

## Regenerative Sustainability and Geodesign in Byron Shire



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### Abstract

Byron Shire, NSW, Australia, aims to transition to zero emissions within ten years in five sectors - energy, buildings, transport, land use and waste. This study investigates the potential of Geodesign to effectively map the shire during this transition.

A contextual study of the shire's residential pockets is initiated using open source Geographic Information System (GIS) data and a typical case study site selected based on demographic information. CO2 equivalents from current electricity usage and offsets from renewable energy systems are added to the database and visualized in ArcGIS software. Site specific benchmarks are derived as the first step of developing a Regenerative Sustainability Design (RSD) strategy using Geodesign tools. The tenets of RS require each building to use systems that enhance overall ecosystem health by achieving positive outcomes for energy, waste, water, biodiversity, etc.

ArcGIS is used for designing built and natural environments in an integrated process. It enables evaluation of RSD alternatives against their impacts, collaborative decision making and community engagement (via apps, online surveys). Vector data can be directly quantified, multiple parameters accounted for and the on-ground situation presented to stakeholders in a legible and easy to understand format. Complex datasets can be quickly accessed and visualized in order to identify opportunities for positive contributions to the community.

This work shows the value of Geodesign for community planning processes to drive positive change. ArcGIS can assist in holistic assessments to identify the most effective retrofit opportunities, monitor the transition to zero emissions over time and inform policy.

**Keywords:** Zero Emissions Byron, Regenerative Sustainability, Net Positive Development, Geodesign, CO2 equivalence.



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## 1. Introduction

Many cities, regions and countries around the world are moving away from fossil fuels and have policies in place for 100 per cent renewable energy targets. A number of these, including Byron Shire Council, were represented at the recent Climate Change Conference COP21 in Paris (COP 21, 2015). This study explores how Regenerative Sustainability and Geodesign can add value to the transition process in Byron Shire and drive positive change.

The World Green Building Council has recently announced the groundbreaking new 'Advancing Net Zero' project which aims to ensure that all buildings are 'net zero' by 2050, to help deliver on the ambition of the Paris Agreement by reducing CO<sub>2</sub> emissions from the building sector by 84 gigatonnes in this timeframe. Participating Green Building Councils agreed on providing training programs and launching national net zero certifications in their countries, either stand alone programs or additions to existing certification tools such as Green Star. Architecture 2030, a non-profit organisation working to reduce emissions from buildings, will be Lead Partner to WorldGBC (WorldGBC, 2016). The Green Building Council of Australia, one of initially eight participating countries worldwide, is promoting net zero as an achievable goal and has announced the introduction of a 'net zero' label to recognize buildings with a neutral (zero) and net positive (beyond zero) impact in energy, carbon and water (Green Building Council of Australia, 2015).

### 1.1 Background – Regenerative Sustainability

Integrating the built and natural environment has been fundamental to the work of architects and planners such as Christopher Alexander, Antoni Gaudi, Frank Lloyd Wright and others. The Ecological Worldview (also known as Evolutionary, Reflective/ Living Systems and Integral - holds that humanity and nature are part of an interdependent and interconnected system (Commoner, 1971; Birkeland, 2012; du Plessis, 2012, Elgin & Le Drew, 1997; Goldsmith, 1988; McHarg, 1969; Prigogine & Stengers, 1984; Wilber, 1990). Carter, Miller, and Radhakrishnan (2001) emphasise the importance of cultivating connectivity with nature and taking personal responsibility for ecological wholeness. Some have called for environmental ethics within the architectural and planning disciplines (Beatley, 1994; Birkeland, 2002; du Plessis, 2012, Fox, 2000, Pedersen Zari, 2012). Hes and du Plessis (2014) have recently discussed the notion of the Ecological Worldview and its implications on the meaning and practice of sustainable architecture.

Hes and du Plessis along with Birkeland (2008); Cole (2012); Lyle (1994); Mang and Reed (2012), Benne and Mang (2015); Dias (2015); du Plessis (2009); du Plessis and Brandon (2014) describe Regenerative Sustainability (RS) as creating a positive impact on the health of the ecosystem and biosphere; architectural design must create reciprocal relationships between buildings and the larger living system.

