3D Land and Property Information System: A Multi-level Infrastructure for Sustainable Urbanization and a Spatially Enabled Society

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Abstract

Urbanization is an inevitable part of the economic development process for any country and is considered a global phenomenon (World Bank, 2009). Currently, 50 percent of the world's population resides in urban areas; by 2050, this ratio will reach 70 percent. This concentration of growth will place increasing pressure on land resources that are already in high demand. The achievement of sustainable development goals is therefore predicated on achieving sustainable urbanization. This paper considers the specific challenges of urbanization on land and property and the development of a three-dimensional (3D) land and property information system as a new tool for managing rights, restrictions and responsibilities as part of a modern land administration system.

This system aims to provide an infrastructure that allows for the integration of information pertaining to the built and natural environments using land and property as a common framework. By facilitating access, discovery, and sharing of land and property information, this system will provide a multi-level infrastructure to link government, industry and citizens to support the functions of a modern land administration system which provides the foundation for realising a spatially enabled society and achieving sustainable development.

KEYWORDS: 3D, land, property, information system, infrastructure, sustainable urbanization, spatially enabled society, modern land administration

1. Introduction

Urbanization is an inevitable part of the economic development process for any country and is considered a global phenomenon (World Bank, 2009). However, it is only in recent years that the rate of urbanization has begun to accelerate. The year 2007 is widely regarded to be a significant milestone in the history of urbanization, heralding the first time more than half of the world's population resided in urban areas. More recently in 2011, the world's population surpassed the seven billion mark. Demographic growth itself is not actually the primary issue; it is where this growth is occurring that is creating challenges for governments around the world. Of these seven billion people, one in two currently live in cities; by 2050, despite little actual increase in the rate of urbanization, this ratio is expected to increase to seven out of ten, reflecting concentrated (and potentially unsustainable) growth in urban areas (UNFPA, 2011; UN-HABITAT, 2010). Considering that the total area of towns and cities make up just three percent of the earth's surface area, sustainable management and development of land and property represents some of the most complex challenges today. These challenges are found at all scales – local, national and regional – and require a concerted and holistic approach if any measure of success is to be achieved.
This paper will firstly reflect on the broad challenges arising from urbanization and examine its consequences in sustainably managing and developing land and property. As land administration systems evolve, the changing roles of government, industry and citizens are examined especially in the context of land and property information production and use. Finally, the concept of a three-dimensional Land and Property Information System (3D-LPIS) for managing rights, restrictions and responsibilities (RRRs) in complex urban areas is discussed as a new land administration tool to achieve sustainable urbanization using Australia as a case study. Although this paper is based on current research into a 3D-LPIS which is only at a preliminary stage, it is envisioned that by providing accurate and timely information about land and property that relates people to activities, this system will be a foundation for realising a spatially enabled society and a tool for delivering sustainable development.

2. The Inherent Challenges of Urbanization

There are many different definitions for the term urbanization due to jurisdictional differences but it is largely acknowledged that urban areas provide a different and typically higher standard of living than rural areas; therefore in simplistic terms, urbanization is the process of people moving from rural to urban areas lured by the attraction of agglomerating economies (World Bank, 2009; UNSTATS, 2011). The incipient problems of higher densities of both economic activity and people exert enormous pressure on land resources, already scarce in urban areas.

Urbanization causes severe environmental, social and economic challenges for managing land resources. Common problems arising from urbanization stem largely from the increasing population density – housing scarcity which often leads to

unplanned development and informal land markets, traffic congestion, pollution, decreased public safety, higher natural resource demands; and increased risk from natural disasters. These challenges although local in scale, often have far-reaching consequences. For example, 20 of the largest cities in the world collectively consume 80 percent of the world's energy resources, and urban areas collectively account for 80 percent of the world's total greenhouse gas emissions (FIG, 2010). These climate change effects contribute to more severe weather events, which ironically have higher impact on urban areas due to its higher population and infrastructure investment; this higher risk will be most keenly felt in the urbanising regions of developing and less developed countries (IPCC, 2007).

Pertaining to land and property, urbanization has led to instances of informal development – most visibly as slums, but often as illegal construction, resulting in the development of an informal land market (FIG, 2010). The slum settlements in Africa and India are common examples. At a broad level, the challenges caused by urbanization are complex and difficult to resolve, least of all because of the rapidity at which they occur. More often than not, institutional arrangements, policies and basic infrastructure cannot keep pace with development (World Bank, 2009). Of the institutional aspects, there is increasing recognition that governance and institutional reform is of primary importance in trying to achieve any measure of resolution (FIG, 2010; GSDRC, 2011). Additionally, these challenges are typically multi-faceted, thereby requiring a concerted effort to coordinate multi-disciplinary approaches to solutions.

