	.0%	40	100.0%

Case Processing Summary – Water Consumption and Cars Owned per Household

Combined		Cases					
		Valid		Missing		Total	
		N	Percent	N	Percent	N	Percent
Water and Car	Fringe Detached	272	100.0%	0	.0%	272	100.0%
	Compact Walk Up	4	100.0%	0	.0%	4	100.0%
	Compact Other	4	100.0%	0	.0%	4	100.0%
	Fringe Other	2	100.0%	0	.0%	2	100.0%
	Dispersed Detached	276	100.0%	0	.0%	276	100.0%
	Dispersed Other	13	100.0%	0	.0%	13	100.0%
	Multi or Sub Regional	14	100.0%	0	.0%	14	100.0%
	Corridor Detached	126	100.0%	0	.0%	126	100.0%
	Corridor Walkup	5	100.0%	0	.0%	5	100.0%
	Corridor Four Storey	10	100.0%	0	.0%	10	100.0%
	Compact Four Storey	37	100.0%	0	.0%	37	100.0%

It is apparent that detached dwellings have a distinct impact on energy use within each of the urban form types. Notice, however, that the combination is important, as detached dwellings achieve lower mean results when urban form moves from fringe and dispersed to corridor. Detached dwellings, which forms most of the “compact other” category, achieves much higher energy consumption than other dwelling types within the compact urban form category and only slightly lower than “fringe detached” and “dispersed detached”. There may be some socio-economic variability explaining this result.

With regard to car ownership in **Fig. 7** below, a more distinct pattern emerges. Detached dwellings are having a major influence over mean car ownership in each urban form group, except this time the reduction in detached dwelling car ownership rates is more distinct when one moves fully from fringe into compact city.

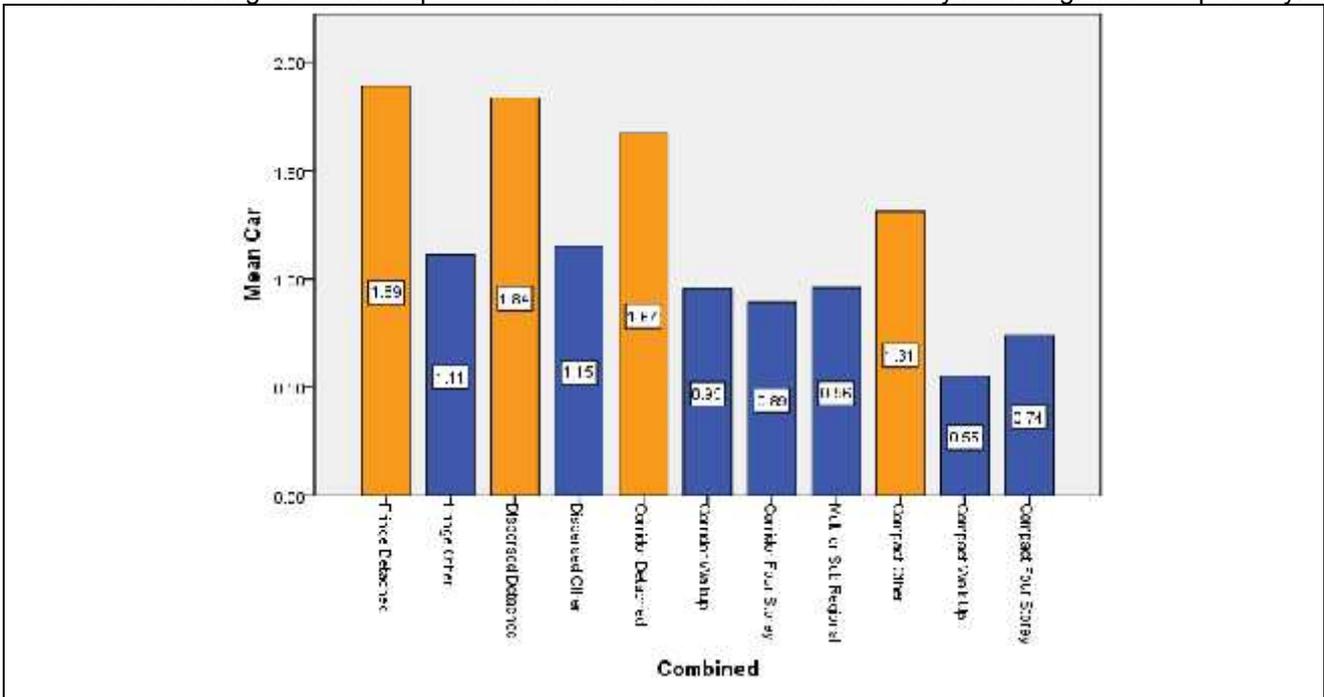


Figure 7 – Urban form with Dwelling Type Variations – Cars Owned per Households

In **Fig. 8** below, water use maintains a consistency across all urban form types and dwellings, except for compact city apartments, which produces a higher mean water consumption rate than the others. These results also require further investigation.