'Regenerative Design' (RD) was introduced by Landscape Architect John T. Lyle (Lyle, 1994). Similarly, circular metabolism models on the regional scale have been theorised since the 1980's (Boyden, Millar, Newcombe, & O'Neill, 1981; Girardet, 1996).

Birkeland's Positive Development (PD) theory, taught and published from 2003, is based on a similar philosophy with a focus on creating net positive ecological gains relative to human consumption. Unlike circular models, PD is an open system approach that suggests how built structures can be retrofitted to become a net positive living environment that actively increases ecological carrying capacity and ecosystem services beyond pre-historic conditions, as well as natural, social and economic capital (Birkeland, 2008).

The term net positive has recently been included in the discussion within the international building research community. The first eco-positive conference stream 'Pushing the Boundaries – net positive Buildings' at SB13 Vancouver (SB13, 2013), explored the notion that buildings can and should have a net positive impact in order to regenerate their larger region. Net zero and net positive principles are also emerging in architectural practice, yet appropriate baselines, timeframes and system boundaries need to be defined (Kibert & Fard, 2012; Cole & Kashkooli, 2013; Renger, Birkeland, & Midmore, 2015).

In this applied research, investigations are guided by the philosophy that buildings must contribute to nature rather than settling to do less harm than the norm. For the purpose of this contextual review, related design strategies are referred to as Regenerative Sustainable Design (RSD) interventions.

## 1.2 Geodesign – History and Definition

Adapting the built environment to geographical surroundings has been a fundamental design practice since the start of human settlement. Recently, the term 'Geodesign' has been introduced to describe this activity and has gained popularity since the first Geodesign Summit in 2010 (Artz, 2013). The contemporary definition of Geodesign refers to a multidisciplinary and collaborative design process that harnesses the power of Geographic Information Science (GIS) data and technologies. Geographical space, its operations and condition are described and assessed on a digital platform to derive evidence-based changes necessary for the health and well being of that space.

Miller (2012) quotes five historically significant developments essential to the genesis of Geodesign. Firstly, McHarg's (1969) design philosophy which proposed a layered approach to regional and landscape planning based on the values of designing with nature. Secondly, the design framework for regional landscape studies developed by Steinitz eventually entitled as the 'Framework for Geodesign' (Steinnitz,2012). This framework advocates the development of six models to assist in a holistic planning process, entitled as 'Representation', 'Process', 'Evaluation', 'Change', 'Impact' and 'Decision' Models. It is technology independent but has been supplemented by work in Harvard's Laboratory for Computer Graphics and Spatial Analysis. Thirdly, the development of computer graphics led by Fisher in the late 1960s and the development of SYMAP, the first computer mapping program popular with planners. Fourthly, Miller (2012) refers to the development of GIS science led by Goodchild and others since the late 1980s. The fifth seminal development occurred when Jack Dangermond, Steinitz' student and founder of the company ESRI, developed GIS digital technology to assist landscape planning processes by coupling Geographic Information Science and the Steinitz' design framework. 'Geodesign' is 'GIS+design' (Batty, 2013) and Steinitz (2016) describes it as an iterative design method that uses stakeholder input, geospatial modeling, impact simulations, and real-time feedback to facilitate holistic designs and smart decisions.

## 1.3 Digital Monitoring for RSD

The concept of Geodesign shows synergies with the regenerative and net positive design paradigms. It adds value to RSD by assisting in brokering agreement between multiple stakeholders who need to agree upon the best course of action (Campagna, 2016). GIS tools enable the transition from 2D maps to '2.5D' reliefs to 3D geographic space and the addition of a 4th dimension by georeferencing time-dependent information. This can support designers in developing evidence-based RSD strategies for the built environment by effectively visualizing, quantifying and monitoring large, complex spatial datasets on the health, status, history and future of the planet. Qualitative and quantitative data from multiple sources such as maps, aerial photos, satellites and surveys and

stored in large georeferenced databases can be integrated into the RSD process to support stakeholders in choosing appropriate development scenarios.

In Urban Planning, land use and natural resource management this process has been used by multidisciplinary teams extensively, permitting the facilitation of planning objectives and plan making through spatial systems analysis and public engagement' (Steinitz, 2016). Smith (2016) explains how open GIS can be used to prepare online and interactive mapping to reach large audiences and highlights the effectiveness of using the technology within the built-environment discipline.