Despite all its challenges, urbanization is in fact, a measure of economic health with the productivity of cities indicative of a country's overall economic well-being (UN-HABITAT, 2010). However, this implies that sustainable development is not possible without sustainable urbanization (FIG, 2010).

If the inherent challenges of urbanization can be effectively managed and resolved, it will be possible to maximize the benefits of urbanization. As such, there are many initiatives targeting the management of cities and sustainable urban development. Increasingly, many of these initiatives show trends towards governance-based approaches, especially those that connect government, industry and citizens (GSDRC, 2011). An initiative with widespread resonance has been the United Nations' vision of the "Inclusive City" which promotes an ideal of equal and full participation by all citizens in the processes of decision-making within cities (see Figure 1). As a paradigm, it proposes that full equality in urban citizenship can only be achieved when the social, political, economic and cultural dimensions of a city are linked. The most recent 'State of the World's Cities' report found that if this paradigm is to translate to reality, these four aspects need to be implemented and managed through a "rights-based framework" that is predicated on inclusion of all stakeholders, flexibility and accountability, and institutional efficiency (UN-HABITAT, 2010: 56).

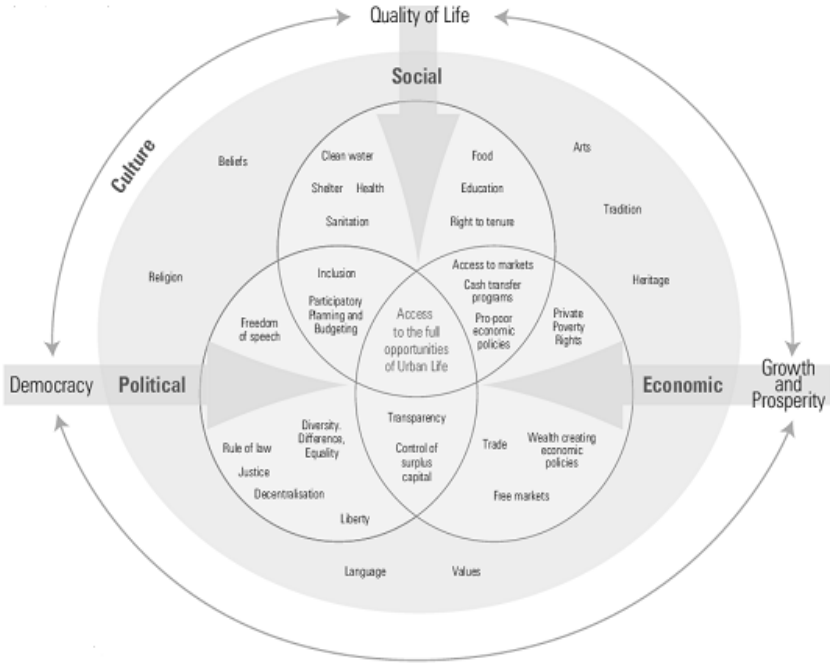

Figure 1. UN concept of an 'inclusive city' (UN-HABITAT, 2010).

This concept of a rights-based framework is aligned with land administration systems which are traditionally built using land parcels as the basis for recording interests in land. However, this traditional construct is being challenged with the emergence of new interests in land that transcend parcel boundaries. Land use in metropolitan areas provides a prime example of these new interests where a high demand for land creates complexities in building structure and use, which in turn results in various permutations of RRRs that are difficult to record, organize, access, maintain, analyze and comprehend if represented in their current format of two-dimensional (2D) (and often paper-based) parcel-based cadastral records. This issue needs to be addressed if the vision of a spatially enabled society is to be achieved, where the whole of society has free access to spatial information and development is encouraged through improved transparency and decision-making, and also the reduction of administrative costs (Williamson *et al.,* 2006; Rajabifard, 2007).

Sustainable development is therefore a key driver for more efficient land administration processes and achieving this necessarily requires an integrated approach to managing land resources (Williamson *et al.,* 2010). This can be facilitated through spatially enabling land and property information. The following section will examine the broad developments that have led to the current interest in 3D technologies as a common infrastructure to manage land and property and potentially,

how this can become a new tool in modern land administration systems. Such a tool would not only improve governance frameworks by facilitating transparency and decision-making, but by providing information in a format that is clearly understood by all stakeholders, will ensure inclusivity through all levels of government, industry and society.

3. 3D and the Geospatial Industry

The current interest in 3D spatial technology is a likely consequence of advancements in 3D technologies, which have brought this technology into the mainstream. A generic Google search under the term '3D' recovers just over 2.3 billion hits with the volume index graph for this search term (Table 1) showing a sharp increase in searches for the term from the start of 2010. Many of the peaks in the Table are associated with searches for 3D television technology. This is occurring against a backdrop of a proliferation of technology into many aspects of life.

