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Improving Urban Resilience in Coastal Eco-Cities: System Integration

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Improving Urban Resilience in Coastal Eco-Cities: System Integration

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Improving Urban Resilience in Coastal Eco-Cities: System Integration

Authors: **N Fernandez, SJ Kim, Z Morsy, VM Novak, K Shiraishi**

Series Editors: **R A Shenoi, P A Wilson, S S Bennett**

Lloyd's Register Foundation

UNIVERSITY OF Southampton

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Foreword

The Lloyd's Register Foundation (LRF) in collaboration with the University of Southampton instituted a research collegium in Southampton between 18 July and 11 September 2013.

The aim of the research collegium has been to provide an environment where people in their formative post-graduate years can learn and work in a small, mixed discipline group drawn from a global community to develop their skills whilst completing a project on a topic that represents a grand challenge to humankind. The project brief that initiates each project set challenging user requirements to encourage each team to develop an imaginative solution, using individual knowledge and experience, together with learning derived from teaching to form a common element of the early part of the programme.

The collegium format provided adequate time for the participants to enhance their knowledge through a structured programme of taught modules which focussed on the advanced technologies, emerging technologies and novel solutions, regulatory and commercial issues, design challenges (such as environmental performance and climate change mitigation and adaptation) and engineering systems integration. Lecturers were drawn from academic research and industry communities to provide a mind-broadening opportunity for participants, whatever their original specialisation.

The subject of the 2013 research collegium has been systems underpinning coastal eco-cities.

The project brief included: (a) quantification of the environmental challenge; (b) understanding of the geo-political legal-social context; (c) one integrated engineering system for a coastal eco-city; (d) economics and logistics challenges.

This volume presents the findings of one of the five groups.

R A Shenoi, P A Wilson, S S Bennett (University of Southampton)

M C Franklin, E Kinghan (Lloyd's Register Foundation)

2 September 2013

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Nieves Fernández, Sang Jin Kim, Ziad Morsy, Vera Novak, Koishiro Shiraishi

September 2013

Cover was modified from Satellite imagery provided by Google Earth©

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List of Abbreviations

BAP: Biodiversity Action Plan

BE: Built Environment

BRE: Building Research Establishment, U.K.

BREEAM: BRE Environmental Assessment Method

BUP: Bottom-up approach

CC: Coastal Climate change

DSS: Decision support system

DQI: Design quality indicators

EAM: Environmental assessment method

EE: Exterior environment

EIA: Environmental impact assessment

EW: Energy/ waste

GHG: Greenhouse gas

HQI: Housing quality indicators

I: Implementation

NGO: Non-governmental organization

P: Planetary boundaries resilience indicators

PV: Photo Voltage solar panels

QoL: Quality of life indicators

S: Social foundation resilience indicators

SE: Social-economic needs

UK: United Kingdom

V: Vitruvian qualities

WtE: Waste to energy

Executive Summary

What is a Coastal Eco-City and what are the core issues that need to be addressed? These were the questions we asked ourselves at the beginning of the eight week Lloyd's Register Foundation Collegium. A key point of leverage seems to be the growing demographic sector of the urban poor, who are vulnerable to the impacts of climate change. Improving the resilience of this sector is an investment that benefits the whole city. The challenge for city planners is to balance the people's needs for an improved quality of life with the planetary needs for a light ecological footprint.

Background research points to the need for a systems approach to planning that engages both private and public sector in the shaping of a vision for Eco-cities. What is lacking is the process and vocabulary to articulate the project values that will determine the course of action for a project.

We have developed a decision support tool that correlates project values with sustainability improvement activities. An index matrix was selected for the accessibility for the user and the data transparency. The initial correlation data was developed by the research team, and statistically analysed to identify the matrix variables which needed to be better defined in order to normalize the data.

The tool was tested with a case study application of the Weston Towers housing, in Southampton. Based on the values and weighting provided by the planning department, a list of activities were generated. A cluster analysis provided systems links to related activities, and can identify synergies that result in project savings.

Feedback from the planning department confirmed that this tool could be used to facilitate dialogue among city officials, developers and service providers. The listing of indicators used in the tool could serve as the vocabulary to define a project value brief that could serve as a guide for value management throughout the project.

The use of the tool could also catalyse innovative ideas. Our group worked with the concept of a coastal farm, which would combine the economic activities of aquaculture with the public use for entertainment and food production, as well as marine research.

A business case for the tool suggests a positioning in the design phase of the BREEAM program, and research to develop the tool from an indexed spread sheet to a web-based tool. The research also provides a solid body of knowledge for contributions to several academic areas, including value management, planetary resilience research and decision-making analysis.

1 Introduction

- *Coastal cities face growing **urbanization of poverty**: ½ the world's population lives in cities, ¾ of all large cities are located on the coast, and urban poverty has increased from 17% to 28% in past 10 years.*
- *The additional resource needs of this population are in direct **tension** with the need for resource reduction to address global sustainability issues.*
- *Urban poor in coastal cities are disproportionately **vulnerable** to natural disasters related to climate change (floods, tsunamis, tornadoes).*
- *Lessons from previous work point to the need for a **systems approach** to housing, improved infrastructure, as well as social systems support.*
- *Solutions should consider a **bottom-up** approach for improved **resilience, sustainability,** and **economic viability**.*

1.1 Introduction

Cities are faced with a mounting tension between the growing urbanization of poverty and the urgency of global sustainability issues. More than half of the world's population is now living in towns and cities. This urban migration has been triggered by economic need, and has resulted in an increase of urban poverty from 17% to 28% in past 10 years. At the same time that cities are grappling with the additional resource consumption needed to provide for this increased population, they are also trying to reduce their carbon footprint and reduce resource consumption to address global sustainability issues.

Compounding the problem is the coastal location of three quarters of all large cities. While natural disasters are not unique to the coast, climate change has increased the frequency and magnitude of these events. Urban poor are disproportionately, due to low adaptive capacity and their dependence on climate sensitive resources, such as food and water.

The consequences of natural disasters are felt beyond the direct impact area. The magnitude of damages wrought by hurricanes and tsunamis call for humanitarian aid and can cause mass outmigration to surrounding areas. This problem impacts us all.

This chapter will explore the specific conditions of the urban poor in coastal cities, study examples of eco-cities and urban renewal, and consider approaches for integrated solutions. Finally, a research gap is identified to shape the research area.

1.2 Urbanization: Social Challenges

1.2.1 What is a City?

European Union regional policy 2012 states that "The lack of a harmonised definition of a city and its functional area has hindered the analysis of cities in Europe." In cooperation with the OECD, the European Commission has developed a relatively simple definition;

- A city consists of one or more municipalities
- At least half of the city residents live in an urban centre
- An urban centre has at least 50 000 inhabitants. It consists of a high-density cluster with a density of at least 1 500 inhabitants per km^2

Cities are first and foremost about people. As such they are governed by organic processes which are constantly changing in nature and character. Tomorrow's city is the product of an on-going struggle between economic, political, ecological, social and gendered interests and forces. Balancing these and creating public good is the key to creating a dynamic, integrated, productive society (UN-HABITAT, 2012).

1.2.2 Growing Urbanization of Poverty

Urbanization of Global Population

The world is undergoing the largest wave of urban growth in history. Despite standing out as centres of civilization and economic activity for eight millennia, cities never attracted more than ten per cent of the global population until the second half of the 19th century. This is rapidly changing. In 2008, the percentage of the world's population living in urbanized areas surpassed 50 per cent. Virtually all the population growth expected at the world level during 2000-2030 will be in urban areas (UN-HABITAT, 2003).

Cities have become the world's social, economic, cultural and political matrix and are expected to remain the sources of investment and innovation. In developing countries in particular, the urban contribution to capital formation and urban participation in the labour force is expected to continue its steady rise (Grimmond, 2007; World Bank, 2008). Cities provide opportunities to achieve scale economies through division and specialization of labour, opportunities or "urban advantage" that are main driving force for people from rural areas into urban areas (Meyer, 2000).

Europe is even more highly urbanized, with more than two thirds of the population living in urban areas. Also, the growing trend of coastal cities continues to be a major influence on the economic, social and territorial development of the European Union (Figure 1).

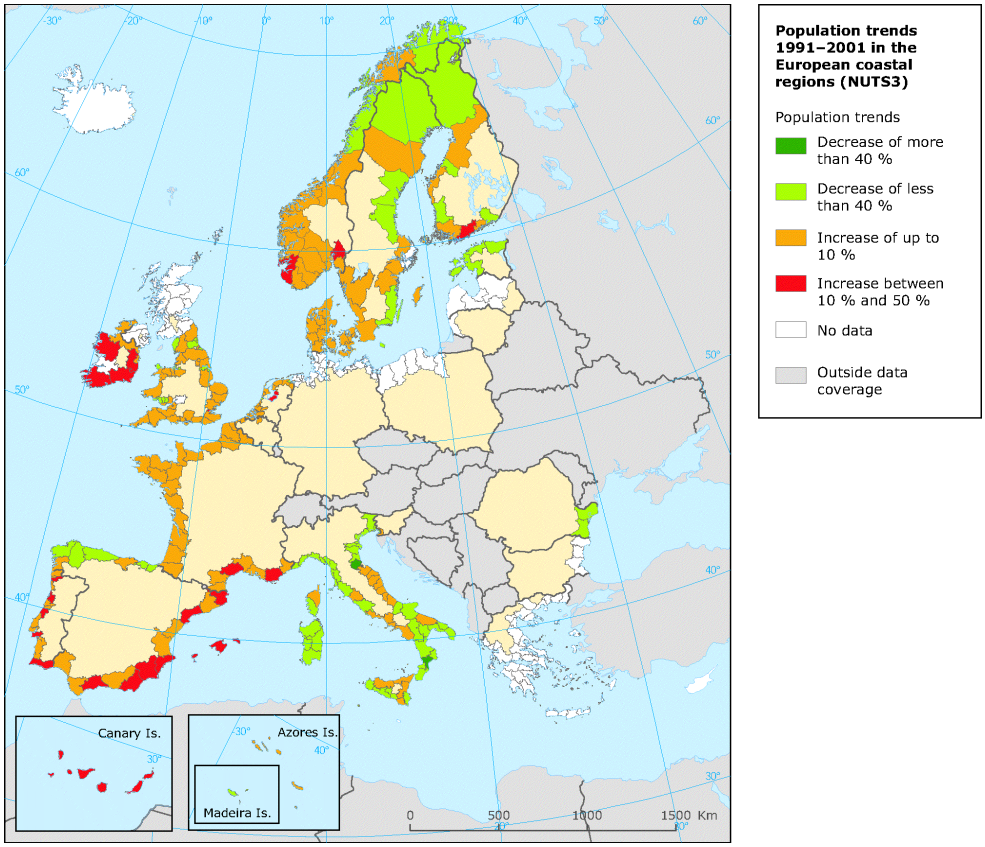


Figure 1: Population trends in European coastal areas

(Source: European Environment Agency, http://www.eea.europa.eu/data-and-maps/figures/population-trends-between-1991-and-2001-in-the-european-coastal-regions)

Increase in Urban Poor

Most of the new growth will occur in smaller towns and cities, which have fewer resources to respond to the magnitude of this change. The relationship between urbanization and poverty is true in 90 per cent of the cases (UN-HABITAT, 2010). In the United Nations Millennium Declaration, the international community recognized that it will have to improve significantly the lives of at least 100 million slum dwellers by 2020. A roof and an address are the first step to a better life, while improving access to basic social and health services, including reproductive health care, is also critical to breaking the cycle of poverty.

The scale of urban poverty is also rising worldwide. The share of poverty in the developing world that is located in urban areas has jumped from 17% to 28% in the past 10 years. In eastern Asia, nearly half of all poverty is found in urban locations, while in sub-Saharan Africa the urban share of poverty is 25%. According to the United Nations, the global urban population will grow from 3.3 billion people in 2008 to almost 5 billion

by the year 2030(UNFPA, 2007). Based on current trends, the majority of the people in the world will soon be living in urban slums (Sabry, 2010).

This urban expansion is not a phenomenon of wealthy countries. Almost all of the growth will occur in unplanned and underserved city slums in parts of the world that are least able to cope with added demands. The pace of urbanization far exceeds the rate at which basic infrastructure and services can be provided, and the consequences for the urban poor have been dire. Failure to prepare for this unprecedented and inevitable urban explosion carries serious implications for global security and environmental sustainability.

The trajectory of urban development and poverty will also shape the fortunes of both middle- and lower-income nations for years to come. The availability of human, financial and physical resources in cities in the poorest countries, as well as the policies that allocate and mobilize these resources in urban areas, are vital elements in combating poverty. But policies, to a certain extent, are a first-order effect of the political and institutional dynamics that characterize cities. Understanding these effects can shed light on how the main policies affecting the urban poor are designed and implemented.

1.2.3 Understanding Urban Poverty

The conventional approach defines poverty as an "economic" problem that can be corrected through more jobs and higher incomes; however, history shows that such "solutions" have offered little help to the long-term resolution of the problem. Instead of asking why households do not make more income, suppose we ask the substantive question of why poor households have problems with adequate nutrition, housing, transport, health care, and so on. The answers we get to these questions are different from those that use the conventional approach.

Food

The urban poor tend to buy a bigger share of their food than rural dwellers, hence their hunger and malnutrition is more dependent on growing and volatile food price levels. Access to food in urban areas is dependent most of the time on cash exchange, yet the low wages jobs often experience seasonal ups and downs (Kennedy, 2003). Urban residents need secure sources of income to combat food insecurity. The steady increases in food prices, climate change, population growth, inefficient markets, the unsustainable use of natural resources and consumption patterns is also putting pressure on current and future food availability and access (Tacoli et al., 2013).

Infrastructure

Infrastructure is a broad concept that embraces public investment in physical assets and social services. Almost by definition, the urban poor lack basic infrastructure services—safe water, household sanitation, solid waste collection and disposal, storm drainage, public transport, access roads and footpaths, street lighting, public telephones, and often other neighbourhood amenities (safe play areas, community facilities), electricity connection, and social services. Governments around the world—rich and poor alike—confront the problem of how to ensure their people have access to efficient, reliable, safe and affordable infrastructure services (Brook and Smith, 2001; Ogun, 2010).

Housing

Housing or (shelter) is the second most important thing for mankind after food. Secure housing that provides a person with safety and comfort can enhance the quality of life and productivity (Gambo, 2012). A community that lacks safe, decent and liveable housing is actually paying a variety of hidden costs that may hamper with its economic productivity. Research suggests that there are direct causal links between poor housing conditions and health conditions (Gambo, 2012). The low income of urban poor is a direct influence on the poor housing quality. For those who cannot afford to own or rent market housing, social housing is rented at subsidized rates. In a number of countries around the world, especially after World War II, governments started to be the main producer of housing, usually in the form of subsidized apartments in high-rise blocks located in large housing estates at the periphery of cities. Social housing projects may also be developed by cooperatives, charities, and housing associations (UN-ESCAP, 2008). The transportation distances and isolation lead to a concentration of social problems, and higher crime rates.

Water

In most of the developed countries in the world, the urban poor are connected to the national water grid systems, but cannot always afford water bills. In the less developed countries without central clean water source, they may not have the financial ability to transport water from its source to their own homes. Public service providers lack the autonomy, financial and human resources or incentives to provide services to urban poor.

Energy

Most of the projected increase in world energy consumption in the coming years will occur in cities of the developing world. The urban poor are faced with the problems of insufficient income to cover monthly heat and energy bills, or even to afford the required

infrastructure, such as meters, wires, or appropriate stoves. This results in disconnection of service, or safety hazards. The World Energy Council (WEC) recommends a three-prong approach with a focus on accessibility, availability, and acceptability to ensure the least possible negative impact on the environment (World Energy Council, 2006).

Increase Crime

Crime tends to be concentrated in cities and correlated with poverty. Rapid urbanization and deteriorating social and economic urban conditions combined with increasing proportions of young people have provided fertile ground for the recruitment into gangs engaged in local crime and violence (Shaw, 2007). Crime also has a direct link to the quality of life. In 2000, almost 200,000 youth murders took place globally, equivalent to 565 children and young people aged 10-29 years dying on average each day, as a result of interpersonal violence (World Health Organization, 2002). High crime rate deters business location in a neighbourhood, which can reduce local job opportunities.

Health Hazards

While the characteristics of each city vary by local context, common urban health and social challenges include overcrowding, air pollution, rising tobacco use, unhealthy diet, physical inactivity and the harmful use of alcohol. Risk factors can also include road traffic injuries or inadequate facilities such as transport, solid waste management, and access to health facilities (McMichael, 2000). Cities are frequently characterized as having better health and social services in comparison to rural areas, yet for low-income classes, access to services may be limited by ability to pay, inconvenient location or hours of operation, and poor quality care (World Health Organization, 2010).

1.3 Coastal Eco-Cities: Sustainability Challenges

Cities in the developing world consume resources at higher rates per capita than rural areas, and account for a disproportionate share of greenhouse gas emissions. At the same time, with their concentration of economic activity and population, along with the coastal location of many cities, they are disproportionately vulnerable to the effects of climate change. In short, cities are at the heart of the problem both in terms of the source of the carbon emissions and the effect that global warming on human settlements.

1.3.1 Coastal Issues

Coastal zones of the European Union are subjected continuously to the natural and cultural processes of weathering, marine erosion, flooding, and landslides. The impacts vary from

one part of the coastline to another depending upon the geological structure of the coastline, the durability of the rocks exposed on each particular coastal frontage as well as the relative exposure of the coastline frontiers.

Recent research has shown that natural processes such as coastal erosion have resulted in the loss or damage to hundreds of properties in recent years whilst the market values of others have been affected because development has taken place at inappropriate locations (EUrosion, 2004). Climate change adds to existing pressure on coastal zones.

1.3.2 Coastal Impact from Climate Change

Significant climate change will occur in the century ahead regardless of the extent of future greenhouse gas reductions. The effects of climate change are apparent and well-documented. The effects are widespread, interconnected, and cumulative.