A number of Geodesign case studies are available on the Esri website; a relevant example is Masdar City, UAE where GIS is used to meet the project's carbon neutrality and zero waste goals (ESRI, 2009). Geodesign tools and strategies applied to ZEB can assist in developing RSD interventions with stakeholders and monitor their implementation over time.

#### **1.4 Zero Emissions Byron (ZEB)**

ZEB is a community led project that was established in 2015 to achieve zero emissions shire wide within ten years, addressing the five key emission sectors energy, buildings, land use, transport and waste. It is a joint initiative of community members<sup>1</sup>, the Byron Shire Council (BSC), the research organisation Beyond Zero Emissions (BZE) and the Centre for Social Change (CSC). Byron is known for its community spirit and for embracing sustainability as a fundamental life philosophy. ZEB's framework aims to go 'beyond zero emissions towards net positive contributions to nature' (Zero Emissions Byron, 2016). The project can build upon many existing initiatives in the shire such as the Green Building Centre, a community-owned renewable energy provider, permaculture gardens and various community activities. An innovative virtual net metering pilot project enables sharing energy resources between buildings (Parkinson, 2015). ZEB has gained international recognition and was represented at the recent United Nations Climate Change Conference COP21 in Paris.

Buildings are a focal point in the community where all other the key emission sectors come together and a hub for social interaction, communication and education. While self-sufficient buildings have been explored for almost half a century (Vale & Vale, 1975), the value of these concepts is now increasingly being recognized (du Plessis, 2012; Pedersen Zari, 2012). An RSD strategy implemented in Byron can inspire others, create meaningful places for people and enhance the community spirit.

To date current baseline emissions have been established for the five sectors and the focus is now on community and stakeholder engagement. Retrofitting opportunities will be prioritized and new buildings encouraged to target self-sufficiency through design most suited to the sub-tropical climate, maximizing passive solar design strategies to minimize active technology and cost. BZE's reports and cost efficiency models will support the transition process (Beyond zero emissions, 2016). BZE's research is complemented by leading concepts in international building research and emerging practice such as regenerative design (Lyle, 1994, 1999), Cradle to Cradle (McDonough & Braungart, 2002; McDonough, Braungart,) and Positive Development (Birkeland, 2008).

#### **1.5 Aims and Objectives**

This study explores (a) the use of Geodesign in a holistic sense to support Byron to regenerate their community towards carbon neutrality and beyond (b) ArcGIS as a Geodesign tool to provide science-based evidence while managing complex datasets during the RSD process.

A broad literature review reveals that there are essential constraints to a design discussion within the current paradigm where improvement of overall ecosystems health is an objective. These constraints are related to systems of energy, waste, water, and carbon, well-being, place, food and so on (Benyus, 1998; Birkeland, 2008; Hoxie, Berkebile, & Todd, 2011; Kennedy, 2010; Mang & Reed, 2012; Pawlyn, 2011; Renger, et al., 2015; Yeang, 1995). The objective of this study is to investigate how Geodesign can assist in addressing whole system solutions. Starting with a contextual review of Byron Shire’s residential areas, the efficacy of ArcGIS as a Geodesign tool for the RSD process is tested and the status of geo-spatial data currently available through open sources are reviewed. Initially, current electricity related carbon emissions are assessed to set first benchmarks for the transition to zero emissions.