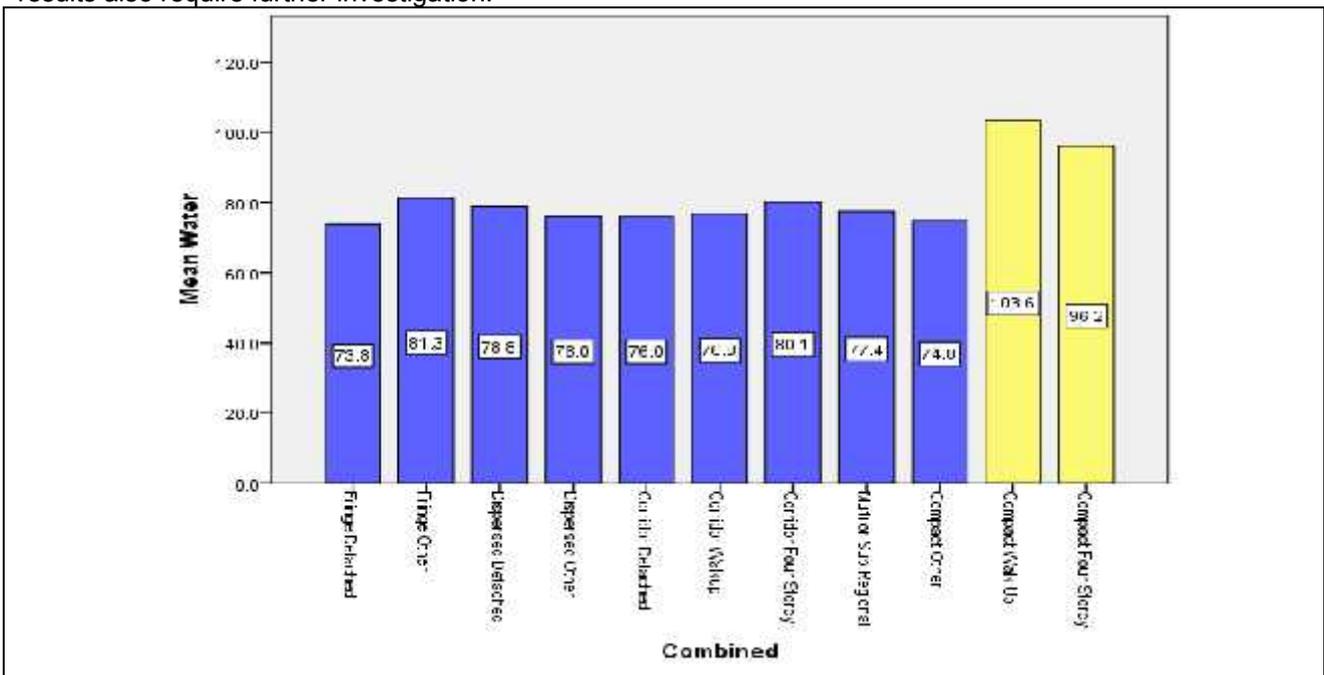


Figure 8 – Urban form with Dwelling Type Variations – Water Consumption per person per year

CONCLUSION

The initial secondary data analysis component of this research has revealed some interesting patterns and raises further research questions. The secondary data highlights a potential link between dispersed urban forms and unsustainable household behaviour related to electricity use and car ownership. Conversely, dispersed urban forms perform relatively better than compact urban forms when it comes to water consumption. The analysis, therefore, reinforces the value of investigating relationships between urban form and household behaviour indices beyond the use of density calculations in order to attain a more accurate picture across a vast metropolitan area like Sydney. It also highlights the value in researching a variety of sustainability indices – some urban form types perform differently for different indices.

Additional statistical analysis is required, however, to compare the influence that socio-economic variables may also be having on these indices. The primary data collection component of this research will also provide some valuable contextual information regarding residents that live within the Case Study CCDs to better understand whether some urban form types exhibit varying socio-economic characteristics related to certain behaviours, as well as provide additional sustainable behaviour data for further analysis.

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