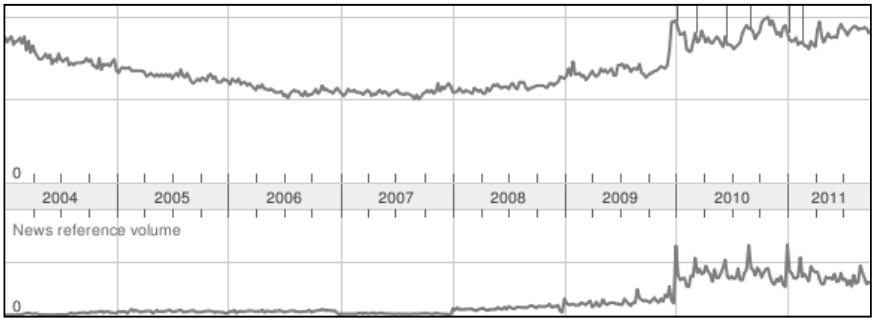

Table 1. Google's search volume index for the term '3D' (http://www.google.com/trends?q=3D).

Stakeholder Group	Planning, Engineering, and Design Phase	Construction Phase	Operations and Maintenance Phase	Total
Architects and Engineers	1,007.2	147.0	15.7	1,169.8
General Contractors	485.9	1,265.3	50.4	1,801.6
Specialty Fabricators and Suppliers	442.4	1,762.2	—	2,204.6
Owners and Operators	722.8	898.0	9,027.2	10,648.0
Total	**2,658.3**	**4,072.4**	**9,093.3**	**15,824.0**

Source: RTI estimates.

Table 2. Table of "Costs of Inadequate Interoperability by Stakeholder Group, Life-Cycle Phase (in $Millions)" (Gallaher *et al.,* 2004: p. 6-2)

This pervasiveness is also evidenced within the geospatial industry. In 2004, the United States (US) Department of Labor heralded geo-technology as one of the three 'mega-technologies' of the new millennium that will catalyse radical changes in society (Berry, 2009). However, while technology has arguably had a positive impact on productivity, its use without common standards is akin to conversing without a common language, resulting in impingement rather than enablement. In a report examining this specific issue for the capital facilities industry, the National Institute of Standards and Technology (part of the US Department of Commerce) reported that the impact of a lack of interoperability between stakeholders cost the industry approximately US$15.8 billion per year (based on 2002 statistics), with owners and operators bearing the brunt of this loss (Gallaher *et al.,* 2004). Table 2 above provides the breakdown of these costs.

This state of affairs is not idiosyncratic. In Europe, a recent study into building information models (the InPro project) similarly revealed that many different and incompatible IT systems exist within the construction industry to cater for its complexities and these systems are either costly or too specific in their application, leading to high investment costs (Gralla *et al.,* 2010). It is therefore feasible to assume that similar trends in costs exist in other countries within a comparable sector. Consequently, the impetus from the development of 3D technologies, geospatial databases and standards has led to the increased concentration on the use of building information models as a key and interoperable management framework for the lifecycle of the building (Bacharach, 2007). More importantly, our drive towards 3D information models for land and property management may come down to one simple, salient point: that it more accurately reflects the world we inhabit.

This push for an integrated platform for land information has as its main driver, the desire for sustainable development of land. This requires current and comprehensive information about the built, natural and physical environments to facilitate decision making that will have environmental, social and economic ramifications (Enemark, 2010). Traditional land administration systems are typically not equipped to cope with complex urban challenges as it is viewed to be too linear and often, too disjointed (Palmer *et al.,* 2009). It has also been increasingly acknowledged that governance lies at the heart of sustainable development and management of land and property, and that new land administration tools need to incorporate and facilitate governance processes (Palmer *et al.,* 2009; Enemark, 2010; FIG, 2010; GSDRC, 2011).

The following section will discuss how modern land administration systems can help deliver sustainable development objectives and the roles that different levels of society play in this new system.

4. Modern Land Administration Systems: The Role of Government, Industry and Citizens

Traditional land administration infrastructure has tended towards being a rights-based framework. In its current iteration as a parcel-based framework, such a system exerts limitations pertaining to the type of information that can be collected and managed, which is proving to be limited in its use, especially as a tool to deliver sustainable development. A modern land administration system needs to be able to provide not just a platform to integrate all types of information about the functions of land (tenure, value, use and development), but also the relevant processes and activities (Williamson *et al.,* 2010). More importantly, as Enemark et *al.* (2005: 53) noted, a modern land administration system (particularly those in more developed countries) should "facilitate sustainable development - the triple bottom line of economic, social and environmental sustainability - through public participation and informed and accountable government decision-making in relation to the built and natural environments".