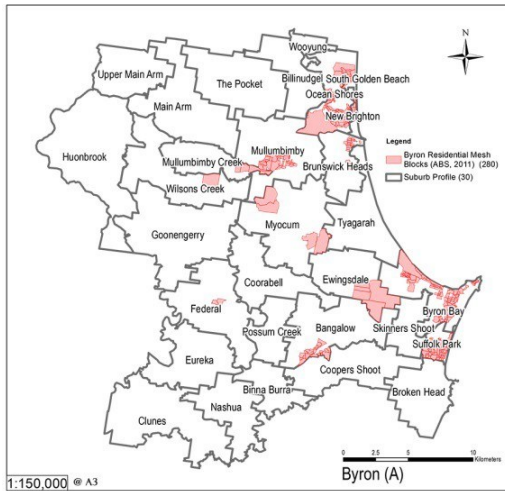


Figure 1: Residential Mesh Blocks in Byron Shire Shire

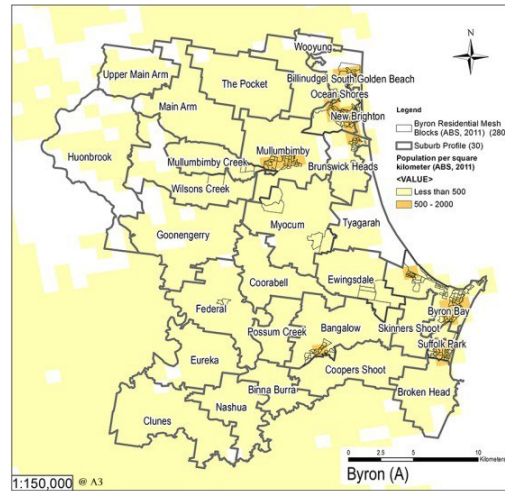


Figure 2: Population Density in Byron Shire

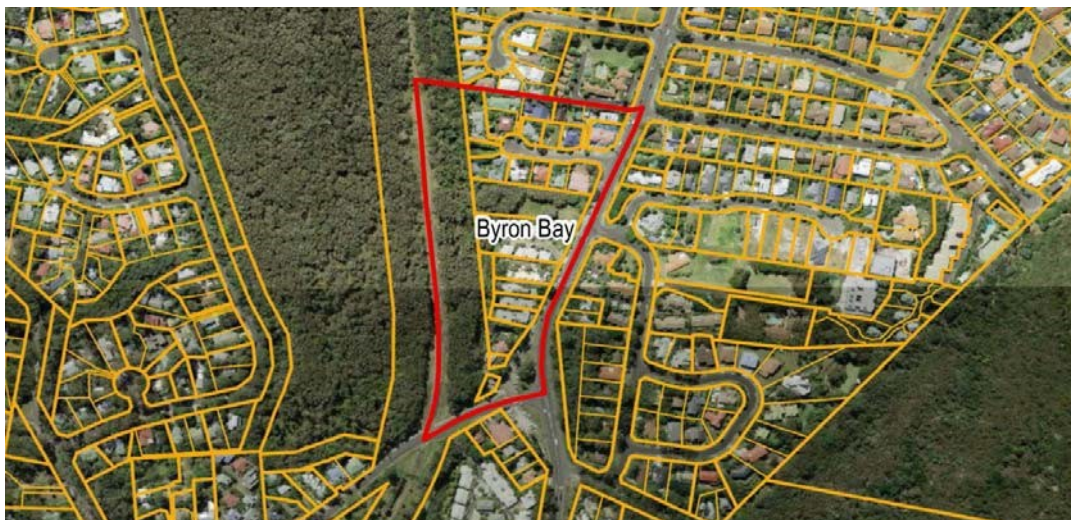


Figure 3 - Case Study Site – Aerial imagery and lots

## 1.6 Limitations / Opportunities

The current contextual review focusses on operational carbon emissions only. It shows the potential of ArcGIS to capture different forms of carbon impacts, for example embodied energy or biomass sequestration. CO<sub>2</sub> equivalent is used as an indicator for quantification; however, this is only one aspect of a holistic assessment in addition to many benefits that ecosystem services provide on the physical, cultural and psychological level (Renger, Birkeland, & Midmore, 2013). Multiple RS parameters can be quantified as well as qualitative factors captured if data are available. The methodology can be extended to include other building types as well as the other ZEB sectors Energy, Land Use, Transport and Waste. Once Geoscape data on built form and vegetation are released later next year (Leary 2016) the calculations can be revised to reflect a more realistic view. Future work will test how Geodesign tools can assist in the iterative process of displaying information to and collecting missing data from the community, documenting progress, refining the RSD strategy upon feedback and monitoring the implementation. Application of an RSD strategy in governance planning and decision making, not only on the technical level, would be most effective. Geodesign can support ZEB in developing implementation programs to reach zero emissions and inform policy.

## 2. Methodology

A seven step methodology is employed to develop a RS strategy for Byron Shire using the Geodesign tool ArcGIS. Due to limited data availability and time, the last step is still in progress.