Climate change has caused changes in European seas surface temperature up to six times greater than average changes in the global oceans in the past 25 years. Over the past century the average temperature has risen by more than 0.6 °C globally and by almost 1 °C in Europe (EEA, 2005). The most visible impacts of global warming on coastal areas are;

- The rise in sea level due to thermal expansion of ocean water, and the melting glaciers and polar ice
- The changing frequency, intensity and spatial pattern of precipitation, coastal storms and other extreme weather events
- Increasing stress on terrestrial and marine ecosystems and species (EEA, 2005)

Increasing sea level (1,7 mm/year) changes the shape of coastlines, contributes to coastal erosion and leads to flooding and more underground salt-water intrusion. Changes in the climate increases the likelihood of unpredictable environmental disruptions of ecosystems such as a collapse of previously reliable food sources, pest outbreaks, catastrophic floods or the disappearance of economically valuable species, and may lead to a loss of biodiversity and socio-economic assets (Fieden, 2011).

1.3.3 Coastal Impact from Urbanization

Coastal zones are among the most productive areas in the world, offering a wide variety of valuable habitats and ecosystems services that have always attracted humans and human activities. The beauty and richness of coastal zones have made them popular settlement areas and tourist destinations, important business zones and transit points. Currently, one

third of the EU population lives within 50 km of the coast, totalling more than 200 million European citizens from the Baltic to the Mediterranean and Black Sea.

People picture coasts as an immutable asset, yet damaging and irreversible changes to coastal ecosystems continue unabated (EEA, 2006/3). Current land use and economic practices often expose coastal populations to threats such as coastal flooding and erosion. These risks may severely compromise relatively high levels of human well-being on the coast (EEA, 2006/6). Coastal zones of the European Union are subjected to a very high degree of land conversion to artificial surfaces for tourism, the most dynamic economic sector on the coast (EEA, 2006/6). These land uses are in direct competition with the space needs of population growth.

Increasing sea-level directly affects the EU economy, as this area generates over 30% of the total EU Gross Domestic Product (GDP). The economic value of coastal areas within 500 metre from the European seas is between €500-1,000 billion. The estimation of costs for protection from increasing sea levels is estimated at around €6 billion (to 2020). This cost is offset by the net-benefits of adaptation, which could be as high as €4.2 billion. By comparison, the economic and ecological damages from doing nothing is likely to greatly exceed €6 billion (European Commission Environment; htttp://ec.europa.eu/environment).

1.3.4 Vulnerability to Natural Disasters

Coastal zones are among the most vulnerable areas to climate change and natural hazards. Natural disasters involve crop damage, housing and similar damages caused by cyclone, flood, river erosion as well as drought and rising salinity. Generally the term vulnerability refers to exposure and difficulty in coping with contingencies and stress. Poor communities will be especially vulnerable due to their low adaptive capacity and their dependence on climate sensitive resources, such as food and water (Poverty-Environment Partnership, 2008). They are the most likely to live in low-lying areas, on steep slopes, in ravines, and in other risk areas. The quality of their housing is poorer and less resistant to extreme weather events. They lack the resources, and often the information, to respond to in ways to mitigate their increasingly precarious situations.

Current thinking on poverty alleviation has focused on the promotion of opportunity (access to resources, services, and productive employment), enhancing security (reducing vulnerability to shocks), and facilitating empowerment (increasing the participation of poor people in decision making) through access to transport infrastructure.

Because of the well-being of populations and the economic viability of many businesses in coastal zones, it is essential to make use of integrated management tools to enhance the protection of coastal resources whilst increasing the efficiency of their uses.

1.4 Eco-cities and Urban Renewal: Lessons Learned

The competing challenges of coastal cities to adapt to urban growth while limiting the impact on the environment has resulted in several experimental models and approaches to eco-cities. The term eco-city was developed by the Urban Ecology Group, and referred to the reconstructing of cities to be in balance with nature (Roseland, 1997). A similar awareness of the environmental footprint of buildings has led to green building programs, such as BREAAM (www.breeam.org), and community efforts to improve the quality of life and social conditions for entire communities.

This report will review examples from each of these categories in an effort to learn of the strengths and gaps in each approach.

1.4.1 New Construction - Eco-Cities

Cities that are faced with growing populations may choose to build new eco-cities to accommodate the influx. While there are currently no set criteria an "eco-city," the term is often used interchangeably with "smart cities" or "sustainable cities" to include the economic, social, and environmental elements of sustainability (Alusi et al., 2011). The World Bank launched an Eco-Cities Program to "provide practical and scalable, analytical and operational support for cities in developing countries to achieve ecological and economic sustainability". The principles of this program include the need for;

- An expanded platform for collaborative design and decision making
- One system approach
- An investment framework that values sustainability and resiliency

While these are sound principles, the implementation of eco-city projects has had a greater emphasis on green buildings, reducing greenhouse gas emissions and information systems to better manage and operate the new technology aspects of the cities (Alusi et al., 2011). These are the most easily quantifiable or objective aspects of city development.

A Harvard study comparing 8major eco-city projects identified the key factors for success. The sample of eco-city projects were Dongtan, Tianjin Eco-City, Nanjing, and Meixi Lake District in China; Masdar City in Abu Dhabi; New Songdo City in South Korea; Sitra Low2Noin Finland; and PlanIT Valley in Portugal.

Notably, the funding challenges of these projects were the heavy capital investment born by the city, while the energy savings are reaped by the building owners. This decoupling suggests public-private partnerships collaboration. Nested within these agreements are also multi-government agreements, and the inclusion of NGOs. The underlying structure of these projects as real estate development projects resulted in a greater emphasis on physical assets and CO_2 management, and the private sector funding favours technology solutions, from smart buildings to renewable energy projects.

While the construction of new cities is necessary and the goals of carbon reduction are laudable, cities exist not for the sake of the buildings, but for the people for which the cities are built. A greater challenge is the support of a social structure to address the quality of life of the inhabitants, particularly the economically disadvantaged.

1.4.2 Urban Renewal

The origin of the term eco-city referred to the reconstruction of existing cities to be in balance with nature. There are also several notable efforts by communities to lighten their ecological footprint and build the infrastructure to support a more sustainable lifestyle. Townships such as Tübingen and Freiburg in Germany have been innovators in the extensive use of renewable energy sources and CO_2 reduction. These programs include initiatives to improve public transportation, install programmable thermostats, and update old heating equipment. Measures such as these have a direct positive impact on the quality of life for all citizens, including the urban poor. These green city initiatives also support local food production such as urban gardening and farmers market distribution, which also transcends social boundaries.

These initiatives are often bottom-up and can engage people at all levels. This is a more sustainable model than a top-down model, builds on existing infrastructure, and is more resilient to change. The problems with this approach have often been in the integration of the many programs by NGOs, public agency programs, and citizen initiatives. The result is missed opportunities, or projects that do not become embedded (and are not sustained) due to lack of key component pieces that could have been resolved with a more integrated approach.

1.4.3 Green Building Models

Green building programs, such as BREEAM were initially developed as environmental impact assessments, structured as indexed checklists. The criteria were originally designed for “green” construction materials and building systems, but have since grown to include

some social interactions and sustainability, such as bicycle commuting and proximity to public transportation.

These programs have helped establish minimum benchmarks for the "greening" of social housing. However, the aggregation of individual "checklist" activities does lend itself to a systemic understanding of the city (du Plessis and Cole, 2011), particularly the resource support structures needed by the urban poor. For example, while availability of child-care may directly relate to transportation, it is measured only in terms of energy consumption.

The need to blend the objective building goals with the social goals is reflected in programs such as Building for Life (www.designcouncil.org.uk), where criteria reflect the importance of functionality, attractiveness and sustainability in well-designed homes and neighbourhoods.

1.4.4 Regenerative Design

While the technical strategies of green design will remain valid, the emerging concept of regenerative design emphasizes a co-evolution of human and natural systems in a partnered relationship (Cole 2012). The key distinction is the shift from a managerial approach that builds, rather than diminishes, social and natural capitals.

The articulation of sustainability in the design phase of a project provides the greatest opportunity for increased value generation for the lowest cost (Rekola et al., 2012) and the inclusion of sustainability discussions in design can help bring issues to the forefront before critical decisions are made (Abidin and Pasquire 2005).

1.5 Solutions for Coastal Eco-cities: Approaches

As noted above, solutions to urban poor are better served by supporting the infrastructure to address long-term resolution of the conditions of poverty. In developing these solutions, there are several key attributes to consider; collaboration, resilience, and systems.

1.5.1 Top Down and Bottom Up: Collaborative Solutions

Top-down development has been considered the most practical management approach and the responsibility of government. However, in the application to climate concerns, this approach significantly underestimated the institutional complexities of the problem while overestimating the ability of politicians to balance climate issues with more immediate public concerns such as jobs and competitiveness (Rayner, 2010). UN-HABITAT has

argued that it is vital to decentralize power. Central governments too often focus solely on the capital costs for cities, ignoring the longer term social needs of the people.

The basic proposition of a bottom-up approach is that policies and activities should be designed and implemented at the lowest feasible level of organization. The process of identification and prioritisation of development issues is done by the people themselves but can be facilitated by district and other staff. The communities themselves also do the local implementation, in parallel to the central government support programmes that are of national priority (Rayner, 2010; Suzuki, 2010).

1.5.2 Improving Resilience

Resilience refers to the ability of a system to absorb disturbance and still retain its basic function and structure (Walker and Salt, 2008). The dynamic condition of resilience is achieved when the natural or human systems can adapt in response to actual or expected changes in climate. A variety of these strategies is already used by low-income groups; moving valuable items; sending children to stay with friends or relatives during disaster events; or constructing flood barriers around their homes. However, in many low-income cities, urban infrastructure is insufficient for dealing with current climate variability.

Designing resilience for coastal eco-cities thus refers to supporting the conditions for resilience systems to ensure that households, communities and cities are able to meet the challenges of today, as well as those that will arise in the future (CLACC, 2012). This can be achieved through the improvement of health and education systems, the provision of adequate shelter, sanitation and drainage, and supporting the social infrastructures. If the conditions for resilience exist, the people can adapt their own coping mechanisms.

1.5.3 Systems Thinking

Resilience is more easily achieved within a system that can provide buffers and balances. Environmental issues are particularly inter-connected, not only within the natural systems, but are increasingly framed within a wider political and social debate (Cole, 2005). As proposed by the World Bank's Eco-Cities, solutions need a systems approach, along with collaborative design and decision making, and investment in resiliency. Indeed, from the Lessons Learned (Section 1.5), there is a need to consider not only the green building and infrastructure, but a much broader consideration of quality of life indicators, social foundations, policy and practical considerations.

1.5.4 Economic Viability of Ecological Solutions

Solutions must show a feasible cost/ benefit, not only for economy but also the environment.

Ecological cities enhance the well-being of citizens and society through integrated urban planning and management that harness the benefits of ecological systems and protect and nurture these assets for future generations.

Economic cities create value and opportunities for citizens, businesses, and society by efficiently using the tangible and intangible assets of cities and enabling productive, inclusive, and sustainable economic activity (Suzuki st al., 2010).

1.6 Research Gap Analysis

Despite large efforts currently underway to enhance urban resilience in the face of climate change, policies at city level are still fragmented and effective tools to support decision making processes are still lacking (Corfee-Morlot et al., 2011). As we learned from the examples of community initiatives to urban renewal (Section 1.4.2), a high level of citizen participation with city governance facilitates collaboration in planning and design. Also, since the citizens are the direct beneficiaries of the design decisions, there is an incentive to invest in a framework that values sustainability and resiliency.

However, the dialogue for creating systems solutions to include the quality of life needs, the issues of global sustainability, and protection from climate change issues is still lacking (Figure 2). We will review this research gap within the scope of the urban poor in coastal cities.

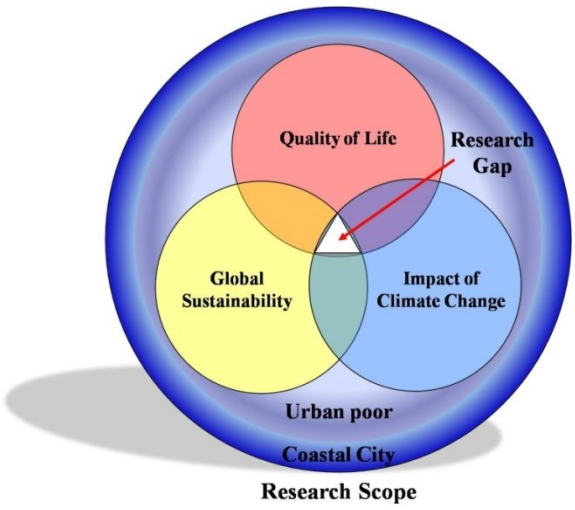


Figure 2**:** Research scope and research gap

2 Research Method

- *Research Aim: Develop a **systems approach** to urban regeneration, wherein environmental and social **values drive** the project **design**, within the context of urban poor in a coastal city.*
- *Methodology- Design Science: Design and test **relevant and meaningful solutions** for real-world problems.*
- ***Fast-track:** Short cycling of innovation and prototype development.*

2.1 Research Aim

The aim of the research is to develop a systems approach to urban regeneration, wherein environmental and social values drive the project design, within the context of urban poor in a coastal city. The research seeks to develop both a dialogue structure to facilitate the systems approach, as well as the vocabulary to articulate the value drivers.

2.2 Research Scope

The motivation of the research is to improve the resilience of the urban poor within a coastal city. This demographic group represents a growing percentage of the coastal urban population, and influences the economic, social, and environmental aspects of a city.

For the scope of this paper, project data from the Weston Towers in Southampton, U.K. was used for the purpose of grounding the research and normalizing the metrics. This housing estate is representative of the social housing towers that were built in the 1950's and 60's, and are still in widespread use in the U.K. and throughout Europe.

2.3 Research Objectives

- Identify the environmental and social values that define resilience for urban poor in coastal eco-cities (academic research)
- Identify systems of sustainability improvement activities (industry practice)
- Develop a tool for a systems approach to urban regeneration (design solution)
- Test the tool on a prototype case study (solution application)
- Assess tool implementation with city contacts (industry contribution)
- Evaluate future research for tool development (academic contribution)

2.4 Research Methodology – Design Science

The research methodology selected for this group project was design science (Figure 3), which is motivated by real world problems and it is distinguished by the "design" of a solution meant to solve the identified problem. It includes an attempt for implementing the developed solution, which implies a close involvement and co-operation between the researcher and practitioners. Since the design solution is created to address a specific problem, it is thus experimental in nature and experiential learning is expected to take place (Lukka, 2003). The methodology is explicitly linked to prior theoretical knowledge, and results in artefacts, which contribute both to the real-world problem, and to theory.

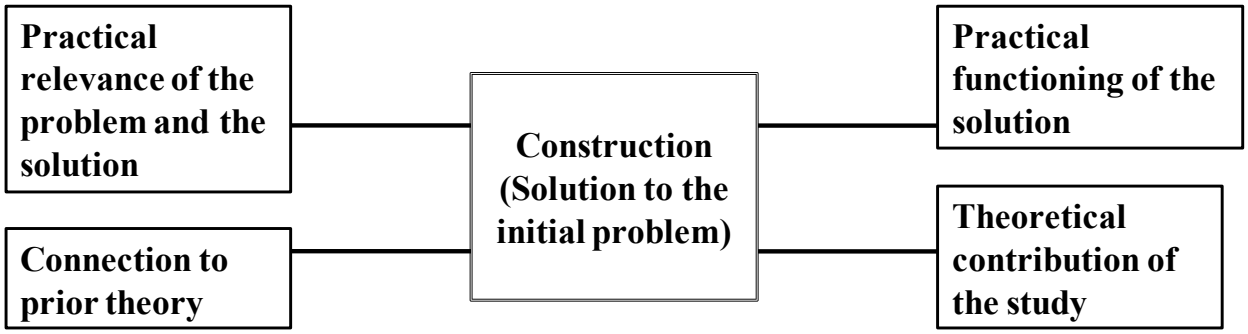


Figure 3: Design Science methodology (Lukka, 2003)

2.4.1 Topic Exploration

The design science methodology places an emphasis on the early phases of research, with a thorough investigation of real world needs and previous research in order to identify relevant and meaningful solutions. Aken (2004) describes the problem solving cycle as defining the problem out of its "messy" context. Schön (1983) places an emphasis on the "naming and framing" of the problem prior to the planning the intervention. Consequently, this team took the time during the first week to really explore two questions;

- What are the key issues of coastal eco-cities?
- What is the point of leverage that can have the greatest impact to solve the problem?

The team members met for the first time at the beginning of the project, so the first week was also dedicated to generating group cohesiveness. This was accomplished through activities of information sharing, with both aural and written communication and a wide range of media, in order to help each member of the group express themselves and have a

voice in the shaping of the project. We believe this extra time was well spent in order to secure consensus on the project scope relatively early in the project.

The sequence of activities for the first week (Figure 4) alternated between group activities and individual research.

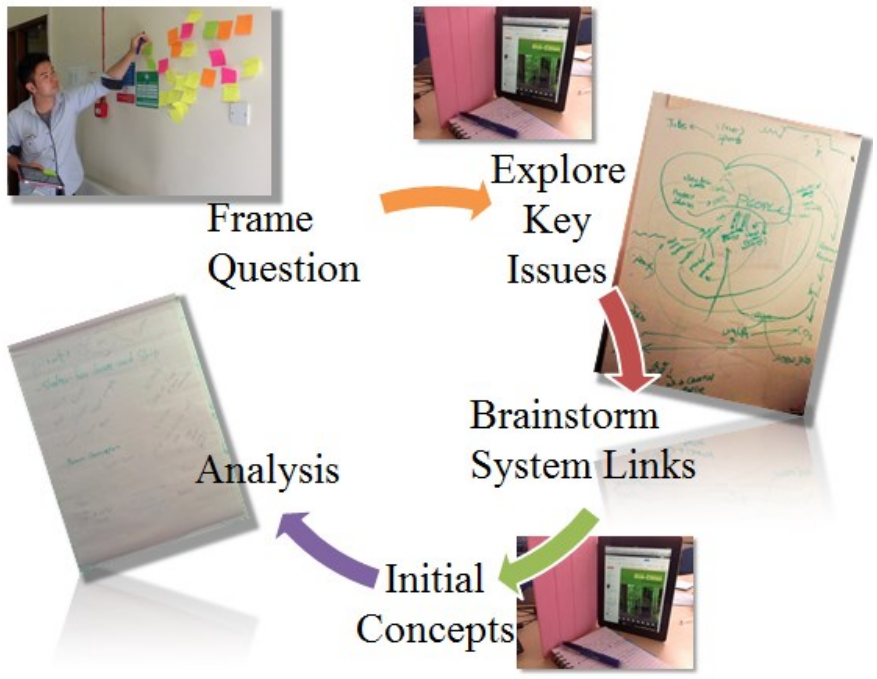


Figure 4**:** Idea Development

Step 1: Frame the question - Initial brainstorming using Post-It notes to collect initial ideas of the Collegium theme, Coastal Eco-cities. These ideas were collated into five key topic areas: people, waste management, land use, natural disaster, and transport.