The administration of land and property plays a vital role in any market economy. Therefore, governments will continue to play a central coordinating role in the modern land administration system, manifest as the cadastral component of the system, which accounts for the administrative, legal and fiscal processes of land and property. Rajabifard et al., (2006) observed that while such a coordinating role will likely be the domain of national governments, state and local governments will increasingly perform more operational functions. Additionally, developments in information and communication technologies (ICT) are rapidly changing the overall dynamics of land and property data demand and supply (echoing a general trend in spatial data use and consumption) such that industry and citizens are increasingly becoming both producers and consumers of this information, albeit to differing extents. This changing dynamic will foster greater linkages between the land administration systems and the people it directly affects thereby ensuring that sustainable development objectives are delivered at all levels.

This widespread use of ICT is an important factor in considering the specifications of modern land administration systems for urban areas. ICT is facilitating the development of new land administration processes between government, industry and citizens. For example, a 2010 study conducted by the Economist Intelligence Unit (EIU) on the use of ICT for city management (Siemens Press Release, 2010) found that ICT has become a basic infrastructure of cities and its use not only facilitated new ways of addressing urban challenges but also nurtured an environment for e-government initiatives to be implemented. This is an important aspect for supporting land administration governance processes as it will improve interactions between government, private industry and citizens.

Increased participation by citizens, fuelled by ICT developments, has also led to a change in their roles as purely data consumers to dual roles in production and

consumption. Consequently, both industry and government are looking to increased engagement as part of modern land administration systems (ANZLIC, 2010). Citizen-reliant initiatives abound, with OpenStreetMap a frequently cited example of how user-generated content can produce an authoritative or quasi-authoritative product. The EIU study also showed a strong trend in user-generated content that focused on urban applications. Citizens were increasingly consuming official datasets and mobile technologies to produce new applications that were relevant to their cities. In a similar vein, increased citizen participation is likely to improve the cycle of information between users, be it government, private industry or citizens. This is critical if land policies are to remain relevant (Bennett *et al.,* 2011).

The modern land administration system therefore needs to effectively engage and promote participation of government, industry and citizens, particularly in urban areas. It also needs to evolve with, and harness, developments in ICT to improve the efficiency of its processes. The concept of a 3D-LPIS is effectively that of a multi-level infrastructure that will enable all parties with an interest in land and property information to record, access, discover, share and manage information about RRRs that is not limited by parcel boundaries. By facilitating access, discovery, and sharing of land and property information, this system will support the processes and broad governance objectives of modern land administration systems and provide the foundation for realizing a spatially enabled society. This has been investigated in the context of Australia and the following section will demonstrate how government, industry and citizens have roles to play in a land administration system if urban development is to be sustainably managed. It will use specific challenges and issues to show how a 3D-LPIS can provide a platform to connect all levels of society to achieve sustainable urbanization.

5. 3D-LPIS: A New Tool for Sustainable Urbanization

A 3D-LPIS is a system that utilizes 3D geospatial technology to respond to the complexities of managing interests in land and property. This has particular application for urban areas where these interests, held as large-scale, people-relevant datasets, are becoming increasingly difficult to record, manage, analyze and comprehend. This is a critical issue as the value and stability of any land market is based on accurate and current information being available to support trading in land rights (Williamson *et al.,* 2010).

This system will enable the visualization of RRRs in a 3D digital format that will represent the data in a way that accurately reflects reality. This will also provide a common infrastructure for all stakeholders upon which collaboration or the management of other information can be based. It will improve access to information, participation in decision making, improve transparency in processes and facilitate multi-disciplinary approaches to urban issues. By providing accurate and timely information about land and property, this system will be a tool for realising a spatially enabled society.

Land administration systems and processes need to be contextualized to be effective hence Australia is used as a case study to show how a 3D-LPIS can support sustainable urbanization.

5.1 Urbanization and Land Administration in Australia

Australia is the sixth largest country in the world and one of the most urbanized albeit least densely populated (Department of Foreign Affairs and Travel, 2008). It is a federated country comprising six states and two territories and occupies an entire continent. More than 70 percent (approximately 15 million) of Australia's population (of 22 million) is concentrated within its five largest urban regions – as this proportion is expected to increase, the management of such large and dynamic urban areas is becoming more challenging (Department of Infrastructure and Transport, 2011). Table 3 below demonstrates the rate of growth of Australia's 18 major cities over the last decade.