### 2.1 Choose Parameters

New South Wales (NSW) Building Sustainability Index (BASIX) has set up benchmarks and targets for energy related carbon emissions within the residential sector (BASIX, 2016), however BZE's reports show that these can be challenged (BZE, 2016). Carbon is chosen as a parameter due to its relevance for mitigating climate change (IPCC, 2014). CO<sub>2</sub> equivalent can be used as an indicator to overlay impacts from different sources (Renger et al., 2013, 2015), e.g. the five ZEB sectors. These can be modelled with Geodesign tools. BZE's initial estimated average electricity use in residential buildings in the shire is used as a starting point.

### 2.2 Identify appropriate scale

Open GIS data was reviewed to identify an appropriate scale for RSD interventions. The majority of ABS spatial data is based on Australian Statistical Geography Standard (ASGS) since 2014. The ABS Main Structure grows smaller from Australia (country scale), to state and territory, to four levels of Statistical Areas (SA4-SA1), to Mesh Block (Australian Bureau of Statistics, 2014). Digital boundaries for Local Government Areas and Natural Resource Management Regions are also available through ABS (Australian Bureau of Statistics, 2012) and can be overlaid in ArcGIS.

The community scale is most appropriate for proposing RSD strategies because resources can be shared and benefits maximized through multi-functional design once regulatory constraints are overcome. However, smaller physical boundaries such as the Mesh Block geography within Byron's Local Government Area (LGA) boundary are a useful starting point for quantification.

### 2.3 Identify a Case

Byron shire covers an area of 566 square kilometres (Byron Shire Council, 2016). Mesh Blocks reflect land use, are the smallest geographical region in the ASGS and also the smallest unit for which census data is available (Australian Bureau of Statistics, 2011b). In order to select a case study site (CSS) that best reflects the situation in the shire, the location of the 280 Mesh Blocks classified as

residential within Byron's LGA boundary is identified (Figure 1). A population grid for Australia based on the most recent census data from 2011 (Australian Bureau of Statistics, 2011a) is overlaid to make comparisons at a regional scale (Figure 2) and identify the typical demographic profile of Byron. From here, the two Mesh Blocks with median number of dwellings and Persons Usually Resident (PUR) are identified. The former is chosen as CSS, reviewed at a larger scale (1:5000) and cadastral and imagery data (Land and Property Information, 2014a,2014b) is overlaid (Figure 3).

#### **2.4 Description of Existing Energy Systems**

Aerial imagery published by Land and Property Information (2014b) is used to identify lots with photovoltaic (PV) systems (Figure 3). Approximate system size is determined. The average annual electricity usage per dwelling in Byron shire has been estimated by BZE as 90 MJ per dwelling per day (Keech, 2015). This, in conjunction with ABS figures for number of dwellings is used to calculate and visualise electricity usage per lot to identify the characteristics of the CSS (Appendix: Figure 4). GIS data for emissions and/or offsets from energy suppliers or other sources such as Council and the community may become available.

#### **2.5 Carbon Sequestration Potential of Remnant Ecosystems on Site**

Remnant Ecosystems for Byron are discovered through a search on the NSW spatial catalogue (Ecograph & Terrafocus, 2012). This information is overlaid in the mesh block to identify and visualize type and location of the ecosystems in the CSS and surrounding context (Figure 5). Carbon sequestration values for these vegetation types can be sourced, the net position on emission / sequestration calculated and visualized via ArcGIS. This assessment can inform the subsequent stages of the design process, be useful for other ZEB sector groups, in particular the Land Use Group, and tie back to Council's revegetation projects.

#### **2.6 Determining the Net Position**

The existing situation in the CSS was assessed and benchmarks for achieving carbon neutral operation established. The preliminary results of baseline emissions, offsets and future targets are shown in Table 1. These calculations can be refined beyond averages once more accurate figures on operational energy usage are available. Additional RSD parameters such as emission/offset data from the other ZEB sectors can be added. Geodesign methods and tools can assist in identifying the net position on emissions and analysing pathways to achieve ZEB's goal of zero operational emissions. Favourable conditions and optimal locations for resource sharing between buildings to achieve net positive status for individual buildings and areas suitable for multi-functional public benefits can also be identified.