Step 2: Explore key issues - Each team member individually researched one of the key topic areas, and then reported back to the group in a meeting the next day.

Step 3: Brainstorm systems links - The team members shared the findings of their individual topic areas. A whiteboard was used to identify links between gaps and opportunities, which identified a common focus on people, particularly the urban poor. In addition, the lack of a systems approach was a common gap in many of the key areas.

Step 4: Initial Concept Exploration - The next step phase of individual research was on the same topic areas, but viewed from the perspective of the urban poor and across the system layers of basic need, natural disasters, and maritime economy. The results were reported in the next team meeting, the following day.

Step 5: Analysis - The final collective team activity was to synthesize the findings and frame the problem. The research gap and research aim were defined. The project context was fixed geographically in Southampton, with a project selection that was generalizable.

Step 6: Investigate research option - This last step of the exploration phase of the methodology was accomplished through dialogue. An index matrix was proposed, which would correlate sustainability activities with each of the values indicators.

2.4.2 Methodology Modifications

Due to the compressed six week timeline of the research period, each of these stages of the project was accomplished with a view toward expediency. Therefore, the order of the steps was contingent upon external parameters. For example, the gap analysis of existing tools was done simultaneously with the development of the tool. This constraint turned into a benefit, since the process of developing the tool generated questions that guided the research into other tools, and the knowledge gained from the methodology research on other tools helped to guide our statistical validation process.

Similarly, the activities of prototyping, tool review and the case study implementation were intermingled. This blending of steps is more dynamic, and reflective of the growing practice or process integration in the construction industry. Thus, while it is difficult to achieve a depth of information in this accelerated process, the degree of innovation can be increased with this short-cycle feedback loop. However, it is our recommendation that these results be considered as a prototype that is submitted to a more thorough review and fine-tuning prior to actual implementation.

2.4.3 Contribution to Theory and Practice

The design science approach provides a linking between industry and academia. In some disciplines, such as building construction, industry innovations may lead academic research. On the other hand, without the grounding in theory and the analysis of the innovations, the potential positive knowledge gain is limited. Equally, the academic analysis can help to identify area of future improvement.

The evaluation of this prototype tool development is reviewed in Chapter 5, and future areas of research are covered in Chapter 7. In addition to the academic contributions of this publication, select sections of this work will be presented to academic journals. The potential contributions to industry are developed in the business model in Chapter 6, and a review of the case study will be prepared for Southampton City.

3 Tool Development

- *Process Gap:* ***Value Generation*** *and Information Flow.*
- *Creating the* ***"vocabulary" of value:*** *design quality indicators, planetary boundaries, social foundation indicators and implementation criteria.*
- *Tool Development:* ***Index matrix*** *correlating* ***value indicators*** *with systems of* ***sustainable activities*** *based on degree of significance.*
- ***Testing and refinement*** *by statistical analysis, prototyping, and case study implementation.*
- *User groups choose weighting of value indicators, and use selection of sustainability activities and clusters to* ***guide project design****.*

3.1 Process Management

This chapter reviews the current issues in process management and the existing value management tools, within the scope of the urban coastal cities.

3.1.1 Information Flow

In any construction project, information flows through many phases. In the case of social housing, it generally starts with the city council, to designer/ developer, and then to the constructor. Along the way, there may be several additional sources of input, from the residence association, NGO's, environmental advisors and other citizen groups. Inevitably, there are more ideas and opportunities than can be accommodated by the budget and are cut to reconcile budget, political expectations, and environmental regulations. The services of constructors are generally procured subsequent to design. Thus, the information flow is delimited at several points of packaging and hand-over, each of which represents a possible loss of distortion of information.

This sequential and isolated processing of information is not well suited to the increasing complexity of construction projects and the additional layers of sustainability. The traditional concept of project management as a conversion process, i.e. getting the task done, is shifting toward a greater consideration of continuous information flow and value generation (Koskela et al., 2002). The focus on value is particularly evident in public projects, such as social housing and health care, which have an increased awareness of the

building's added value for society rather than only the initial capital costs. Project values are ultimately made explicit as project objectives and quality (Thomson et al. 2003).

3.1.2 Value and Quality

Value identification tools are traditionally used in a client brief to help make values explicit. These have typically been delimited by a functional or utility viewpoint. However, sustainability issues are inherently resistant to being broken down into isolated criteria. For example, reducing the consumption of hot water is a function of water, but also of heat, natural resources, carbon footprint, and even ecology. Furthermore, it can contribute to quality of life through improved personal health and food safety. The difficulty has been in the articulation of sustainability as project values, as this is both more complex and yet more fundamental. Currently, the design process does not have a placeholder for this activity, nor are there tools to facilitate the dialogue.

The lack of well-defined project values can result in confusion in defining project quality. Quality management tools are implemented at the point of design, in construction, and upon project completion – often using different quality markers that are not always aligned. In many cases, these quality measures are based on quantifiable objects or measurements, and are not well suited to convey value statements, such as sustainability.

As a result, current quality management is focused on safeguarding the deterioration of functional project values, as defined in the specifications. The final project is invariably scaled back from the original concept. A new approach is needed that can support the creation and generation of *added value* throughout the design and implementation. This can only be achieved if the project brief includes the expression of the project values, as they are related to the impact on quality of life and environmental concerns.

3.2 Existing Tools

The following sections are a review of some of the tools that are currently used to measure and assess quality on a project.

3.2.1 Housing Quality Indicators

The HQI system is a measurement and assessment tool to evaluate housing schemes on the basis of quality rather than just cost, and take place as part of the review of applications for affordable housing providers seeking funding through the National Affordable Housing Programme (NAHP) and Affordable Homes Programme (AHP) in the U.K.

"Quality" in the HQI is defined by 10 indicators that measure the context and surroundings (Location, Site – visual impact, layout and landscaping, open space, routes and movement) as well as the unit design (Unit size, layout, noise, light, services & adaptability, accessibility within the unit). The scoring also incorporates the Code for Sustainable Homes, which is based on BREEAM (Building Research Establishment Environmental Assessment Method) mandatory performance levels set in the key areas of energy efficiency, water usage and additional sustainability points. HQI now also includes the Building for Life vision of what a house should be: functional, attractive, and sustainable.

The inclusion of the Code for Sustainable Homes and the Building for Life criteria both leverages the work from agencies such as BRE, and recognizes the need for interoperability of sustainability tools.

3.2.2 Design Quality Indicators

The Design Quality Indicator assessment is a review of the design process and product, and takes place during the design phase. The need to assess the effect of building properties on social values was identified by the British Rethinking Construction Agenda (Strategic Forum for Construction, 2002) as part of an effort to reframe procurement discussions as the best value rather than the lowest price. In response, the Construction Industry Council, U.K., developed Design Quality Indicators (DQI) that describes this assessment in terms of Vitruvian qualities. Vitruvius, a Roman author, architect, and engineer, is famous for asserting in his book *De architecture* that a building structure must exhibit the three qualities of "*firmitas, utilitas, venustas"* (solid, useful, and delight). In 2003, the DQI toolkit was launched as an online resource for the new construction and refurbishment, and now also offers DQI tools for the specific applications of health buildings and schools.

According to the DQI website, the intent was to facilitate a dialogue among stakeholders about common goals, interrogate designs, and investigate the supply chain. DQI is implemented through structured workshops and online questionnaire for clients, designers and users to gather their perception about a proposed design. DQI was intended to complement process measures, such as Key Performance Indicators, and product measures, such as sustainability assessments (Prasad, 2004).

While DQI has done much in the UK to stimulate discussion about quality and value in construction (Prasad, 2004), a critical review of the work identifies several problem areas (Markus, 2003). The first is the ambiguity in DQI between measuring the product of

design versus improving the process of design. The second is the intermingling of subjective and objective measurements on both sides of the evaluation - the item under review and the evaluation itself. Additionally, while the deliberate emphasis on the subjective user input (qualitative) is a welcome deviation from other expert-oriented tools based on objective, quantitative measurements (Dewulf and Meel, 2004), a subjective opinion about a subjective topic creates a level of ambiguity that hinders analysis. Markus (2003) suggests that the lack of rigor in the crafting of the questionnaire has resulted in problems with the validity, reliability and consistency of the tool.

The DQI also serves as a 'tool for thinking' by introducing the discussion of value and quality (Gann et al., 2003). Thomson (2003) explores the opportunity for DQI to educate the industry and its customers in the understanding of quality and value, and to develop means of framing design activity so that the delivery of value can be monitored and managed (Figure 5). He proposes that a means of delivering value could be established if a process model also reflected the contributions that individual design tasks make in forming a product's qualities. This could take two forms: design tasks themselves (or the flow of information between them) could be described in terms of their response to project values, or measurements of product/process qualities could identify the response to project values.

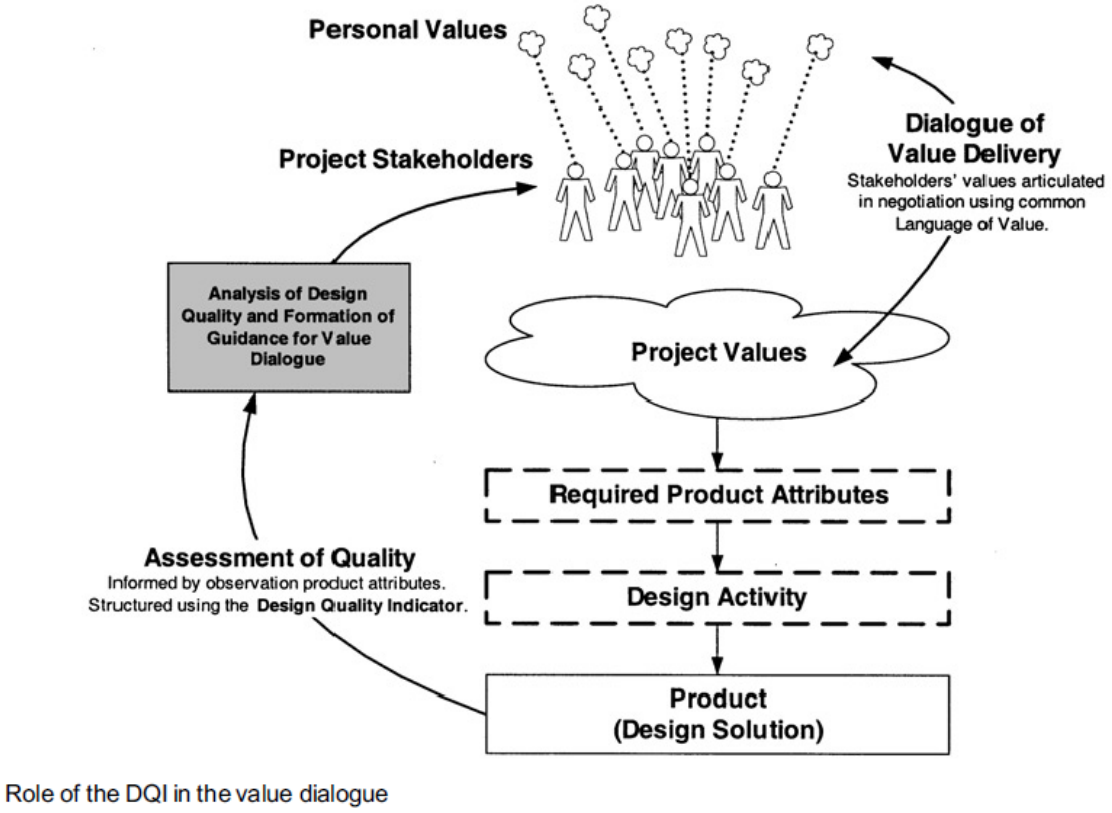


Figure 5: Managing quality and value in design (Thomson, 2003)
(Source: www.dqi.org.uk)

3.2.3 Environmental Impact Assessment

Environmental impact assessments (EIA) were first developed in the 1970's to understand the potential impact of a project on the environment in order to guide future decision making. There have been many variants of EIAs implemented around the world, including index approaches, systems diagrams and simulation modelling.

One of the earliest EIA index checklists was the Leopold Matrix, which correlated the activities of a project with impact on environmental factors both in magnitude (from -10 to +10) and importance (from 1 to 10). Measurements of magnitude and importance tend to be related, but do not necessarily directly correlate. Magnitude can be measured, in terms of how much and how badly an area is affected by the development, but importance is a more subjective measurement and is dependent on other factors, such as the resilience or the alternatives of the affected system. This subjective element is one of the main difficulties with such a scale-weighting checklist. One of the approaches to stabilize the correlation numbers was developed by Sondheim (1978), who attempted to broaden the basis of weight allocation by creating a weighting panel from the organization using the Matrix. Each member of the panel completes the matrix correlation, and these are amalgamated to produce a single correlation scheme representative of the panel's view. Yapijakis (1983) proposed an adaption that was based on the proposal that some of the environmental impact areas were of a global nature, and a stable weighting could be derived from the input by a transnational team, with a similar amalgamation as suggested by Sondheim. Other cross points of the matrix are more regional or project specific, and would be completed by the implementation team.

In addition to the environmental impacts, Yapijakis also introduced economic impacts and the "manageability and technology level" (Wathern, 1994). This recognizes the importance not just of the initial capital cost, but also the factors that affect implementation and maintenance.

Currently, one of the most widely used methods of environmental impact assessment is BREEAM. More than 250,000 buildings have been BREEAM certified and over a million are registered for certification in the UK and in more than 50 countries around the world. It was developed by the Building Research Establishment (BRE) as an Environmental Assessment Method (EAM). BREEAM continues to evolve, with new versions for other construction sectors (superstores, homes, refurbishment), and grow in scope to include the perspective of communities.

The primary measurement of BREEAM is carbon emissions, but also addresses good management, water consumption, bio-diversity, transport, pollution, longevity etc. One noted omission is the carbon emissions relating to construction, only in the materials of the final product. The carbon emission measure normalizes the discrepancies often found in measurements related to energy consumption, but is a much harder number to generate.

As an environmental assessment tool, the BREEAM measurements are taken at the completion of the project. However, the greatest potential impact of the tool is in the design phase, where the criteria are taken into account. Critics of this tool refer to it as a "tick-box" exercise to sustainability, and point to the tendency for the design to comply with criteria. Additionally, there are some sustainability activities which are not rewarded in this system and others which might be implemented just for the sake of points. However, there is also the opportunity to leverage the considerable information provided by BREEAM to educate the supply chain, increase awareness of sustainability issues and establish quality control management linked with the delivery of documentation.

The development of BREEAM for Communities has also sought to integrate sustainability earlier in the master planning through a three step process. The first step assesses the issues and opportunities of the project site and considers the impact of the project on the community. This also includes the assessment of social and economic well-being. The second step considers the proposed layout of a development, integrating the knowledge from detailed surveys regarding flood risk, ecology, energy, transport, demographics and the local economy to find the most sustainable design solutions for the site. The final step focuses on the specific activities for the design. An inherent opportunity from this procedure, though not explicitly identified, is the alignment of the city vision, project goals, and the site analysis in order to guide the design choices. However, the BREEAM for Communities does not include a procedural guide for this value definition step.

3.2.4 Quality of Life Indicators

Enhancing Quality of Life (QoL) has long been an explicit or implicit goal for social housing projects, but defining QoL and measuring progress toward meeting this goal remain elusive (Costanza, 2006). This is not due to the lack of research in this area, rather the complex nature of the topic. In recent years, Urban Quality of Life has attracted widespread research attention, in response to the rapid urbanization of the world population and the resulting deterioration of this urban QoL. The most affected demographic sector is the urban poor, as they often lack the economic means to compensate for negative impacts. This deteriorating quality of life can be document

through crime statistics, availability of health care and transportation, and environmental factors such as air or water pollution. Positive change of these same metrics may indicate an improvement of QOL, but are an incomplete representation of the complexity of the issues. D'Acci (2012) presents Urban Quality of Life as a hierarchical multi-attribute concept characterized by several underlying attributes that, in turn, are defined by more specific underlying attributes. These attributes can be categorized in several ways:

- Monetary -property-value, willingness-to-pay, cost-benefit, positional
- Quantitative- numbers / types of urban attractions, distribution
- Subjective -life satisfaction, wellbeing, ranking/rating evaluation

The monetization of QOL is a function of free market exchange, and is "implemented" at the point of commercial transactions or the valuation of such transactions. The quantification approach is often used in project assessment tools, such as the BREEAM (and LEED) criteria that scores the interconnectivity of a property based on the number of commercial establishments within a certain distance. This quantification approach is also used by the Housing Quality Indicator, which sets minimum values for unit size and layout. This monetary or numerical approach can be helpful in determining minimum standards or to make initial assessments, but are not a complete measurement of subjective well-being, such as happiness and life satisfaction. For example, the relationship between per capita income and life satisfaction is influenced by the amount of goods and services needed to sustain life. A person living in a society that provides job security, health care and a means of producing food may find happiness with a lower income.

The World Health Organization defines Quality of Life as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns" (WHO, 1995). However Surit (2008) pointed out that appropriate tools for measuring QoL of the urban poor are rare and undertook research to develop such a tool for the urban areas of Thailand. The result of questionnaires to 523 subjects in five different communities identified the following indicators of QoL with the factor loading:

- Safety - accessibility to police .80, fire station .78, and hospital .76,
- Security (with job .74, family and community.79),
- Personal satisfaction (job .73, "warming" family .76),
- Satisfaction with the environment (quality of air .80, solid waste management .73, water quality .61).

- Civil and human rights (freedom of speech .71, religion .82, good relationships with community members .67, willingness to participate in community activities .63).

Interestingly, the security with housing condition was rated relatively high (.68), whereas the comfort of the housing condition was one of the least important items (.45). This raises the point that QoL may be a mix of objective and subjective factors.

3.2.5 Environmental Resilience Indicators

The concept of planetary boundaries was developed by the Stockholm Resilience Centre (Rockstrom, 2009). Concerned that the anthropogenic pressures on the Earth System have reached a scale where abrupt global environmental change can no longer be excluded, they proposed a new approach to global sustainability. They have identified planetary boundaries within which we expect that humanity can operate safely. Transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems. The researchers at the Stockholm Resilience Centre have identified nine planetary boundaries and, drawing upon current scientific understanding, proposes quantifications for seven of them.