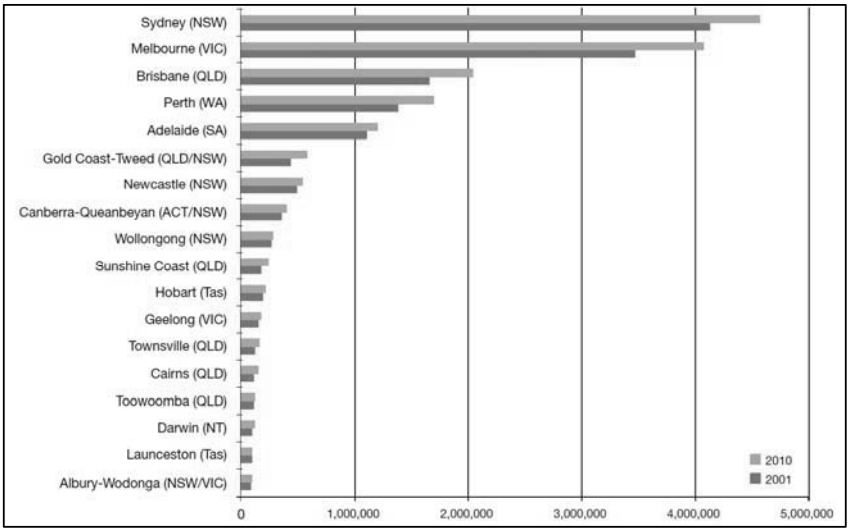

Table 3. Population change in Australia's 18 Major Cities (2001-2010) (Department of Infrastructure and Transport, 2011: 6)

Land administration has long been the purview of the state governments (to be henceforth considered synonymous with territory). This responsibility is formally recognized in the Australian constitution. The federal (national) government plays little or no direct role; however, relationships exist at this level due to non-statutory organizations such as the Australian New Zealand Land Information Council (ANZLIC),

the Intergovernmental Committee on Surveying and Mapping (ICSM) and PSMA Australia Limited (previously known as 'Public Sector Mapping Agencies' but now known as PSMA Australia and henceforth referred to as PSMA). Based primarily on the Torrens system, the land administration system of each state share similarities with each other but is sufficiently differentiated to provide for a complex national landscape.

Land and property information plays a vital role in Australia's economic, social and environmental well-being. A buoyant and secure land market is essential for economic prosperity; effective management of the built and natural environment is necessary for sustainable development; and land information is vital in administering to the needs of citizens by linking location to activity (Wallace *et al.,* 2010). Nonetheless, it is difficult to paint a clear picture of the value of the land and property industry in Australia. Using land tax as an oblique way of considering value, the amount collected by all levels of government in the last financial year (2009-10) amounted to AUD$31 billion, an increase of 14 percent over the previous year and accounting for ten percent of total revenue (Australian Bureau of Statistics, 2011). Reflecting the way land is administered in this country, property tax provided the greatest source of revenue – 37 percent of total revenue intake – for state governments (Australian Bureau of Statistics, 2011). The value of this industry also has a multiplier effect on affiliated sectors such as construction, and ancillary industries like property management and real estate transaction services. For example, within Victoria, every dollar spent on construction generates three dollars in other sectors (Master Builders Association of Victoria, 2009).

Land ownership in Australia is recorded and reflected in its cadastre, or the land and property map base. This is predicated on a legislative framework dictating processes relating to land ownership (and associated RRRs) and boundary definition. This has been catalogued as 2D textual cadastral records in the past but these records are increasingly being stored in digital cadastral databases. A 2008 workshop organized by the ICSM found that cadastral systems amongst the states generally had a high level of integration between survey and title data with other forms of information which was accessible via online services, and that this data tended to be of high quality and integrity (ICSM, 2008). It therefore found that there was high confidence in the systems by its users and a low incidence of disputes in transactions.

However, in a recent in-depth study looking at four parcels (albeit only in the states of Victoria and New South Wales), Bennett (2009) found that whilst 'above the line' interests (i.e. interests on title) were relatively easily discovered, this comprised only a small percentage of all interests associated with a property and that the majority of interests were in fact, 'below the line' interests. These ranged from zoning to heritage information, and there was no singular or systematic way to discover and access such information. A logical corollary is the existence of complex, and perhaps disparate, administration systems and processes. The following section articulates in greater

detail some of the current issues of land administration within Australia and how this transposes as drivers for a 3D-LPIS.

5.2 Current Land Administration Issues and Drivers for a 3D-LPIS

The land administration system in Australia is widely regarded to be of high quality and integrity; however, there are some acknowledged issues. Due to the pluralism that exists, and the preliminary stage of current research into 3D-LPIS, this section will reflect broad issues, or at least common ones across the eight state-level jurisdictions.

At the most intrinsic level, the lack of a single federal authority with overarching responsibility for land administration places Australia's system in stark contrast with modern land administration theory (Bennett *et al.,* 2011). This absence makes it difficult to aggregate information collected at local and state levels up to a national level (although PSMA fulfils this task to some extent with the production of fundamental national datasets). In a country where 70 percent of the population (and increasing) resides in urbanized areas, this poses a real challenge to the federal government's ability to fully understand the complexities of urban challenges from a national perspective. As Kelly *et al.* (2011: 10) noted, "When no one level of government owns the challenge, it is easier to avoid difficult decisions about managing the effects of population growth". This issue could translate as a key strategic driver for the development of a 3D-LPIS.