#### **2.7 Development of Comparative Values – Work Under Progress**

Work is under progress to review methodologies for collecting critical, place- specific data such as building footprints, Gross Floor Area (GFA) of dwellings and material use for the RSD strategy. Extensive data searches on open platforms revealed no information available in ESRI formats for GFA. Mapdata Services, a digital mapping company is currently working on a dataset titled Geoscape Data which will supply data on Australia's built environment, physical structures, land and vegetation (MapdataServices, 2016). The availability of this information in the near future will enable assessment of the relation between natural systems and built form. In-house work on determining

appropriate methodologies for updating and automating processes for collection and displaying information to monitor progress towards carbon neutrality targets and beyond will continue.

### 3. Results

ArcGIS has proven to be a fast and effective tool in analysing the depth of open information available through ABS, NSW Spatial Catalogue, NSW Globe, and NSW LPI Web Services. ABS data used to inform this study is available in spreadsheet and ESRI shapefile vector format which can be directly quantified. The capabilities of the software to add data and visualize results of the existing average baseline operational emissions in the residential mesh block were tested. Embodied energy of buildings technology and other emissions are not considered in this study. The potential to include carbon sinks from biomass sequestration is outlined only and subject to future research. Missing GIS data has been identified. The geo-spatial information discovered on open databases has proven to be a useful starting point for developing an effective RSD strategy. Quantitative as well as qualitative factors can be captured via Geodesign tools depending on data availability.

#### 3.1 Energy Systems / Carbon Offsets

##### 3.1.1 Existing Situation:

In the CSS, 22 lots with 36 dwellings are identified in the Mesh Block. Five types of lots are distinguished through ArcGIS colour coding based on total GHG emissions (Appendix: Figure 4). The variance in each lot is due to number of dwellings (single, double or multiple) and electricity offset through PV (currently only 5 per cent). Once more location specific information is added to the database, appropriate retrofit strategies can be developed. The annual electricity usage, related carbon emissions and recommended minimum future targets are shown in Table 1 below.

##### 3.1.2 Future Target:

Strategies for achieving the future target of carbon neutral operation depend on location, building / construction type and user profile. BZE's initial report for the ZEB project indicates that through retrofit; typically a Byron house can expect a reduction of 48 per cent in electricity use (BZE, 2015). Retrofits upfront are critical in order to minimize PV system sizes and cost. ArcGIS can assist ZEB in identifying where the highest and lowest GHG emissions occur. Based on this a location sensitive RSD strategy, implementation and monitoring program to reach the zero emissions can be developed.

#### 3.2 Proximal Carbon Sinks

Ecosystem data overlaid on the CSS (Appendix: Figure 5) that moist to dry and swamp Sclerophyll forest and woodland; Heathland and other bushland exist on site and within close proximity. For this 2007 mapping ground-truthing is stated as work under progress at time of release. Visual reconnaissance of imagery is under progress to review accuracy of this data. Similar to the energy related CO<sub>2</sub> equivalents, the carbon sequestration potential can be added to the database and different scenarios modelled and monitored in real-time applications.

Table 1: Net operational carbon position/yr (based on 2011 data)

Colour Code / Description	Number of lots	PV Installed	Electricity use <sup>1</sup> (kWh)	Electricity offset by PV <sup>2</sup> (kWh)	Net electricity use (kWh)	Current GHG equivalent = minimum future target (t CO <sub>2</sub> ) <sup>3</sup>
White Vacant <sup>4</sup>	1	No		0	0	0
Yellow Single dwelling	3	Yes	27594	9965	17630	15
Blue Double dwelling	3	No	55188	0	55188	47
Green Single dwelling	13	No	119574	0	119574	103
Purple Multiple dwellings (6,8)	2	Yes - 1 No - 1	128772	6898 0	121874	105
<b>Total</b>	<b>22</b>		<b>331128</b>	<b>16864</b>	<b>314266</b>	<b>270</b>

<sup>1</sup> Based on estimated average daily electricity use of 90 MJ/dwelling \* 365 days \* 0.28 (conversion factor MJ to kWh). Assumed to be drawn from grid. Source: (Keech, 2015).

<sup>2</sup> Based on average daily electricity production of 4.2kWh \* 365 days \* 0.25 (conversion factor). Source: Solar choice (2010)

<sup>3</sup> Based on NGA factors for NSW = 0.86 (Australian National Greenhouse Accounts, 2015)

<sup>4</sup> Vacant lot at time of the census. Recently been redeveloped. Excluded to maintain consistency within the study.