3.3 Gaps - Process and Tools

3.3.1 Process Gap - Needs Analysis

The review of the tool identifies a recognized need to frame environmental issues within a wider political and social debate. While the environmental assessment tools provide an objective evaluation of ecological impact, they need to be balanced with a much broader perspective that considers quality of life and design quality.

A process gap is identified on several level (Figure 6):

- Articulation and definition of value vs. quality control
- Interface between academic knowledge and practical industry.
- Value dialogue at the project inception, PRIOR to design detailing

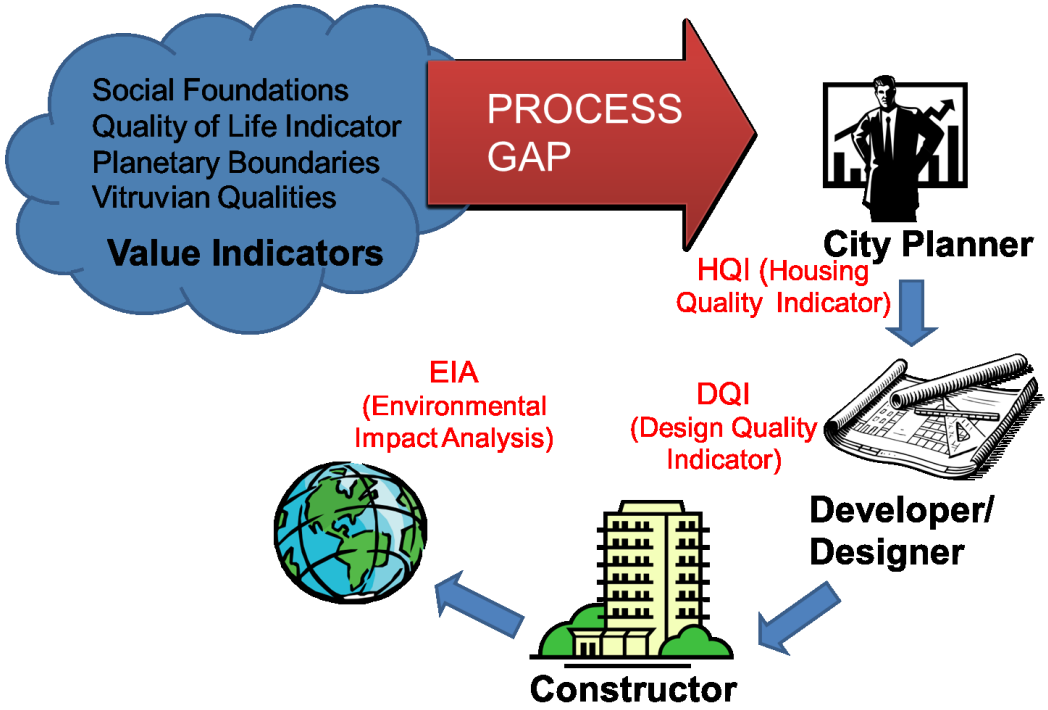


Figure 6: Process Gap

Furthermore, the lessons learned from the existing tools are:

1. Clearly distinguish between subjective and objective. The review and proposals for improvement of DQI suggest measurement that aligns design tasks (objective) to project quality (subjective).

2. Stabilize the data in EIA Matrix. Stabilize as much scoring as possible through aggregation, and identify the cross-points that need to be locally derived.

3. Integrate sustainability, social needs, economic. Also include manageability and technology levels that can impact the implementation and the long term maintenance.

4. Integrate or identify interoperability with existing tools - As the example of HQI demonstrates, there is an opportunity to leverage the strengths of existing tools through the addition, or integration, of a specific function.

Thompson (1990) proposes that a means of delivering value could be established if a process model also reflected the contributions that individual design tasks make in forming a product's qualities. This could take two forms: design tasks themselves (or the flow of information between them) could be described in terms of their response to project values, or measurements of product/process qualities could identify the response to project values.

Based on these lessons, the decision was made to correlate the individual sustainability activities to project value indicators. In order to capture an integrated system approach, the indicators categories would include social foundations, planetary boundaries, as well as design qualities and implementation factors.

3.3.2 Methodology - Lessons Learned

The demise of checklist index-type methods was predicted in the past (Bisset, 1994) in favour of the more complex systems such as multi-attribute utility theory, systems diagramming and simulation modelling. However, it is clear from the review of currently used tools that the index methodology is still very much in use. It is interesting for our research to identify the reasons both for the predictions and for the survival of this format.

Early criticism of the EIA tends to fall into five categories (Kennedy, 1984). They were deemed to have little effect on the decision-making process, few tangible environmental benefits, and inadequate opportunity for public input as well at the increased cost from the difficulty of implementation and the project delay. However, evidence over years of use have shown that EIA have significantly impacted the decision making process, and increased awareness of environmental issues have resulted in protective measures (Wathern, 2000). Costs vary by project, but the additional early planning often saves time and money in implementation. However, a lesson learned is the need for a tool to be easy to implement, and have the flexibility to include public input.

Index methods continue to be in use because the tool amalgamates information into total indices, presenting decision makers with an easy selection of best alternatives. The transparency of the information also facilitates further exploration of the data and logic behind the alternatives. This is helpful if the decision makers want to verify the premises on which the decision was built. However, this simplicity comes at the risk of inaccuracy, based on data with subjective scaling and weighting.

Thompson (1990) identifies a potential for separating the impact magnitude from the impact significance, and retaining the decision of magnitude to those appointed or elected for that purpose. Furthermore, Thompson recommends that quantitative data should not be given undue emphasis over qualitative, since the conversion of raw data by scaling, ranking or rating results in a loss of information that may be of use to the decision-maker. Finally, the lessons learned from the design quality indicators is that subjective and objective data can produce the most meaningful results when they are handled in separate categories.

3.4 New Tool Development- SInRG

3.4.1 SInRG Tool Description

The Sustainability Innovation and Resilience Generator (SInRG) tool provides several functions:

- Facilitate dialogue about project value
- Correlate project values with sustainability activities
- Guide selection of activities based on value weighting
- Generate innovative thinking for sustainability activities and systems
- Strengthen resilience through systems implementation
- Reduce implementation costs by harvesting synergies of systems

The data in the SInRG tool is organized in a spread sheet using the readily available Microsoft Excel, which was selected as universally available software and therefore provided the possibility for user groups to adapt the tool to their own locations and needs. Subjective data is represented by the indicators in the x axis, and the use of tool requires the decision maker to choose the impact magnitude (Figure 7). Objective data is represented by the activity items in the y axis, and is expressed qualitatively. In the cross-cells, the scoring of the correlation is done by the tool developers and it is a quantification of the degree of correlation.

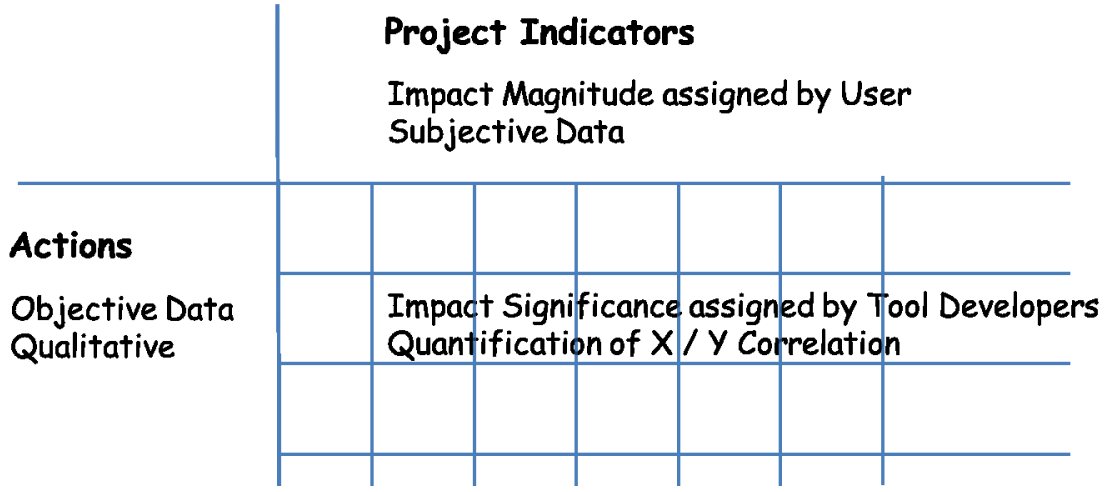


Figure 7: Tool Framework

This methodology also drew from the EIA improvements suggested by Sondheim (1978) and Yapijakis (1983), as was explained in Section 3.3. With regard to the criticisms of EIA, this has been designed to be easily implemented and serve as a facilitator for open public dialogue.

3.4.2 SInRG Tool Development Process

The SInRG tool was developed in several steps that are detailed in the following pages. In brief, the steps of this process are the follows:

Step 1: Development of activities and indicators (Section 3.2.3 and 3.2.4)

Step 2: Decision of the scaling-weighting method (Section 3.3.1)

Step 3: Decision of the best scoring method for this tool. (Section 3.3.2)

Step 4: Statistical analysis of the indicators involved in the tool.

Step 5: Statistical analysis of the activities involved in the tool.

3.4.3 Value Indicators

The indicators are organized into four areas: Implementation, Vitruvian Ideals, Social Foundations Resilience and Planetary Boundary Resilience Indicators. (explained in detail in Appendix B). The resilience indicators were defined and selected based on research in the area of sustainability resilience and quality of life indicators. The Vitruvian Ideals were selected to provide a measure of the merit of the activity or product itself (durable, useful, beautiful). The fourth area of indicators concerns the legal and economic considerations of implementation, which can be customized by the user to reflect the local conditions.

3.4.4 Sustainability Improvement Activities

The Sustainability Improvement Activities were organized by systems: Exterior Environment, Built Environment, Socio-Economic Needs, Energy/Waste and Coastal/ Climate Issues. These general categories represent a typical segregation of decision making that occurs in such projects. While there are certainly some overlaps of these system boundaries, they are typically not integrated in project implementation. For example, a tower building refurbishment that includes the building façade and the thermal fabric might also include a retrofit to heating and cooling equipment. However, it is less likely to also consider landscaping for heat management, shading, or water management. The social and economic well-being of the residents can also be impacted by both internal and external environment changes. These systems areas are often represented by different decision making entities, or are financed through different funding mechanisms.

An overview of the SInRG tool format is shown in Figure 8. Each of the sustainability activities is described in Appendix B. This list of activities is not meant to be complete nor exclusive; however the framework may serve as a way of organizing data from new ideas for sustainability improvements.

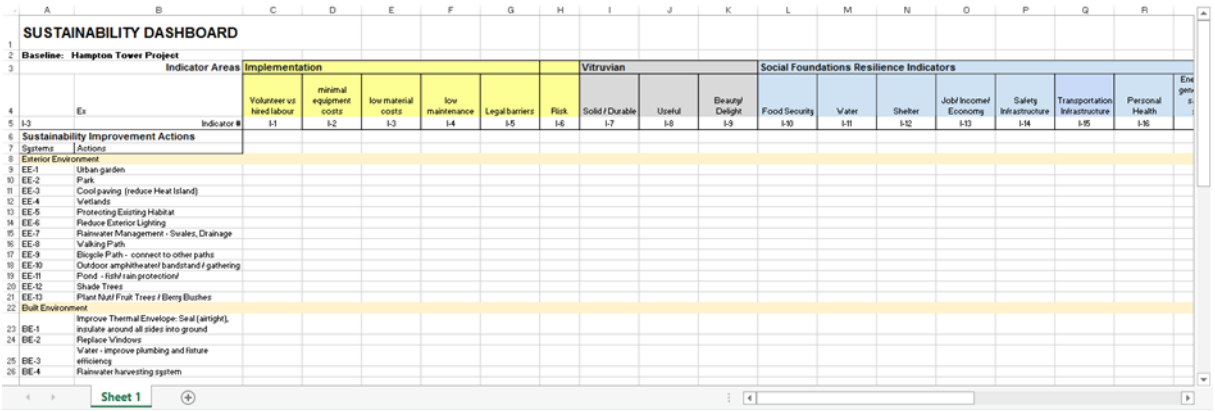


Figure 8: View of the matrix used for scoring the magnitude of importance

3.5 SInRG Testing and Refinement

3.5.1 Scaling - Weighting Method

One of the problems in develop this kind of tools is the scaling-weighting approach. There are a lot of mathematic methods, but each one is used for a different kind of tools. The choice of the method can be determined by the Table 1.

Table 1**:** The treatment of significance among EIA methodologies (Thompson, 1990)

Treatment of significance	Significance?	Extent of guidelines	Use of aggregation	Use of public opinion input	
	Significance handled distinct from magnitude	Explicit guidelines	Yes	No	Dee et al (1973); Soloman et al (1977), Odum et al (1971) Ross (1976); Krouskopfet et al (1972)
		Some guidance	Yes	No	Stover (1972) Sondheim (1978) Crawford (1973)
				Yes	Hill (1966)
			No	No	Clark *et al* (1983)
		No guidance	No	No	Leopold (1971)
	Significance **not** distinct from magnitude	Some guidance	Yes	No	Soil Cons Service (1977); Fischer and Davis (1973)
			No	No	Multiagency (1972); Environmental Impact Center (1973)
				Yes	Walton and Lewis (1971)
	Significance **not** considered explicitly		Yes	No	McHarg(1969); Loran (1975); Adkins and Burke (1974)
			No	No	Vertinsky et al (1973); Environment Canada (1974); Keeney and Robiliard (1977); Sorensen (1971)

The methodology that is best suited to our purpose is highlighted in blue in Table 1. In the SInRG Tool, the weighting of significance is handled distinct from the weighting of magnitude because the significance (the relationship of indicators to activities) is decided by the research team who is developing the tool, but the magnitude (of the indicators) is decided by the user. The research documents in Table 1 provided some methodological guidance for developing the SInRG Tool.

Sondheim (1978) suggested a method of aggregation to take into account the perspectives of different kind of people. This method was used in the development of EIAs. With this methodology, each member of the development team produces an individual scoring scheme. All these schemes are amalgamated to produce a single scoring scheme representative of the team's view. Since the researchers were the only population that was involved in this activity, the public opinion does not need to be taken into account.

It is argued with this method that the subjectivity involved in these computations is hidden within a spurious objectivity. It is also argued that these methods are needlessly technocratic and complex, and aim to inhibit wider involvement in project decision making. We have addressed this concern by allocating the decision of the weighting of magnitude to the user group.

One important drawback to this method is the manner in which they compartmentalize and fragment the item. The scaling-weighting checklist is simply a list of factors, changes of which are assessed on isolation and it is focused on features that can be quantified. This does not encourage a systems approach. We have addressed this concern by including cluster analysis of the activities, which can identify synergies among action items.

3.5.2 Scoring

The scoring is based on the perception of the significance of that activity to the indicator, relative to the baseline project and to the other activities within that system (e.g. the exterior environment). If the significance is positive, this is scored between 1 and 5 depending on the degree of the significance (5-high, 4-moderately high, 3-medium, 2-some, 1-a little). If there is no significance from the activity in the indicator, the score is 0, and if the activity is harmful for the indicator, the score is -1. The numbers are not representative of any specific quantifiable metric, but are an indication of perceived significance. This could also be represented as a star rating (5 star, 4 star, etc.). Thus, the

numbers provide an ordinal number relationship of relative importance within any indicator category.

The initial scoring for the SInRG Tool was developed by the members of the research team. each member of the research group filled out it based on their best judgement. Each member of the team is from a different nationality so they were asked to consider the matrix from the perspective of a coastal community from their country: Egypt, Japan, Korea, Spain and US. Although the number of participants is not high, the variability of their backgrounds is fairly large, and provided a good basis for the initial scoring.

3.5.3 Indicators Statistics

With the scoring information derived from the five group members, a statistical analysis was developed. The five main statistics were studied: maximum, minimum, mean, median and standard deviation. This analysis is detailed in the charts of Appendix C.

The standard deviation numbers were used to identify the indicators which needed to be better defined, because the high deviation of the data reflected a disparity in understanding among the team members probably due to a misunderstanding of these indicators.

The highest standard deviations were in the columns of seven indicators:

- Shelter
- Safety infrastructure
- Energy saving
- Political voice
- Social equity
- Gender equality
- CO_2 emissions

So these seven indicators were redefined to make the SInRG Tool more robust, as explained in the following paragraphs.

The revised definitions are reflected in the Appendix B.

Shelter: It is defined as “a place giving temporary protection from bad weather or danger”. To qualify this indicator, the question to ask is “does it directly improve the physical shelter of a person?” The qualification of this indicator is shown in Table 2.

Table 2**:** Shelter Indicator - Scoring

Score	Description
5	Ultimate improvement of the shelter
4	Very good improvement of the shelter
3	Good improvement of the shelter
2	Normal improvement of the shelter
1	Poor improvement of the shelter
0	Not relevant
-1	Destruction of shelter

Safety infrastructures are "all the infrastructure which help in the safety and wellbeing of community, for example roads, flood control, waste and hazardous material disposal". To qualify this indicator the question is "does the activity directly improve the safety infrastructure?" The possible answers are as shown in Table 3.

Table 3: Safety Infrastructure - Scoring

Score	Description
5	Ultimate improvement of the safety infrastructure
4	Very good improvement of the safety infrastructure
3	Good improvement of the safety infrastructure
2	Normal improvement of the safety infrastructure
1	Poor improvement of the safety infrastructure
0	Not relevant
-1	Destruction of safety infrastructure

Energy savings are "all the activities which helps in savings of energy consumption, for example using low energy light system". The question to understand this index is "will this activity help in any direct way?" and the possible answers to qualify this indicator are as shown in Table 4.

Table 4**:** Scoring of energy saving indicator

Score	Description
5	It produces energy, not only saving
4	It saves a high quantity of energy
3	It saves a good quantity of energy
2	It saves a normal quantity of energy
1	The contribution to this saving is poor
0	Not relevant
-1	It uses more energy than the energy that it generates

Political voice: "refers to the sum total of political inputs that citizens in a democracy use to control who will hold political office and to influence what public officials do". To qualify this activity, it is necessary to answer at the following question "will this activity help directly or indirectly affect one's political voice or political point of view?" with the following scoring in Table 5.