At a state level, ongoing and recent changes and restructures within government agencies responsible for surveying, registration and land administration matters are compounding the already complex institutional processes that exist. Looking further afield to the 563 local governments that also have land planning and management responsibilities for their own jurisdictions, Australia is faced with a significant land and property information management challenge (in legal, institutional and technical administration aspects). As a country, this reflects a land administration system that, although sound, is fairly disparate and complexities in bureaucracy and institutional processes inevitably result in higher costs to all stakeholders; addressing this issue is identified as a driver for the development of a 3D-LPIS.

These issues are being addressed in some way for the first time by a federal government with the publication of the National Urban Policy (NUP) in 2011 that was produced in consultation with state governments. The NUP is framed around addressing the broader urban challenges of the nation but also has implications for land and property management – it specifically looks to establish a framework for inclusive participation by sub-national governments, industry and citizens in sustainable urbanization of the country's cities (Department of Infrastructure and Transport, 2011). The NUP is one of three key policies that have been produced that will be used to guide sustainable development in this country. Table 4 provides a summary of the goals, objectives and principles that are to be adopted by all levels of government. In summary, the policy has as its main goals:

- improving productivity;
- improving sustainability and resilience of built and natural environment;
- improving the liveability in terms of housing, transport and community services; and
- improving governance through integration of processes, engagement and evaluation.

The implementation of the NUP can be seen as a key driver for the development of a 3D-LPIS in Australia as such a system could help facilitate many of the policy objectives by providing a common framework for all stakeholders to collaborate within and for all relevant information pertaining to the tenure, value, use and development of land and property to be integrated. Such a platform is aligned with modern land administration theory where the interaction of these functions is necessary to deliver policies aimed at achieving sustainable development (Williamson *et al.,* 2010).

GOALS		OBJECTIVES		PRINCIPLES
	PRODUCTIVITY	1.	Improve labour and capital productivity	Efficiency
		2.	Integrate land use and infrastructure	Value for money
		3.	Improve the efficiency of urban infrastructure	Innovation
	SUSTAINABILITY	4.	Protect and sustain our natural and built environments	Adaptability
		5.	Reduce greenhouse gas emissions and improve air quality	Resilience
		6.	Manage our resources sustainably	Equity
		7.	Increase resilience to climate change, emergency events and natural hazards	Affordability
	LIVEABILITY	8.	Facilitate the supply of appropriate mixed income housing	Subsidiarity
		9.	Support affordable living choices	Integration
		10.	Improve accessibility and reduce dependence on private vehicles	Engagement
		11.	Support community wellbeing	
	GOOD GOVERNANCE	12.	Improve the planning and management of our cities	
		13.	Streamline administrative processes	
		14.	Evaluate progress	

Table 4. Overview of goals objectives and principles of Australia's National Urban Policy (Department of Infrastructure and Transport, 2011: 18).

The following section discusses how a 3D-LPIS could help achieve these goals, especially with relevance to land and property, and in doing so, how it could improve the current processes of the various land administration functions.

a. Improving productivity

The scope of productivity as defined in the NUP encompasses labour, industry, knowledge, land and infrastructure. Pertaining to land and infrastructure, efficiencies in productivity is to be gained from more holistic planning incorporating social and

economic aspects as well as improving transportation modes. This is relevant to improving the functions of land use and development.

A 3D-LPIS could provide a platform to catalogue and connect 'above the line' interests with a specific property's 'below the line' interests. When this is visualized in a holistic manner, it could potentially result in improved analytical capabilities and therefore a way to improve current regulatory processes. This could potentially yield economic benefit especially since recent modelling carried out by the Reserve Bank of Australia demonstrated that zoning regulations that impeded development in urban areas generally resulted in higher housing prices (Kulish *et al.,* 2011 in Kelly *et al.,* 2011). This would also address the current difficulty in discovering all interests pertaining to a property in a simple and systematic way, and result in greater transparency in associated processes that would directly benefit government agencies, industry and citizens. The integration of all interests in land and property would also assist in planning efforts to reduce urban sprawl. This is an important issue for urbanising regions as urban sprawl has implications for productivity as it typically results in congestion, longer commuting times and increased costs of travel. Increased distance from established regions also impacts upon liveability by limiting citizens' access to opportunities and can result in diminished labour resources for businesses located in urban areas.

The NUP also prioritizes maximising returns on infrastructure investments. In research carried out in Europe for the InPro project, Schade (2007) found that an office building will cost at least three times its capital cost over a 25 year period but if more investment and emphasis is given to the planning and development stage, it will result in less costs being incurred by the building over its lifetime. Similarly, this system is well suited to provide a collaborative environment for developers, architects, planners and surveyors (amongst the most common professions engaged in the development phase of a building) to achieve the most efficient and sustainable building design pre-construction.

b. Improving sustainability

This goal aims to improve sustainability of the built and natural environments through protection of the environment, improvements in air quality, sustainable management and increasing the ability of cities to adapt and respond to natural disasters. These various aspects are increasingly being regulated through the emergence and development of new RRRs over land as a way to achieve sustainable development (Bennett *et al.,* 2007; Enemark *et al.,* 2005).