## 4. Discussion

### 4.1 Data Availability

Extensive amount of geospatial data is available in the Australian context. ABS data has been collected on a national scale. These datasets are in different formats and can be confounding in their complexity. By using the Geodesign tool ArcGIS, ZEB can quickly derive useful regional information from these extensive nation-wide datasets. Here, a typical residential CSS at the local scale was identified and its specific characteristics reviewed. Freely available web services of Land and Property Information (2014a, 2014b) and raster data were used to inform this study. In NSW, cadastral vector data (e.g. in ESRI shapefile format) needs to be purchased from the NSW Digital Cadastral Database. Energy and vegetation related GIS data from energy providers, Council and/or agencies such as MapDataServices may become available and will be vital for the development of an effective RSD strategy, implementation and monitoring program.

### 4.2 Manual vs Automated Process

Due to the small size of the chosen CSS it is possible to manually review the data to extract the necessary information. For a shire wide application, automated processes need to be followed. Vector data enable direct quantification of large datasets. This will save significant time and effort for monitoring future progress towards zero emissions.

### 4.3 Improving Accuracy

The calculations in this contextual review are based on average values for electricity usage per dwelling and estimated installed capacity of PV systems. These can be replaced if more accurate figures become available. Once the existing situation is mapped across the chosen parameter (for

example, energy, carbon, waste, water etc.), appropriate system boundaries and timelines can be set. However, too detailed calculations can distract from the larger goal to reach zero emissions; it is more effective to focus on maximizing positive contributions.

#### **4.4 Development of RSD Scenarios**

ArcGIS can assist in identifying patterns hidden within the vast amounts of conventional data available such as extensive ABS data in spreadsheet format. Factual numbers provide a backing that empowers the RSD process. ZEB can rapidly compare locations and draw conclusions on the character of specific places in Byron. Applied in a holistic sense, this Geodesign tool can assist in revealing optimal locations for creating net positive community benefits. Based on GIS mapping of existing circumstances, location sensitive, user specific and most cost-effective retrofit strategies can be developed. Multiple scenarios can be compared and assessed (Larondelle, Frantzeskaki, & Haase; Pettit et al., 2015; Smith, Bishop, Ford, & Williams, 2009) to identify the best pathways for ZEB to acquire and monitor its zero emissions target.

#### **4.5 Staging and Implementation of Design Interventions**

ABS's Mesh block geometry is freely available. The efficacy with which analysis is performed at this scale implies that mesh block geometry could be used to monitor RSD interventions shire wide in the further development of the ZEB project. Mesh blocks for other building types can be identified and the framework developed within this contextual review extended to the other ZEB sector groups Energy, Land Use, Transport and Waste. Additional parameters such as waste, water, food, health, well-being and so on can be investigated and monitored over time.

#### **4.6 Emerging Technologies**

Software such as ESRI's CityEngine is a promising technological advancement that could be used to generate 3D urban environments to validate the RSD strategy. This would provide visualisations for RSD scenarios depicting the appearance of Byron's built and natural environment as it tracks towards zero emissions (e.g. 3d scenes, videos, fly-throughs). Such visualisations would assist in exploring how our dynamic earth systems may change and how we may thoughtfully support this change (Dangermond, 2009). Further, dynamic simulations of our constructed and natural systems can support the management of design interventions that create a healthier planetary system (Jackson & Simpson, 2012) and effectively communicate this to the Byron community.

## **5. Conclusion**

Transitioning to a zero emissions world requires an understanding that humans and nature are an inter-connected and interdependent system. The complexity with which this system changes can be made more comprehensible through the use of Geodesign tools currently available on the market. GIS is widely used in different disciplines but few examples have been discovered where the technology is used to implement zero emission targets. ArcGIS is a powerful tool for supporting the integrated design of built and natural environments. Complex data can be customized, directly quantified and displayed in an easy to understand format, across different scales from regional to local. The technology can be used to document progress and monitor the implementation of the RSD strategies by developing public platforms showing real-time web maps and/or 3D scenes.

The Geodesign methodology developed in this study shows the potential for an effective mapping of the existing situation in Byron Shire, monitoring towards its future zero emission targets and

identifying opportunities for net positive contributions to the region and community. The present investigations address zero operational carbon in buildings only; however this can be extended to a full life cycle approach and monitoring the transition in the other ZEB sectors Energy, Transport, Land Use and Waste.