Table 5**:** Scoring of political voice indicator

Score	Description
5	Add more to the political awareness
4	This activity is very good for political awareness
3	This activity is good for political awareness
2	This activity is normal for political awareness
1	This activity is poor for political awareness
0	Not relevant
-1	Negative effect for the political awareness

The social equity is defined as "providing equal opportunity in safe and healthy environment to people of different social classes". This activity is difficult to score with the same rate than the others, because something can influence positively or negatively to the social equity, but a partial rating from 1 to 5 is not easy. So the scoring for this activity was simplified, as in the following Table 6.

Table 6: Scoring of social equity indicator

Score	Description
5	The activity adds positive value to social equity
0	Not relevant
-1	The activity adds negative value to social equity

Gender equality is "the measurable equal representation of women and men. Gender equality does not imply that women and men are the same, but that they have equal value and should be accorded equal treatment". To qualify this activity the problem of partial ratings is the same as with social equity, and it is reflected in the scoring per Table 7.

Table 7: Scoring of gender equality indicator

Score	Description
5	The activity adds positive value to gender equality
0	Not relevant
-1	The activity adds negative value to gender equality

CO2 Emissions: The scoring of the CO_2 emissions is easier if the rates are defined as percentages and not only quantitatively, so the new scoring is as shown in Table 8.

Table 8: Scoring of CO_2 emissions indicator

Score	Description
5	Positive improve of the CO_2 emissions,100%
4	Very good reduce of the CO_2 emissions, 80%
3	Good- reduce of the CO_2 emissions, 60 %
2	Normal - reduce of the CO_2 emissions, 40%
1	Poor - reduce of the CO_2 emissions, 20%
0	No reduction of the CO_2 emissions, 0%
-1	Increase of the CO_2 emissions

With this increased precision of the new description of the selected indicators, it should help the tool scoring to be more robust (with lower standard deviations).

3.5.4 Activities Statistics

After this, the scoring of the activities was studied for consistency. First, the standard deviation of all the activities was studied. The result was that all the activities have similar average of standard deviations, so there is no problem with the definition of the activities.

In addition to standard deviation analysis to look for consistency of the data, we also did two other statistical analyses of the activities, first a correlation analysis and then a cluster analysis. The correlation matrix has been calculated among the activities and a Pearson's test has been done to those correlations, determining the significant correlation between parameters with a significant level of 95%. With this correlation matrix it is possible to see the high relationships existing between different activities because they contribute positively or negatively to the same parameters. An overview of this correlations matrix is shown in Figure 9, and it is detailed on Appendix D.

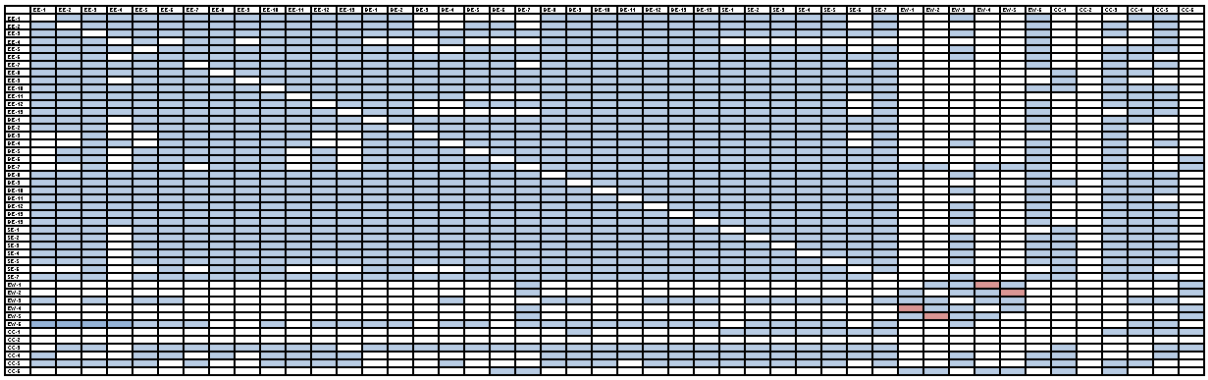


Figure 9**:** View of correlation matrix

As shown in the overview, both axes represent all the activities. The blue boxes are those that have a significant correlation, the white boxes are those without significant correlation and the red boxes are those with correlation of 1, so they have a total correlation. It is shown that between the three first groups of activities, exterior environment, built environment and socio-economic needs the significant correlations are more numerous than with the other two groups, energy/waste and coastal/climate issues.

The total correlations are between activities of the group of energy/waste:

- waste management-reuse / waste to energy plant
- waste management-minimization / biomass

A stars graph analysis provides a visual method to see similarities between the relationships of the indicators (Figure 10). Each tip of the star is one of the indicators (Figure 11); the more similar the stars, the more similar the value of the indicators.

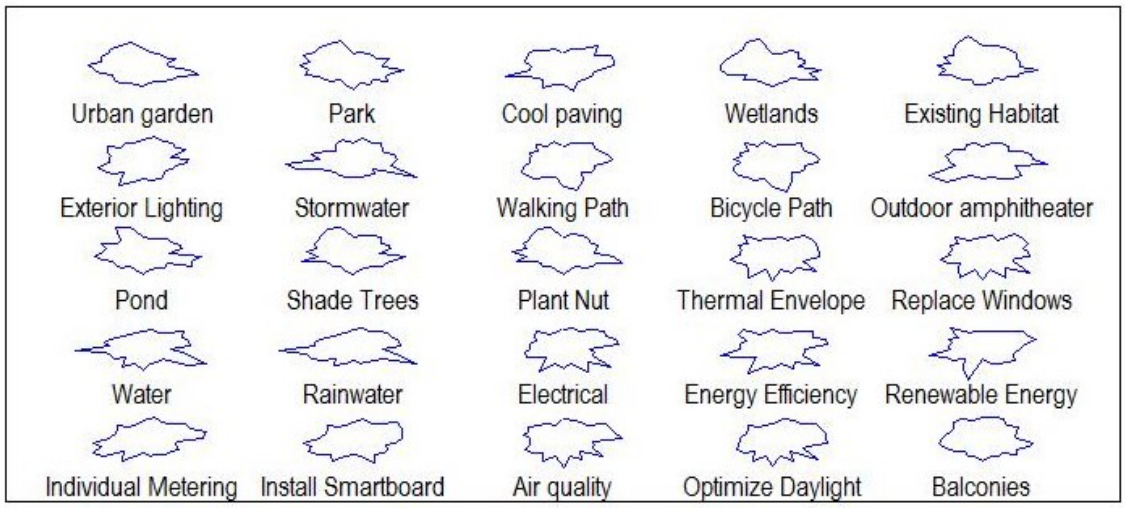


Figure 10**:** Stars graph analysis

For example, with this picture is possible to see the similarity between the walking path and the bicycle path, or between the water and the rainwater harvesting system.

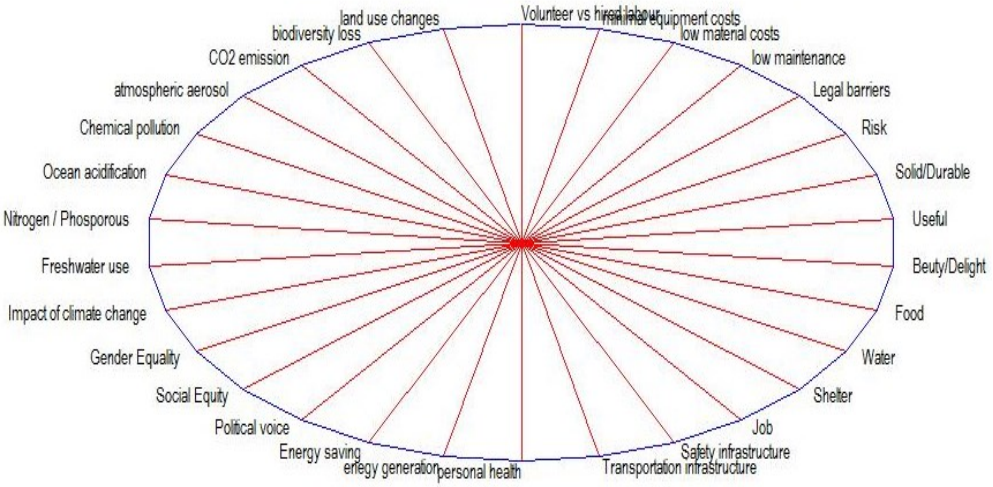


Figure 11: Glyph for stars analysis

To try to better define these groups and also to try to determine if the tool is working, a cluster analysis was then completed. The result of this cluster is show in Figure 12. With this cluster, it is observed that the SInRG Tool is well defined because the activities that are similar and grouped together in the tool are also grouped together in this analysis. In the graph, six groups are observed, while seven activities fall outside of any group.

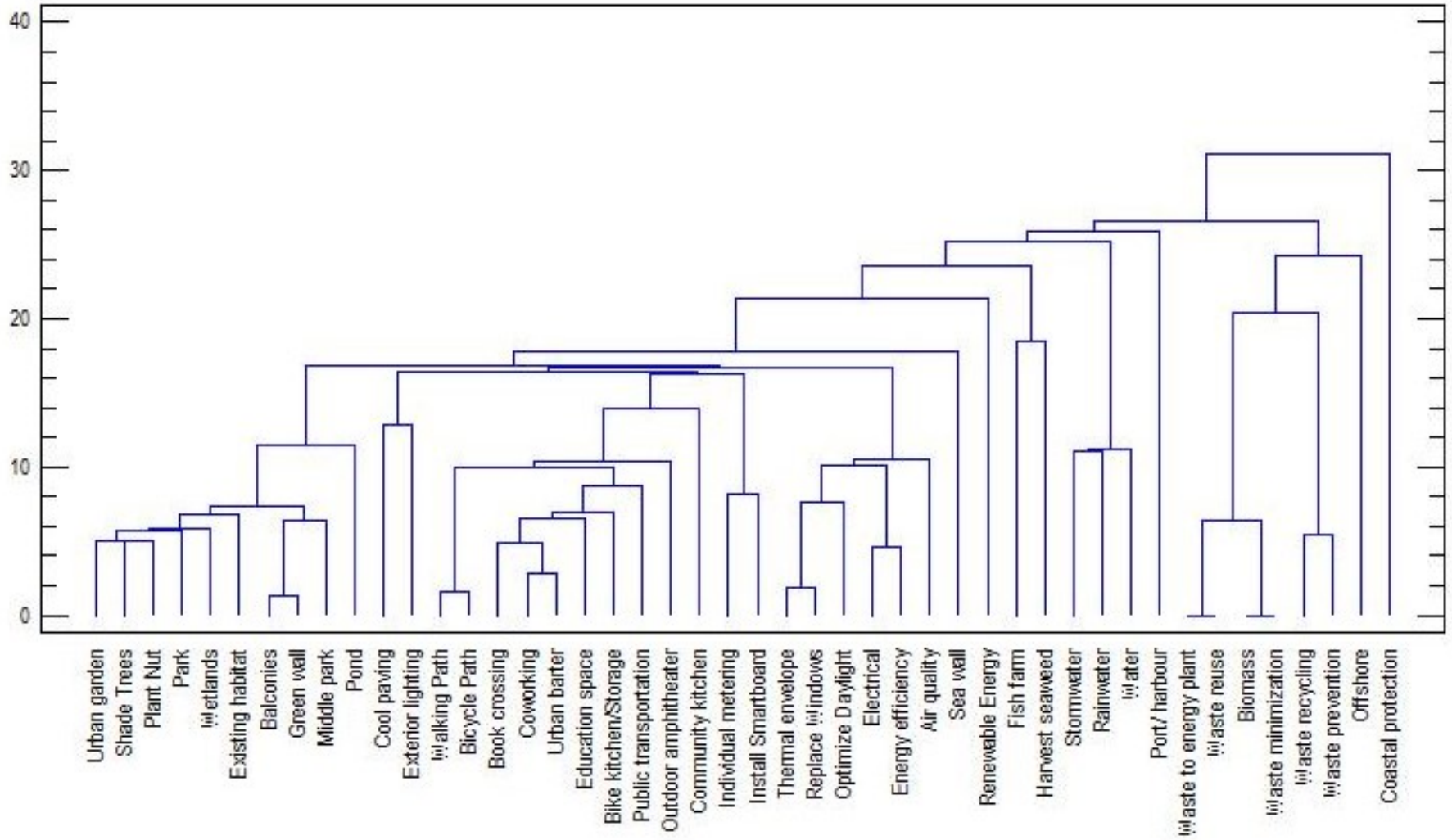


Figure 12: The results of cluster analysis

Group 1 is formed by the activities derived of the "green infrastructures" (Table 9). All these activities are grouped together because they are positive for the planetary boundaries resilience indicators, as impact of climate change or CO_2 emissions. Some of these activities also provide food security and may provide social and gender equality.

Table 9**:** Group 1 of cluster analysis

Number	Activities
1	Urban garden
2	Shade trees
3	Fruit trees / Berry bushes
4	Park
5	Wetlands
6	Protecting Existing Habitat
7	Green wall
8	Balconies
9	Interior Green space
10	Pond
11	Cool paving
12	Reduce exterior lighting

Group 2 combines the "social issues" of the activities and the "transportation issues" (Table 10).

Table 10: Group 2 of cluster analysis

Number	Activities
1	Walking path
2	Bicycle path
3	Outdoor amphitheatre
4	Book crossing
5	Co-working
6	Urban barter
7	Education space
8	Bike kitchen
9	Community kitchen
10	Public transportation

Group 3 are the activities that mainly involve an energy saving (Table 11)

Table 11**:** Group 3 of cluster analysis

Number	Activities
1	Improve thermal envelope
2	Replace windows
3	Electrical – upgrade wiring, low energy fixtures
4	Improve efficiency of heating / cooling
5	Optimize daylight
6	Air quality
7	Individual metering and payment
8	Install Energy Dashboard

Group 4 involve the activities related to rainwater (Table 12).

Table 12: Group 4 of cluster analysis

Number	Activities
1	Storm water management
2	Water – improve plumbing and fixture efficiency
3	Rainwater harvesting system

Group 5 involves two of the four studied activities of waste management (Table 13). Those two activities are more similar than with the other two because they have similar values for the most of the parameters of planetary boundaries resilience.

Table 13: Group 5 of cluster analysis

Number	Activities
1	Waste management – recycling
2	Waste management – prevention

Group 6 is the other four parameters of the waste energy group (Table 14). Those activities are positive for energy saving and energy generation.

Table 14: Group 6 of cluster analysis

Number	Activities
1	Waste to energy plant
2	Biomass
3	Waste management – reuse
4	Waste management – minimization

Only seven of all the activities studied are not included in any group. Five of them are those related to the sea (Table 15).

Table 15: Activities not included in groups in cluster analysis

Number	Activities
1	Solar PV or thermal
2	Harvesting seaweed system
3	Fish farm
4	Sea wall
5	Port
6	Offshore
7	Coastal protection

In these groups, we can see that some kind of activities may be developed in place of others, if the activity chosen by the tool is impossible to develop for the project. The cluster information can also be used to consider the implementation of additional activities in the group. This supports a systems approach, and may leverage the overlap between activities to capture synergies and cost savings.

This clustering may also be used to spark new innovations. This was the case for our research, where we were thinking about possible links between the outlier activities listed in Table 15. This generated an innovative idea, which is described in Section 4.3.

3.6 User Application

The SInRG Tool is designed as an activity selection guidance tool for urban refurbishment or redevelopment projects. It is envisioned that the decision makers will be city planning members, along with developers, architects and other public entities who have an interest

in the project. This team will choose the impact magnitude (weighting) of the indicators that are best suited for their project. While this is easily said, it is important to note that a dialogue about project values is not typical. Project discussions are more often oriented around the objective items, such as building size, materials and even energy efficiency standards. Even in the BREEAM for Community program, the first step is a resource assessment that is followed by the selection of the sustainability activities. The needs of the people and community, expressed in subjective terms, are not included in the design dialogue.

The indicators listed in the SInRG Tool represent a vocabulary of subjective project values that could be used to shape and stimulate this discussion of project values. Once the planning team has agreed on the project values, they would allocating impact weighting to each of the related indicators. The weighting is then formulaically compared to the scoring index, and the calculations generate a selection of activities which are most applicable to the identified indicators and their importance ratings.

For example, a community planner wishes to improve certain values in a redevelopment project, as expressed by the indicators food security and social equality, but also prefers to engage community volunteers for implementation. The appropriate indicators would be selected, the magnitude (or weighting) assigned, and the calculations would generate a list of recommended activity items.

A point of differentiation from existing programs is the intent of the SInRG Tool is to serve as a decision guidance tool, rather than a benchmarking tool. The decision making team will consider the recommended activities and the activity cluster; then look for anomalies, synergies or alignment with other resources before making their final decision. The benefit of the use of the SInRG Tool is that this final decision making can be guided by the recommendations and that all of the decision makers gained a deeper understanding of project through the discussion of the project values.

The data in the SInRG Tool is compiled in an Excel format, so that it is easily accessible and can be customized by user groups:

- Activity items can be edited and new activity items added.
- Implementation scoring can be tailored to individual locations
- Additional indicator columns can be added.

3.6.1 Decision Analysis Methods

In order to implement the SInRG Tool, the decision makers will need to prioritize the project values and assign weighting to the indicators. This process is often challenging due to the numbers of stakeholders and the alignment of their perspectives (Goodwin and Wright, 2004). Also, the inclusion of the public in the decision-making increases the need to leave a transparent audit trail, for accessibility of information to all concerned parties and also to be able to review the decision premises.

Dialogue can generate a raised consciousness about sustainability and social issues, and the indicators can help to articulate the project values. Defining the problem and forming a decision by consensus can create a shared vision and gain commitment on the course of activity (Drucker, 1971). While it involves more time upfront, there is no need to spend time on selling the decision. Also, the dialogue can lead to synergies and insights. The decision analysis can be the "framework for thinking that enables different perspectives on a problem to be brought together with the result that new intuitions and higher-level perspectives are generated" (Phillips, 1989).

When the decision analysis involves several individuals, there are essentially two approaches; mathematical and behavioural, or a combination of the two. Mathematical aggregation involves techniques such as the calculation of a simple average of the individual judgements. The problems with this approach are the loss of detail resulting from the quantification of rich data, and the assigning of input weighting. Behavioural aggregation avoids the numerical reductions, seeking rather to reach a group consensus through dialogue (Goodwin, 2004). Of course, the greatest risk with this approach is the inability to reach consensus.