Likewise in Australia, new legislation aimed at mitigating climate change has recently been passed such as the National Greenhouse and Energy Reporting Act 2007. Such legislation implies the possibility that carbon and energy information will become mandatory elements of a modern land administration system for Australia. A 3D representation of property could provide an appropriate infrastructure to enable such information to be collected and managed, because land and property information is

used as the common denominator. This information could then be accessed and used by relevant industries such as risk and disaster management.

c. Improving liveability

Liveability is a fairly broad goal and the objectives the NUP seeks to achieve targets of affordable housing, improvements in public transport and supporting communities. Where a 3D-LPIS could directly support this goal is in the processes associated with land use and development.

There is a well-acknowledged shortage in affordable and appropriate housing supply in Australia's major cities, with factors such as land use policies and construction costs resulting in development more likely to occur at the edge of cities than within, and a tendency for single-unit dwellings to be built rather than multi-unit ones (Kelly *et al.,* 2011). Table 5 below shows the comparison between construction costs of building in established areas (infill) versus on the edge of cities (greenfield) in five of Australia's major cities. A 3D-LPIS could help planners achieve better urban design by providing a visual representation of the types of land use currently in place, as well as the types of structures and how these may impact upon the well-being of residents in adjacent properties. It could provide analysis by spatial clustering of land use type to ensure an appropriate mixture of land use. It could also provide a spatial representation of land use policies to foster understanding of these policies and evaluate their relevance to the communities they serve.

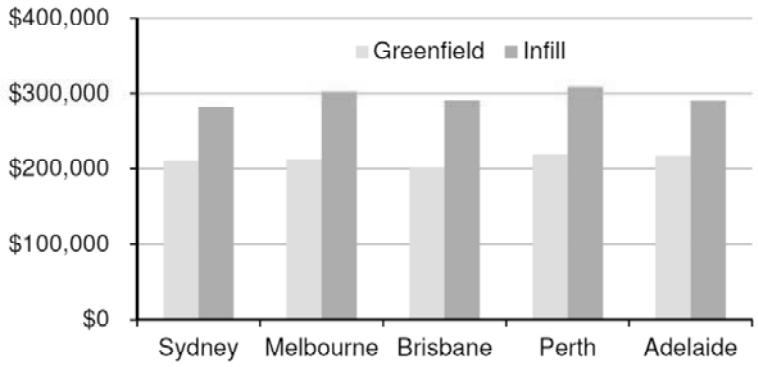

Table 5. Construction cost differences between infill and greenfield developments in five Australian cities (Kelly *et al.,* 2011: 28)

ICSM's review of cadastral systems in Australia (2008) noted that there has been an increase in boundary disputes, exacerbated by a general trend towards using litigation to resolve disputes. This can result in higher costs to all parties (and tax payers)

involved in land development, as well as generating ill will amongst communities. For example, the Gold Coast City Council, a local government, has found their legal costs for resolving land development disputes to be approximately AUD$6.8 million a year (Potts, 2011). A 3D-LPIS could provide an authoritative, but perhaps more importantly, easily visualized and comprehensible source of information that could assist in boundary disputes between neighbours (and reduce the costs of disputes) and support the aims of improving liveability in communities.

d. Improving governance

The goal of governance aims to improve upon current institutional processes to support the achievement of all other goals but particularly with regards to the planning and management of cities, the streamlining of administrative processes and evaluation mechanisms.

The three objectives are perhaps less distinct and more inter-connected: the improvement of one necessarily benefits the others. Complex processes impact upon the ability to sustainably plan and manage, in addition to impacting upon transparency and creating legal loopholes. A 3D-LPIS could facilitate open access of information and communication between stakeholders by providing land and property data in a (comparatively) more comprehensible format, that is, 3D visualization. This would be in line with existing federal initiatives within Australia supporting an open government based on principles of information, engagement and participation (Australian Government Information Management Office, 2011). This system would not only link citizens with governments and industry with each other, it could link the various levels and branches of governments dealing with land and property matters.