The usefulness of interactive Geodesign tools towards encouraging community participation during the design and implementation process can become essential to the success of ZEB. Stakeholder opinions and missing data can be collected and integrated to refine the RSD strategy. Qualitative as well as quantitative RSD parameters can be captured, depending on data availability, and the most suitable transition programs developed. This digital mapping for ZEB could inform existing projects within BSC and policy. Other councils and LGA's with similar aspirations as Byron shire could also benefit from the application of Geodesign to monitor regenerative and net positive development.

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## 8. Endnotes

Both authors are members of the Zero Emissions Byron (ZEB) Buildings Group. The co-author is a representative of this group.

## 9. Appendix



Figure 4: Case Study Site – Energy Systems – Existing Situation

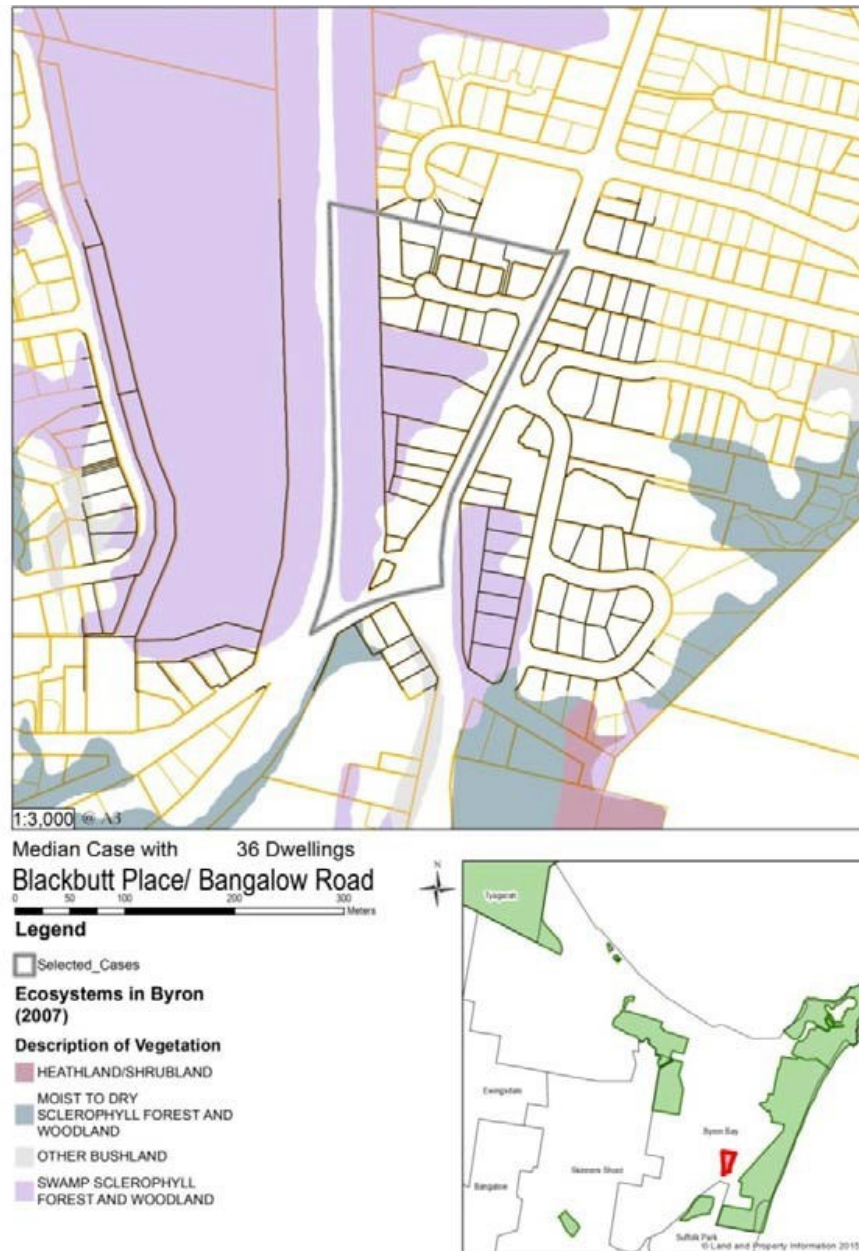


Figure 5: Case Study Site - Proximal Carbon Sinks