Structured group processes have been developed to blend the benefits of both approaches, while addressing the problematic aspects. Common to several of these processes is the emphasis on the overall objectives of the project. These can be evaluated by attributes, which are a measure of performance in relation to an objective. Applying this to the SInRG Tool, decision makers will derive a numerical score to measure the attractiveness of each objective (indicator) based on the attributes (context specific to project).

One of the decision analysis methods involving multiple objectives is called SMART (Simple Multi Attribute Rating Technique). The approach is to disassemble the problem into parts, supporting a better understanding of each part, but losing the holistic perspective. Nonetheless, the simplicity of both the responses of the decision maker and the transparency of the analysis has led to wide-spread acceptance of this method,

especially in ad-hoc groups needing with a short time-frame for decision making. Attributes are assembled in a value tree, and measures the performance of the project alternatives on that attribute. The attributes are then assigned a weight, and the weighted average of all the values become the basis for a provisional decision. Thought the procedure is straightforward, the valuation of the attributes and their weighting is still very difficult, and has generated several variations of SMART.

Another method that is based on attributes is the Choosing by Advantages Decision Making System (Suhr, 1999). Distinguishing features of this approach are that the attributes are not compared directly, rather across advantages relative to a criterion. The criteria are established by the decision-maker, based on the project parameters. The priority of a criterion can be written as a want (desirable) or a must (mandatory), which becomes a decision threshold. The relative importance of the advantages to each other is weighed first, and this drives the rest of the weighting. The process is accomplished on a simple matrix structure, on a piece of paper, which encourages group dialogue and is easy to follow.

Multivariate analysis methods are generally more complex and lack transparency, and therefore may not be suitable to this application because participants may be suspicious of the results. Also, these methods do not facilitate dialogue, which is a key part of the application of the SInRG Tool.

4 Case Study

- *Precast concrete tower project: Study findings **transferable** to similar **social housing 'towers'** that are common in UK and Europe.*
- *Weston Shores has a history of **fishing** and **seaweed harvesting**.*
- *Projects values to address needs of high numbers of **young unemployed population.***
- *Activity selection based on **cluster groups** strengthens **systems support** for indicators.*
- *The SInRG Tool supports **synergy and innovative solutions**.*

4.1 Social Housing 'Towers'

The selection of a concrete housing 'Tower' was intentional, for reasons of relevance and transferability. Precast concrete buildings were a phenomenon of post-war Europe from the 1950s through 1970s, built in response to the housing crisis from the large migration of people to the cities. They were designed as a rectangular block of 5 to 9 storeys, aimed to achieve the cost advantages of standardized projects.

In the UK, the British tower block was celebrated as new modernism in the style of Le Corbusier and Gropius. The 1956 Housing Subsidy Act offered higher public subsidies the higher the building, and 4,500 tower blocks were built by 1979. They were often clustered into public housing estates with 500- 600 dwelling units total (Howes, 2002). While these buildings were inexpensive to build, durability and quality was lacking. Already during the 1970's and 1980's problems arose with concrete spalling and cracking where water had penetrated into the panel junctions. Also, the panels suffered from serious condensation problems due to the lack of water barriers and minimal insulation. Window frames rotted and services, such as elevators, were often malfunctioning. This deteriorated housing environment led to social problems and increased crime. Some of the worst affected blocks were demolished, and others were sold to tenant associations. However, the government still retains the responsibility for the repair and refurbishment of many.

This is not unique to the UK. Similar government housing was built throughout the old Soviet Union countries. For example, it is estimated that one third of the people in the Czech Republic still live in these flats. Similarly, the government in the US experimented

in the 1960's and 70s to use high-rise apartments as a means for providing affordable housing. These "housing projects" soon became known as ghettos of crime and poverty. These are mostly being torn down and replaced.

The challenges of refurbishing tower blocks are many, but social housing is at such a premium in the UK and other urban areas that tearing them down is not always the best option. While the primary concern is that of safety and functionality, there is merit in exploring the possibilities of implementing more comprehensive refurbishment that could also create more sustainability communities.

4.2 Weston Towers - Case Study Information

4.2.1 Weston Shore – Fishing Community

Weston shore is one of the few remaining open shoreline and beaches in Southampton City and is a special and unique place for its rich history. Weston is located along the southern coast of England, on shore of the sea waterway leading to the port of Southampton. Weston was originally a small fishing community, dating back to the end of the 10th century. A Seaweed Hut that used to stand on Weston Shore appears on 17th century maps. It was used to store the fishermen's equipment. According the Southampton City Council website, "the Seaweed Hut consisted of a wooden framed building clad in seaweed that served Weston Hard. The building was demolished in 1967 but remains of it have been found during recent archaeological excavations. The building's origins probably date back to at least the 18th century and it served local fishermen up until at least the early-20th century."

4.2.2 Urbanization

Weston became part of Southampton in 1920, when it started to become more urbanized. The bulk of Weston was built to satisfy the post-war demand for new housing in Southampton. The Weston shore area is the southern border of the five Council tower blocks. The area was occupied by a landfill and the factory "Rolling Mills" which was demolished after World War II. This process of increasing urbanization continued throughout the 20th century, culminating in the sub-urban landscape of the present, dominated by a number of late-20th century tower blocks.

Weston is now home to a high proportion of young people (26.2% under 18 compared to 20.5% in the city). The vast majority of people (over 95%) are white British, and over a third of all households in Weston live in accommodation rented from the Council (2001

Census). The neighbourhood has a number of retail facilities, but no significant local employment. Historically, men from the Weston Towers worked in the now closed Vospers shipyard. Unemployment is a problem, especially amongst the youth. In particular local people feel intimidated by young people hanging around in gangs (Weston Youth Survey, 2003). Community priorities for Weston include:

- Reduce criminal damage and graffiti
- Reduce alcohol-related juvenile nuisance and anti-social behaviour.
- Reduce anti-social behaviour from off-road, mini motorbikes and motorbikes

4.2.3 Location

The Weston Towers is a very distinctive landmark when approaching the port of Southampton by sea (Figure 13), as they are located along the shoreline on a hill near the east shore (Figure 14). The five blocks of flats along International Way are the Hampton Tower, Le Havre Tower, Copenhagen Tower, Oslo Tower and Rotterdam Tower. Each one of the towers is a 13 storey tower block of 40.20 meters of height with 104 flats, 52 of which are one bedroom and 52 of which are 2 bedrooms. The community of Weston anchors the southern edge of the City of Southampton, and is accessible by city busses.

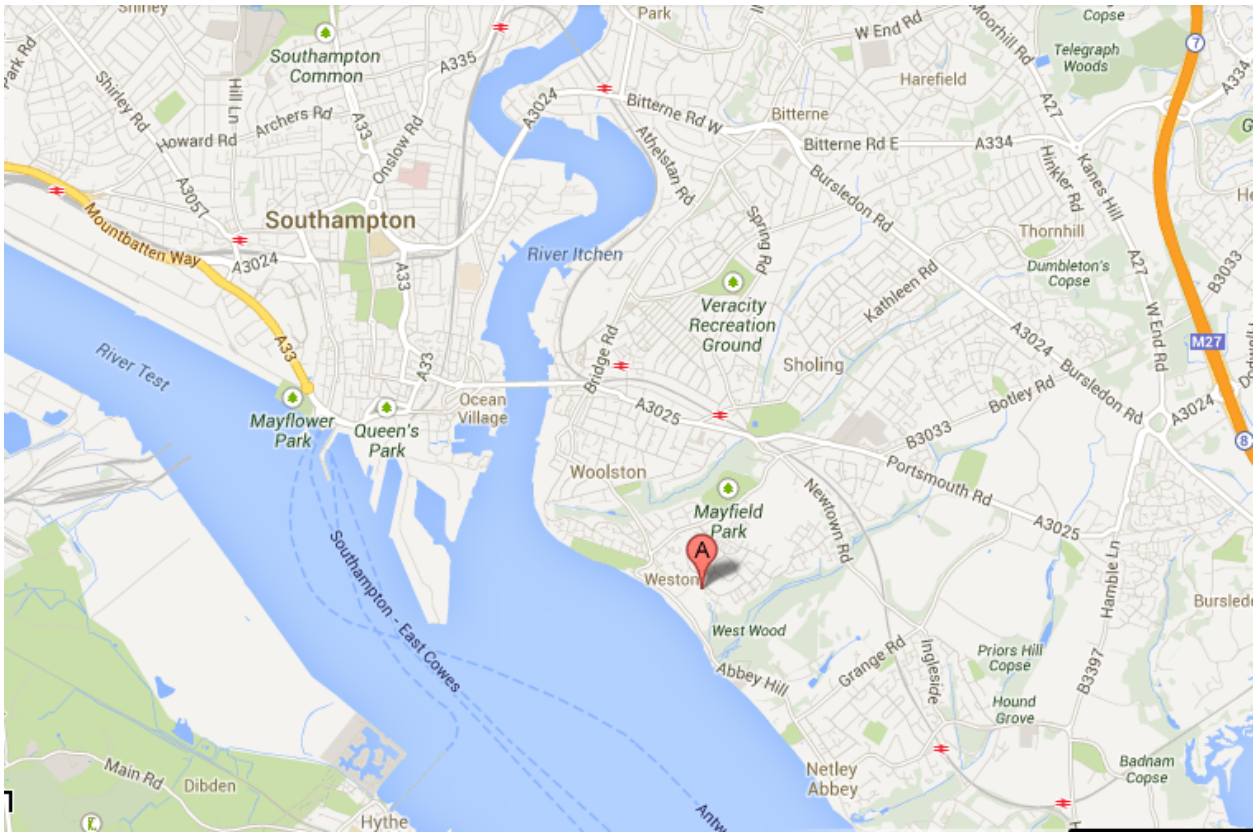


Figure 13: Location of Weston on the Southampton Waterway *Google Earth©*

Figure 14: Location of the Weston Towers near the shore *Google Earth*©

The inter-tidal mudflats along the Shore are of international importance for the waterfowl and it is designated a site of Special Scientific Interest (SSSI). Managed by the Natural England Agency, these sites were created to "preserve our remaining natural heritage for future generations. Wildlife and geological features are under pressure from development, pollution, climate change and unsustainable land management. SSSIs are important as they support plants and animals that find it more difficult to survive in the wider countryside. Protecting and managing SSSIs is a shared responsibility, and an investment for the benefit of future generations." Weston Shores are also Southampton's only significant publicly accessible water frontage.

4.2.4 Recent Improvement Projects

The Weston Shore and Towers have been fortunate to have several very significant improvement projects. Over £1million of government grant was invested in improvements to Weston Shore, and a Heritage Lottery Fund bid was successful in raising over £400,000 to implement the Weston Shorescapes Heritage Project developed by environmental public artist, Abigail Downer (**Error! Reference source not found.**). Carried out between 2005 and 2008, the projects included upgrading and renovating the four shelters from the 1930's, reclaiming and drainage of the natural salt marsh area, re-vegetation of the landfill area with wildflowers meadows, establishing the "Pirates" playground, as well as the walking and cycling paths.

In 2011, the Weston Towers also received a major upgrade for energy efficiency. Southampton City Council obtained over £6 million from the community energy saving program that was used for photovoltaic panels, double glazed windows, new wall insulation and replaced external wall panels. The old heating system was also replaced with a centralized gas powered boiler.

4.3 Selection of Criteria for Case Study

As discussed in 3.4 User Application, the selection of the criteria is intended to be generated through a dialogue and collaborative effort of the key stakeholders in the project. Had this been an actual application of the SInRG Tool for the Towers, the primary decision makers would have been the Weston Regeneration Board, which is a partnership of 10 community representatives, 6 service provider representatives, 2 City Council representatives and support provided by Council Policy coordinators. Service providers membership draws from Southampton City Primary Care Trust, the Police, Jobcentre Plus and Sure Start Weston. This discussion of the vision and values of the project would have also included Council officers from Housing Services, Open Spaces, Environmental Health, Youth Services, and from Chamberlayne Park School (the local secondary school).

In the intended application, this team of decision makers would use the indicators of the SInRG Tool to generate a dialogue about project values and objectives with the aim to identify the most suitable indicators and appropriate magnitude. Since this case study was effectively a prototype trial of the SInRG Tool, the selection of indicators and the magnitudes were provided by our contacts in the planning division of Southampton City. These were the sustainability development officer and the carbon reduction officer. Their selection of indicators and allocation of magnitudes of these indicators are shown in the Tables16-18.

Table 16: Case Study Magnitude: Implementation and Vitruvian

Implementation						Vitruvian		
Volunteer vs hired labour	Minimal equipment costs	Low material costs	Low maintenance	Legal barriers	Risk	Solid / Durable	Useful	Beauty/ Delight
3.00	1.50	2.00	4.00	2.00	3.50	5.00	3.00	2.00

Table 17: Case Study Magnitude: Social Foundations Resilience Indicators

Social Foundations Resilience Indicators											
Food Security	Water	Shelter	Job/ Income/ Economy	Safety Infrastructure	Transportation Infrastructure	Personal Health	Energy/ Fuel generation or safety of supply	Energy Saving	Political Voice/ Self Governance	Social Equity	Gender Equality
3.00	5.00	3.00	5.00	5.00	4.00	5.00	4.50	5.00	4.00	5.00	0.00

Table 18: Case Study Magnitude: Planetary Boundaries Resilience Indicators

Planetary Boundaries Resilience Indicators								
Impact of Climate Change	Freshwater Use	Nitrogen / Phosporous	Ocean Acidification	Chemical Pollution	Atmospheric Aerosol	CO 2 Emission	Biodiversity Loss	Land Use Changes
5.00	5.00	0.00	0.00	0.00	0.00	5.00	5.00	3.00

4.4 Solving for the Criteria

The magnitudes are entered into the calculations, which generate a list of the most suitable activities to develop for this purpose. The qualification of the activities is shown in the Table 19, organized from highest value to lowest values.

Table 19: Magnitude of activities for the case study

Activities	Magnitude	Activities	Magnitude
Energy efficient heating/ cooling	3.58	Pond - fish/ rain protection	3.28
Renewable energy - solar	3.57	Water/ plumbing upgrade	3.27
Electrical - upgrade	3.54	Shade trees	3.26
Improve thermal envelope	3.53	Install individual metering	3.25
Replace windows	3.51	Co-working	3.24
Bicycle path	3.50	Outdoor amphitheatre	3.22
Walking path	3.49	Biomass	3.21
Offshore power generation	3.46	Rainwater management	3.18
Public transportation	3.45	Harvesting seaweed system	3.17
Port/ harbour	3.43	Plant nut/ fruit trees/ berry bushes	3.15
Sea wall	3.40	Protecting existing habitat	3.15
Coastal forest	3.39	Balconies/ stairwells "Green" wall	3.14
Cool paving	3.39	Urban barter	3.14
Education space	3.38	Rainwater harvesting system	3.12
Optimize daylight	3.37	Exterior green wall	3.12
Waste minimization	3.36	Urban garden	3.11
Waste to energy plant	3.35	Wetlands	3.09
Waste management - reuse	3.35	Fish farm	3.09
Bike kitchen/ bike storage	3.35	Interior green space	3.08
Reduce exterior lighting	3.34	Park	3.07
Community kitchen	3.31	book crossing	3.06
Air quality	3.29	Waste management	2.94
Install energy dashboard in each flat	3.29	Waste management - prevention	2.77

The first seven activities items in the ranking have already been implemented in the Weston Towers. As noted above, the towers and the adjacent beach benefitted from recent improvement projects, and the improvement activities selected by the SInRG Tool are fairly typical sustainability activities.

Of greater interest are the additional activity items and the related items in the cluster groups. For example, if walking path, bicycle path and public transportation are in the same cluster group, other activities of the same group contribute to the same indicators. Selecting items from the same cluster group helps build the system support for that indicator and is likely to have synergy of implementation, thus achieving some cost savings. For example, items in the cluster group of green space are all likely to employ landscapers or gardeners, who can more efficiently install all the component pieces as part of one plan, rather than individual activity items at different times.

Of the next five activities, four of them are based on developments of the shoreline or in the sea (offshore power generation, public transportation, port/ harbour, sea wall, coastal protection). As noted in the case study background, this shoreline is a protected SSSI area, as well as the only remaining beach in Southampton, precluding the possibility of development in the sea. The only activity that is possible is the Coastal Forest. Fortunately, this project site has a large expanse of land between the shoreline and the Towers that is suitable for planting trees. One part of the site was a landfill and is therefore not able to be developed with buildings, only vegetation. A coastal urban forest also provides additional opportunities of "fostering biodiversity, in enhancing human health and wellbeing, and in reducing noise and polluting" (Rogers 1999).

Looking at the remaining activities that can be developed in this case study, and discarding the activities that have already been developed, the list of activities the research team proposes to develop are :

- Social spaces – alternate uses of spaces on the ground floor of the buildings:
- Bike Kitchen
- Community kitchen
- Education space
- Urban barter
- Co-working
- Book crossing
- Gathering spaces: Outdoor amphitheatre
- Protection from storms (climate change): Coastal forest

4.5 Recommendations of Additional Activities

The recommended activities for this case study are social activities and the coastal forest. The social activities can directly contribute to the community priorities of crime and fear reduction, because with the activities in the space on the ground floor there are people around day or night providing informal 'eyes on the streets' that may help in the security feelings of the citizens. (Tapping 2008) Also, the Weston Youth Survey (2003) identified the need to increase the availability of facilities and activities for youth, as a pro-active approach to reduce crime caused by youth hanging about in groups with nothing to do. Therefore, many of the social activities have been developed with special attention to young adults.

4.5.1 Bike Kitchen

Bike kitchens are repair shops set up for the purpose of supporting the use of bicycles for transportation and leisure. They are generally organized as a cooperative or a non-profit association, and are supported by volunteer labour and donations. Organizing a bike kitchen is particularly applicable to the Weston Towers on several fronts.

The Weston Towers have an unusually high access to bicycle paths and recreational cycling for a city site. As part of the Weston Shore improvements, the cycle access and new off road cycle routes were created linking Weston Towers to the shoreline and to the cycle path in Westwood. Westwood is a nature reserve covering 150 acres of mixed habitat, where park rangers offers after school activities throughout the year. Additionally, one of the National UK bike routes runs along the Weston Shoreline.

For work commuters, the National UK bike route connects into the city centre. There are also two bus route that services the Weston Estates, First Hampshire #11 and R1. Unfortunately, they are not currently equipped to carry bicycles, which would have increased the flexibility of the bicycle commute.