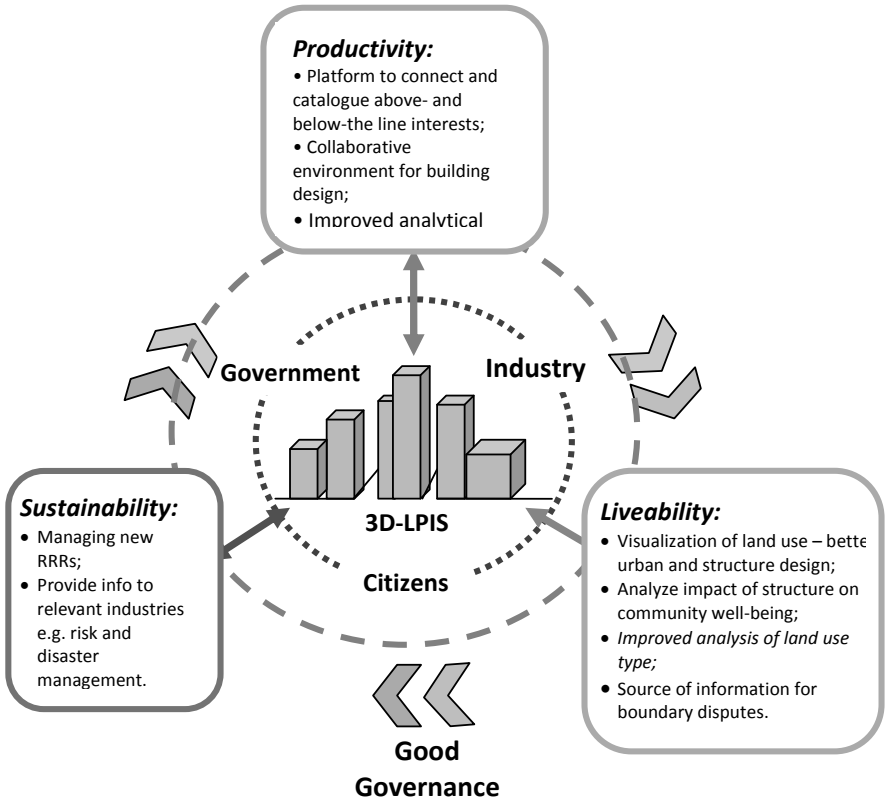

Figure 2. Facilitating Australia's National Urban Policy – 3D-LPIS to connect and deliver policy goals.

Figure 2 (above) conceptualizes the use of the 3D-LPIS by all levels of society to organize and manage the requisite information pertaining to achieving the goals outlined in the NUP by cataloguing and visualising land and property RRRs. The facilitation of the three goals of liveability, sustainability and productivity is inter-related and necessarily requires good governance. The integrated delivery and management of land and property information is necessary to deliver sustainable development objectives (Enemark *et al.,* 2005; Williamson *et al.,* 2010). As the cadastre in Australia provides a record of title and current ownership, it provides the appropriate basis of fundamental and authoritative data for a 3D-LPIS as the registration of property provides a mechanism for maintaining currency of ownership

data – from this base, it is then possible to relate to other types of data and/or information.

In summary, a 3D-LPIS could help facilitate policy goals by providing a way to integrate previously disparate sources of information, and consequently, provide improved analytical capabilities which would provide new insights for managing land use sustainably. The integration and streamlining of information would improve governance processes by facilitating engagement with stakeholders (be it government, industry or citizens) in the form of better access, transparency and feedback avenues.

6. Future Research

This paper has discussed a 3D-LPIS at a largely conceptual level due to the fact that ongoing research is still at a preliminary stage. Whilst significant research exists regarding the technical aspects of 3D systems (in general) for land and property data, it is acknowledged that a significant gap exists in the current body of work regarding furthering understanding of the institutional benefits of such technologies especially with relevance to cadastral data (Paulsson and Paasch, 2011). Therefore, the aim of this ongoing research into a 3D-LPIS is to utilize a multi-disciplinary approach to develop the institutional, legal and technical specifications for such a system to be implemented in Australia and determine if many of the conceptualizations mentioned in this paper will bear out in reality and can be evaluated against real life applications. It is envisioned that the outcome of this research this will likely provide a roadmap for other jurisdictions to demonstrate how a 3D-LPIS could be successfully introduced into current land administration systems.

7. Conclusions

This paper has shown that urbanization is an inevitable process and the challenges arising from urbanization have complex and multi-scale environmental, social and economic impacts that must be addressed. Sustainable urbanization is therefore necessary for sustainable development. The confluence of several drivers such as development of 3D technologies, the emergence of new interests in land because of urbanization, and the inability of traditional land administration systems to cope with complex urban challenges have all resulted in the increasing use of 3D spatial technology as a new tool in modern land administration systems.

The concept of a 3D-LPIS is proposed which uses 3D spatial technology to store, manage and visualize above and below the line interests (RRRs) in land and property. Such a system would enable integration of previously disparate sources of information pertaining to the built and natural environments, thereby resulting in improvements in access to information, participation in decision making, transparency in processes and

facilitate multi-disciplinary approaches to complex urban issues. Australia was used to provide context to demonstrate the potential of a 3D-LPIS to support the various functions of land to facilitate sustainable urbanization objectives as part of a modern land administration system. In a country where cadastral information (in many cases) is still held as 2D textual records, such a system would represent a significant evolution of its land administration system and provide a foundation not just for a spatially enabled government, but ultimately, a spatially enabled society.

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