Therefore, the infrastructure of paths already exists for bicycle commuting and recreations paths. But do the residents have bicycles? Is there safe storage, and do they have the means to repair the cycles?

A bike kitchen could provide an organizational mechanism to get bicycles donated for the younger children, a place for teenagers and adults to learn about bike repair and have the tools to make their own repairs. It could also provide some bicycle education. As bike kitchens are typically run by volunteers, this could provide some occupation for the young people and help them to learn some skills.

The non-profit component of bicycle kitchens is sometimes linked with a for-profit bicycle shops. The closest existing shop is JMJ cycles, http://www.jmjcycles.co.uk/. The proximity to the National Bike Route could also be leveraged for clientele, or to organize group rides and fund raising events. The capital outlay for essential tools, equipment and a supply of parts is estimated at £5,000 - £8,000.

4.5.2 Community Kitchen

In Peru "comedores populares", or community kitchens, arose as a survival strategy among urban residents around major cities during the 1960s and 1970s. Massive migration from rural to urban areas in that time produced large impoverished squatter settlements on the outskirts of large cities. Rural migrants and the urban poor banded together in this kind of "social activities" to help mitigate the problem. Nowadays, a number of developed countries encourage community kitchen with the same objective.

A community kitchen, as its name suggests, is a kitchen where a group of people prepare meals together. It can help improve food security for participants by increasing physical and economic access to adequate amounts of healthy food. Furthermore, it may be possible that if one person (or family) is not able to pay its own food, a shared fund might be initiated.

Participation in a community kitchen also has several other benefits:

- Learn how to prepare healthy, tasty and nutritious meals on a budget
- Develop food knowledge and cooking skills
- Become more skilled in budgeting and shopping
- Learn how to read food labels, and understand nutrition
- Build confidence in cooking and feel more comfortable in the kitchen
- Cook in a social atmosphere and meet new friends
- Teach healthy cooking to people living with alimentary diseases as diabetes.

The scale of the community kitchen depends on the available budget, space and targeted groups. Some guidelines on starting up and operating community kitchens could be adopted from leading organizations in Australia, Canada, and Scotland (see references in Appendix B).

- British Colombia: Kitchen was initiated in 1992, and receive fund from NGOs.
- Aberdeen: C2Cook. Community program fostered by city council.
- Scotland: Community Health and Food CHFS.

For the case study of the Weston Towers, the idea is to develop community kitchens in the ground floor of the buildings. These spaces can serve the function of a social gathering space for the people who live in the building where they can prepare healthy meals every day. Also it may be possible to channel municipal or non-profit funding to be able to provide "free meals" to the people that cannot pay for it themselves. This is also an opportunity for the young adults at the Weston Towers to participate and learn new skills.

As a general rule, commercial kitchen designers allow about 10 square feet per person in dining space and five square feet per person for the food preparation, storage, service, and cleaning areas. About 60 percent (300 square feet) would be designated for preparation space with the remaining 40 percent (200 square feet) for storage, cleaning, and service (http://www.extension.iastate.edu/publications/pm2071.pdf).

An example of a community kitchen is shown in Figure 15 as an idea to develop in this case study.

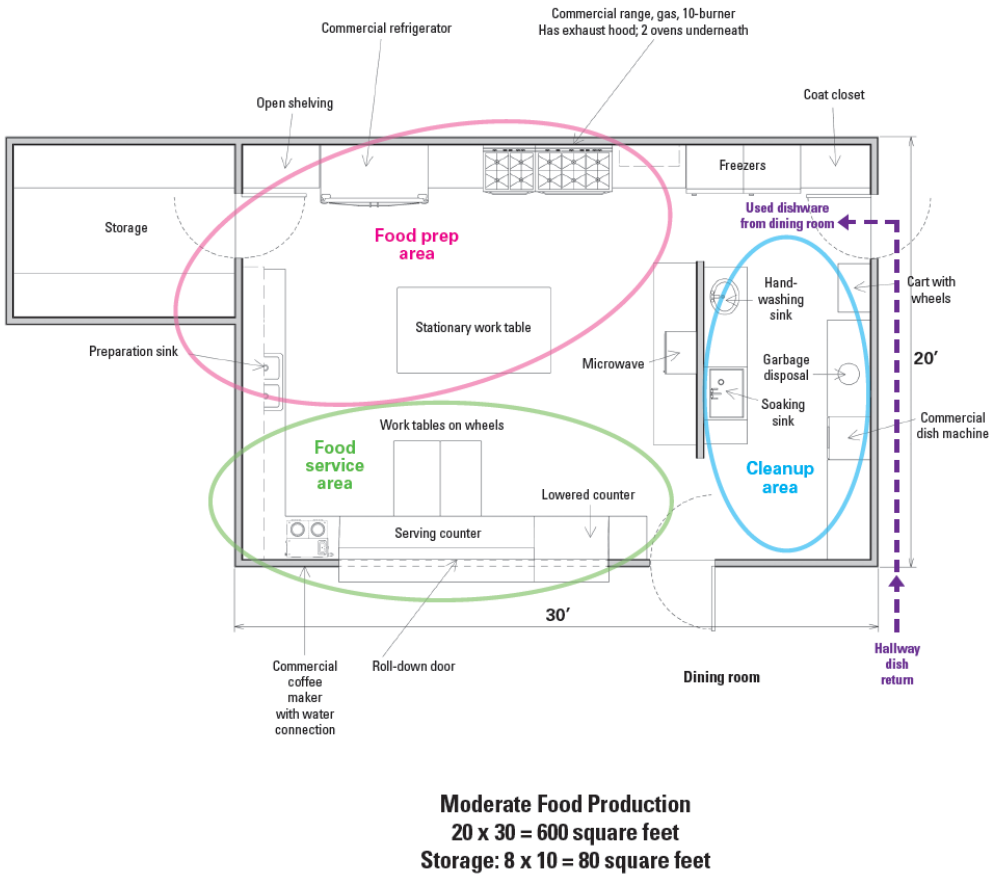


Figure 15: Community kitchen plan example
(Source: http://www.extension.iastate.edu/publications/pm2071.pdf)

4.5.3 Education Space

The concept of a communal education space is intended to serve all age groups, and a wide range of needs. It can be developed for formal children's education, crèche, or part-time children's crafts or recreation. This same space can be re-used in the evenings for adult education, for outreach programs by community education or specialty training. An indoor gathering space can be used for young adult after school activities, such as chess clubs, drama or music.

This space can also serve as the space for the book crossing (exchange), as well as the urban barter. If this space is built adjacent to the community kitchen, it can serve as the 'classroom' for teaching nutritional education.

In response to the need for activities for the youth in the area, the suggestion is made to consider leveraging the SSSI designation of the Weston Shoreline. The SSSI is administered by Natural England, and owned by the City of Southampton. Natural England offers student placements and volunteering, and this education space could be used for training. Environmental volunteers are mostly involved in habitat restoration and wildlife monitoring (Russell, 2009). Currently, volunteers tend to be older, but the link that Natural England has with schools could help to structure a program to engage younger adults. This would be particularly applicable for projects requiring a higher level of activity.

The capital outlay for an education space can be scaled, based on available funding. An education space can be as simple as four walls, some chairs and tables. Depending on the uses, this space would benefit from surfaces for writing (whiteboards), projectors, and a computer. If this is to be used for children education, smaller desks and chairs increase the ease and safety of use, and storage space is needed for supplies.

4.5.4 Urban Barter

Historically, barter was the exchange way which people changed items before money was used (Figure 16). In these days, the concept of barter is used more generically, to indicate the exchange and reuse of goods between people. Barter is very good for reuse, waste management, environmental, etc. The barter activity may not require a specific area, but it is easier if there is a designated space that everybody knows and can access.

Figure 16: The scheme of barter system
(http://urbantips.wordpress.com/2012/04/03/im-bringing-back-the-barter-system/)

An urban barter could be established in the Weston Towers, within unoccupied flat in the ground floor. In this flat it is possible to install shelves and tables to put all the stuff available to sell or change, like shown in Figure 17. The shop can be also be used to generate revenue for other community activities, by providing a "donation jar." These donations could also go to support some staffing jobs for the store. Part of this space could be set aside for clothing repairs or alterations, for knitting or sewing circles and supplies.

Figure 17: Urban Barter Space
(Source: http://www.greenpointnews.com/entertainment/1284/second-hand-shops-feast-on-our-culture-of-excess)

A similar idea to the bike kitchen is a small items repair shop, which could be set up in support of the urban barter space. Small items can be refurbished prior to being put into the exchange shop.

These types of activities are well suited to young adults, and can help them learn skills of merchandising, textiles, and repairs that can serve them in future jobs. This is also an opportunity to learn about community support and service. These small workshop spaces could also become outlets for creativity and bring joy to people's lives.

4.5.5 Co-Working

Co-working is a style of work that involves a shared working environment with people that are not employed by the same organization (Figure 18). Co-working is not only about the physical space, it is also about establishing the co-working community. Its benefits can already be experienced outside of its spaces, and it is recommended to start with building a co-working community first before considering opening a Co-working space (Source: http://coworking.pdworks.com)

Figure 18: Coworking space
(Source: https://goodcoworking.com/locations/avila-coworking-lisboa)

Because many people live together in residential buildings such as the Weston towers, co-working system can be very useful. One of the ground floor flats could be re-purposed as an office where people that live in the towers can work and cooperate with their neighbours. A schematic example of this kind of spaces is shown in Figure 19. This space might be located adjacent to the Education Space, to share common needs.

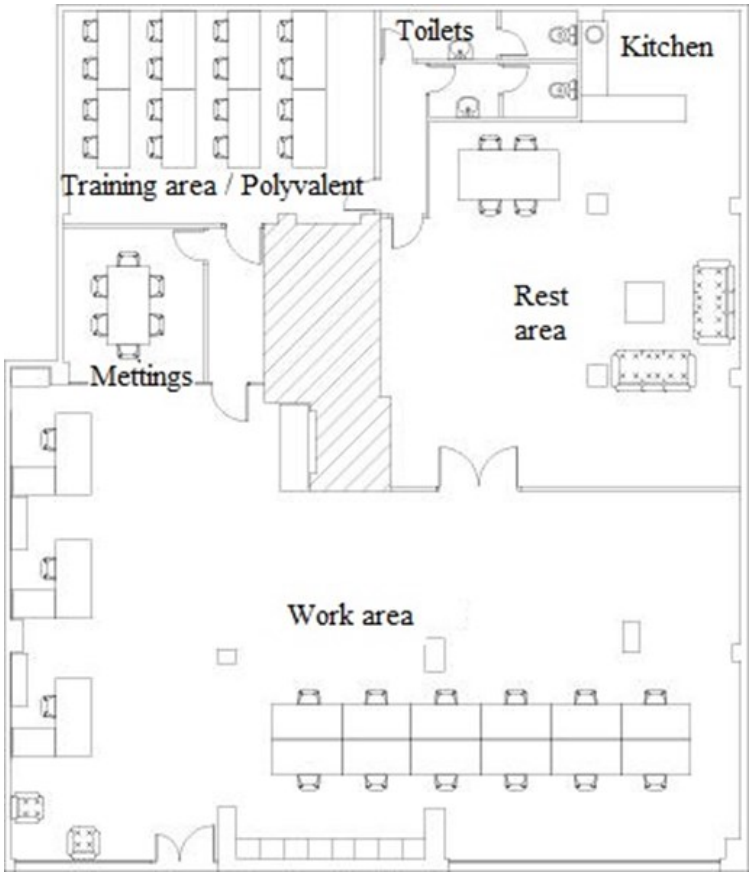


Figure 19: Co-working Space Schematic – Weston Towers

(Source: http://www.shuttleideas.com/formacion/creatividad/)

4.5.6 Book Crossing

Book crossing is defined as "the practice of leaving a book in a public place to be picked up and read by others who then do likewise" (Source: www.bookcrossing.com). The idea of book crossing started in 2001 with Ron Hornbaker and the web site www.bookcrossing.com with 3R (Read, Register and Release). Since then, the idea was developed by many people and is now a global phenomenon (Figure 20).

In Hornbaker`s idea, there is a website where the participants self-registered the book check-out and return. This avoids the need for an administrator, and saves on cost. Of course, the success of this system is dependent on honest and accurate participant reporting.

Figure 20: A forest of book crossing trees has sprouted up on the streets of Prenzlauer Berg, Berlin
(Source: http://inhabitat.com/book-forest-fallen-tree-trunks-transformed-into-a-free-book-exchange-in-berlin/)

For the Weston Towers proposal, the "book crossing" point would be located in a ground floor space, possibly sharing with one of the previous functions, such as the urban barter. With this activity, people should be able to improve their knowledge and it may be also be used for the people that are studying in the educational space. If the space is enough, some armchairs can be placed for making a "reading area" so it also may be a social space for the people of the community (Figure 21).

Figure 21**:** An example of book crossing area
(Source: http://www.shuttleideas.com/formacion/creatividad/)

An example plan is shown in Figure 22, built in three of the existing flats in the Hampton Tower.

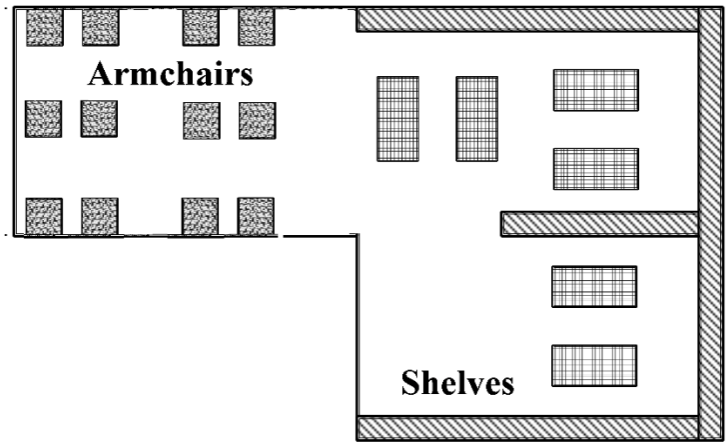


Figure 22: An example of a book crossing in the Hampton Towers.

4.5.7 Outdoor Amphitheatre

The amphitheatre is an ancient form of performance space that has recently seen a resurgence of many modern examples all over the world, particularly ones that are built into the landscape (Figure 23). Traditionally, an amphitheatre is an open, circular or oval building with a central space for the presentation of dramatic or sporting events surrounded by tiers of seats for spectators. A contemporary amphitheatre is a curved, acoustically vibrant performance space. Amphitheatres can also be very simple spaces carved into a hillside, and can represent different kind of spectacles for entertainment and community gatherings.

Figure 23: Minack Theatre, Cornwall

The benefit of the amphitheatre in this public space is that all the people can go to see those spectacles and promote the social life and the social equity among different kind of people. Plus, it can encourage young members of the society to express themselves in a non-hostile environment, where they can have the guidance required.

To develop an amphitheatre it is necessary to take into account different factors such as:

- Orientation. The orientation depends on the schedule and the use for which it is intended. In the case of semi-opened amphitheatres, the orientation may be north-south or south-north to avoid the glare from the setting of the sun. This orientation may be also determined by the breezes, either to increase cooling in hot climates, or to protect from cold winds in cold climates.
- Sound. The origination of the amphitheatre design was for the purpose of eliminating echoes while amplifying the sound to reach all the spectators with the same volume. To solve the echo problem, amphitheatres are developed without right angles between walls and ceiling, use a convex form or incorporating an inclined surface. Absorbent material can also dampen the echoes. Standing structures, sometimes curved or "bowl" shaped (referred to as band shells), are sometime built both behind the stage and behind the audience to improve the sound quality. It can also serve to contain the sound within the space, limiting the disturbance to neighbours.
- Visual. The floor inclination and the curve of the seating area should permit the viewers to look over the person's head located in the row in front of them, and to have a clear view of the stage.

The idea of this activity in the Weston Towers case study is to provide a social space for the community people where they can go to concerts, shows or only to meet friends. The residents of the Towers could organize their own concerts, or the Community could use this space to generate revenue by making this space available for other groups to rent. Since there was no previous of existing amphitheatre in this location, a new one will need to be built.

As seen in Figure 27, the proposed location of the amphitheatre lies well away from the flood zone, which is further north and runs along a stream. The terrain between the Towers and the shore has an incline that would be suitable for an amphitheatre, and it would have a nice view over the water. Finally, the proposed site for the amphitheatre is clustered with the other public park uses, such as the playground and terrace. Access

could be both from the Towers and the shoreline, and the existing parking along the shore could be used for this purpose. This activity could be integrated with the following activity of the coastal forest, which could provide a backdrop to the uphill side of the amphitheatre that would also provide a noise buffering for the Towers.

4.5.8 Coastal Forest

The action selection proposed several options to protect the Towers against natural disasters and to provide them with a sustainable coastal area. However, the location of the Weston Towers is next to a protected part of the sea, so it is not possible to develop any activity in the water.

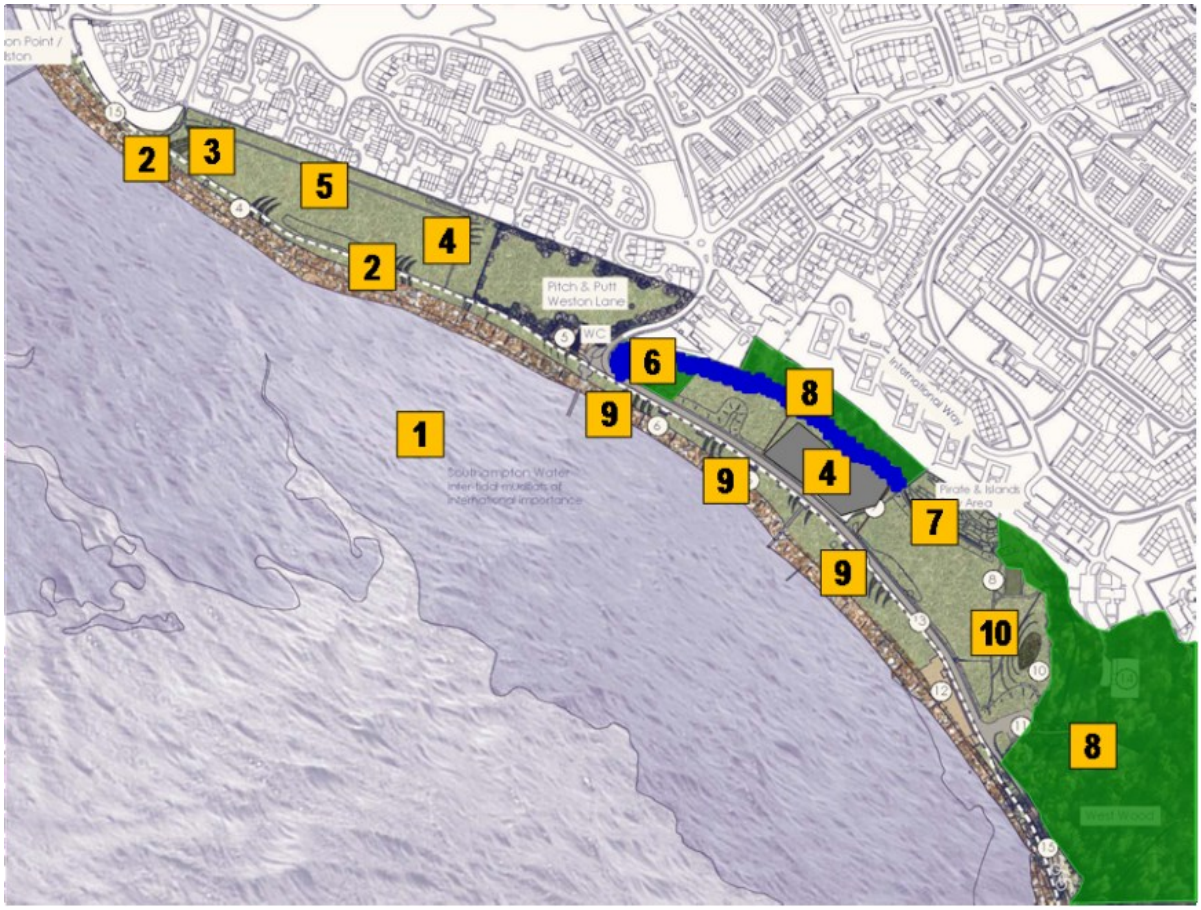
To protect this area against the climate impact of the sea, the coastal forest seemed to be a good solution. The location of the coastal forest may be in the area located between the beach and the Towers, show in Figure 24.

Figure 24: Location of the coastal forest
(Source: Google earth©)

There are several constraints in this area that need to be considered when planning the coastal forest (Figure 25):

- Flood zone
- Previous landfill
- Current land use and pathways
- Native plant and wildlife heritage

The flood zone is indicated in blue, and runs along the cliff. The forest could help stabilize the soil to prevent erosion during floods. The landfill area is currently covered with native flowers. We propose to increase the width of the urban forest and introduce taller species of trees to provide greater protection from storms. Also, while the underlying landfill material may call for some extra care for the first few years of the trees, the additional root structure of the trees can help stabilize the soil and prevent erosion or flood damage in extreme weather events.



① Timber stake alignments
② Remains of sea wall
③ Remains of sea road
④ Landfill area
⑤ Timber conduit

⑥ Site of rolling mill

⑦ Weston Hard and approximate site of Seaweed Hut

⑧ 1930s Beach shelters

⑨ West Wood: boundary banks

⑩ Proposed Amphitheater

⑪ Location of anti-aircraft ‘Z’ battery

⑫ West Castle

⑬ Netley Castle

⑭ Remains of Netley Abbey

Figure 25: Proposed Location of Coastal Forest and Amphitheatre

The superficial area of this zone is formed by alluvium soil as shown in Figure 26. The alluvium is normally soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. A stronger, desiccated surface zone may be present. (Source: British geological survey)

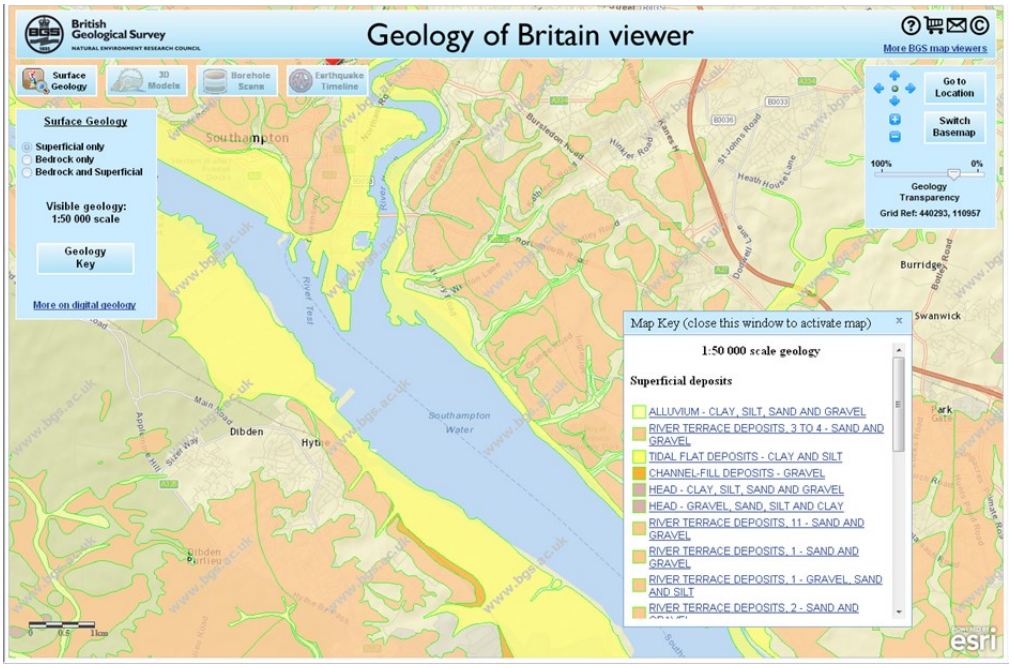


Figure 26: Superficial deposits of the area studied (British geological Survey)

The bedrock geology is formed by an Earnley sand formation, as shown in Figure 27. This kind of bedrock is formed by a glauconitic silty sands and sandy silts.

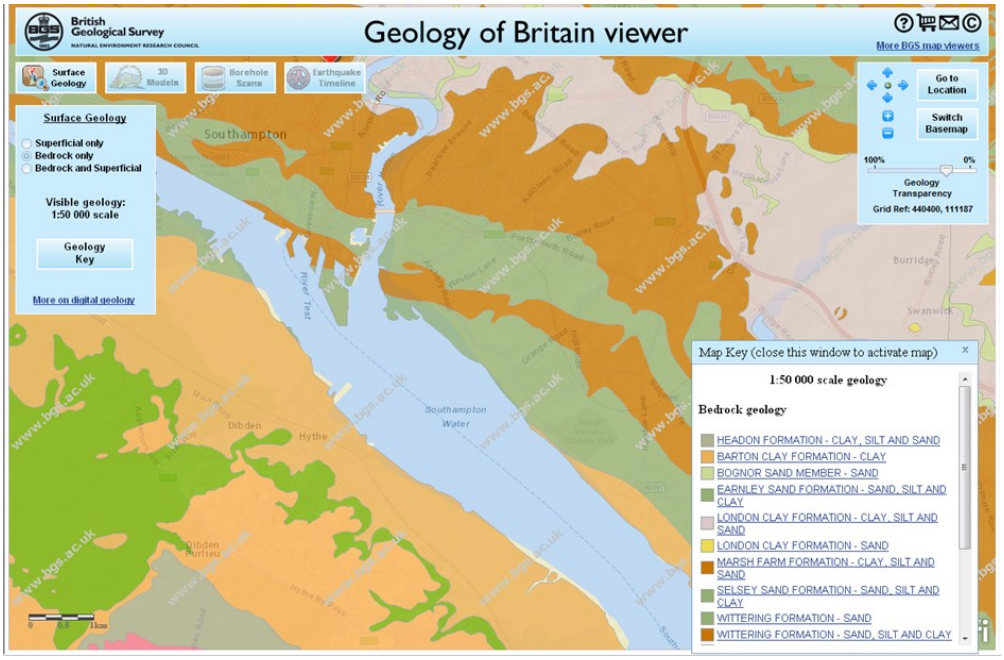


Figure 27: Bedrock geology of the area studied (British geological Survey)

The following Table 20 lists the types of trees that will grow in this type of soil, and can provide protection from storms.

Table 20: Trees to plant in the coastal forest.

Apples and Crabapples	European Larch and Tamarack
Norway and Silver Maple	Ohio Buckeye and Horse chestnut
Common Honeylocust	Hawthorn
Aspen and Cottonwood	Lindens
River Birch	Bur Oak and Eastern Pin Oak
Kentucky Coffeetree	Swamp White Oak
White, Black, Green Ash	Willow
Elms	

4.6 Innovative Idea – Coastal Farm

A powerful function of the SInRG Tool application is as a catalyst for innovative thinking. As discussed in Section 3.5.4, the activities were grouped into clusters with similar indicators. Only seven of all the activities studied were not included in any group (Table 15). Five of those are related to the sea. Our team looked for a connection between these activities and ways in which ports, people and nature can be brought into harmony. The resulting concept development is an example of creative thinking that can be catalysed by the use of the SInRG Tool.

The Coastal Farm is an innovative concept of sustainable and resilient infrastructure that is an integrated system of economic activities, community uses, and environmental resource regeneration. There is really no limit to the types of activities that can be included, but our initial concept has identified eight independent infrastructures with different purposes: seawall, seaweed farm, fish farm, coastal forest, port, coastal vegetation, market and research institute.

Our concept of Coastal Farm was inspired by the attraction named "Umi-Farm" in the Yokohama Hakkeijima Sea Paradise which is the aquarium located in Yokohama city, Japan (Figure 28). In that attraction, there are some fish ponds where visitors can catch fish by fishing or grasping the fish with their bare hands. They can also bring the fish they have caught into the restaurant, where it is cooked and served as part of a meal. There is also a marine research institute that provides educational activities for the visitors to learn about the sea and marine life. Through these activities, the visitors can learn about sources of food and gain some understanding of the maritime environment.

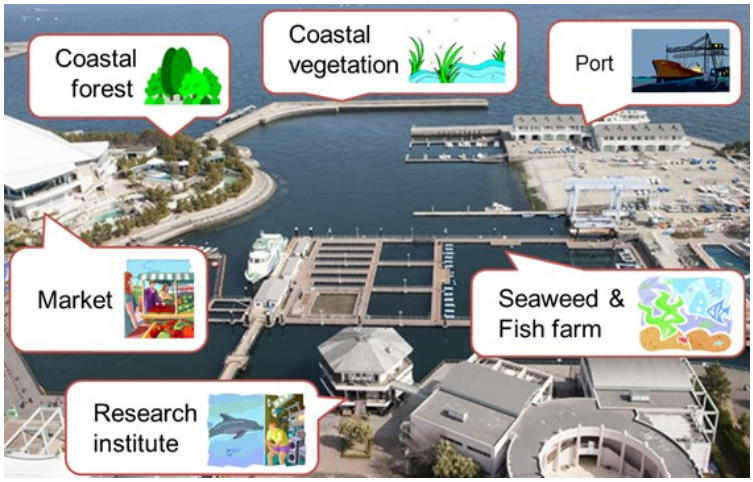


Figure 28: Coastal Farm built on Umi-Farm in Yokohama

(Source: Yokohama Hakkeijima Sea Paradise)

While the Umi-Farm is a very interesting tourist attraction, we have chosen to include these activities in a working environment that can directly contribute to the well-being of the local people. This might be considered a more modern concept of a working coastal community. By adding revenue generating activities, such as fish and seaweed farming, the Coastal farm can provide jobs and food for the people. If a port is added to the farm, it can provide transportation. Therefore, we can choose the activities for coastal farm based on the benefits that the community needs.

One schematic plan of this infrastructure is shown in Figure 29.

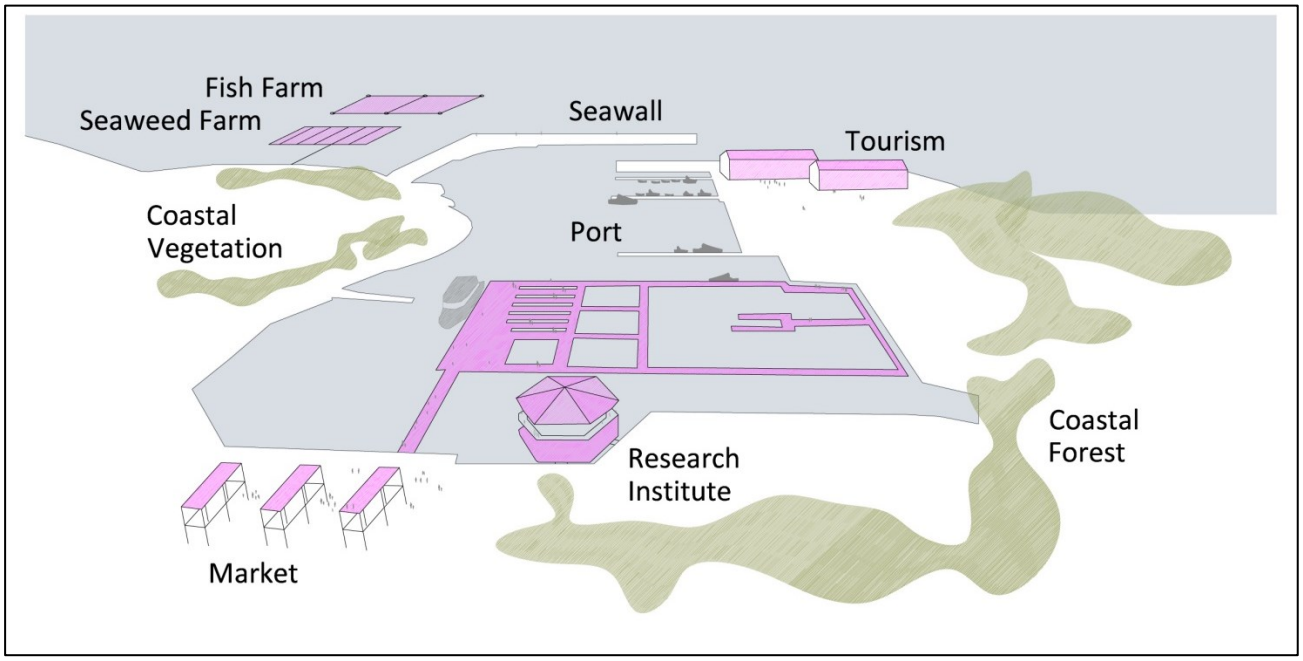


Figure 29: Schematic of Coastal Farm (Courtesy of Dr. Nuria Nebot 2013)

Current ports have functions of logistics and transportation but the relationship between environment and human are not considered. However, we must create a new innovative port to solve environmental problems and to provide the people more comfortable environment. In order to solve these issues, the port must contribute to following seven functions: Job, Safety, Food, Economy, Transportation, Environment and Education. These functions can be realized by combination of the eight infrastructures of a Coastal Farm as shown in Figure 30.

Figure 30: The relationship between the infrastructures and the functions.

A brief explanation of the functions of these activities is detailed below, and the first five are detailed in Appendix B.

Coastal forest

A coastal forest consists on planting trees in the boundary between the sea and the land. The main objective of a coastal forest is to protect the land against natural disasters such as tsunami or storm surge. The trees of the coastal forest may absorb the energy of the waves and decrease the damage caused by the disaster. A full description of a coastal forest was included in the case study in Section 4.5.8.

Coastal vegetation

The implementation of coastal vegetation is due to the capture of blue carbon. Blue carbon is the carbon captured by the world's oceans and coastal ecosystem. This activity consists of planting or protecting the coastal vegetation as mangroves, sea grasses and salt marsh grasses, because these plants sequestrate carbon up to 100 times faster than the terrestrial forests as shown in Table 21.

Table 21: Comparison carbon sequestration of coastal vegetation and terrestrial forest

Characteristic	**Coastal vegetation**	**Terrestrial forest**
Sequestration rate gC m $^{-2}$ yr^{-1}	High: marsh 210, mangrove 139, seagrass 83	Low: tropical 2, temperate 1-12, boreal 1-2
Sequestration permanence	High	Low
Fire risk	None	High
Carbon saturation potential	Low	High
Area	Low	High
Recent loss rate and trend	1-5% yr^{-1}, increasing	0.8% yr^{-1}, stable or decreasing
Self-expansion potential	High / Rapid	Low

Source: http://www.thebluecarbonproject.com

Seaweed farm

Seaweed farming refers to the harvesting and cultivating of seaweed under controlled conditions. It is a traditional industry in the U.K. For example, the remains of a seaweed hut were discovered on the Weston Shore dating back to the 17th century. At that time, seaweed was collected for iodine production and for commercial purposes, such as the production of glass, fuel and insulation. Recently, there has been a resurgence of interest in seaweed for human consumption and agriculture (animal feed and soil enrichment). The European seaweed industry has also persisted due to the discovery of hydrocolloids and especially alginic acid.

While the world production of seaweed increases by 5.7% every year, the production in Europe has decreased by almost one third since 2000. The reversal of this trend will depend on the development of value added products and transfer of expertise. (www.netalgae.eu). This industry depends on close collaboration between scientists and fishermen, and results in high skill jobs.

Seaweed farming is also dependent on the access rights to foreshore and coastal resources. Whereas these are considered public domain in Southern Europe, in the U.K., part of the foreshore (area between edge of high and low tides) can be privately

owned. Also, harvesting below the low tide mark anywhere in the UK requires a lease from the Crown Estate (authority) in addition to one from the beach owner (access).

Fish farm

Fish farming is the farming of saltwater fish under controlled conditions and provides the people the foods and jobs. European freshwater fish farmers are fighting a battle on two fronts: On the one hand, with the spread of globalisation they are increasingly forced to compete with producers from countries with far lower costs of production. On the other hand, they have to conform to the stringent demands of European and national legislation with regard to product quality, environment and health. In addition, there are legal restrictions on the discharge of effluents, water extraction, the use of chemicals and genetic modification. The success of Europe's freshwater aquaculture sector depends, to a great extent, on farmers' abilities to face these challenges (Sustainaqua 2006).

Integrated Multi-Trophic Aquaculture (IMTA)

Integrated Multi-Trophic Aquaculture offers a solution to the challenges mono-culture fish farming by combining the farming of fed aquaculture species (e.g. finfish), with inorganic extractive aquaculture species (e.g. seaweeds) and organic extractive species (e.g. suspension- and deposit-feeders) cultivated in proximity (Figure 31).

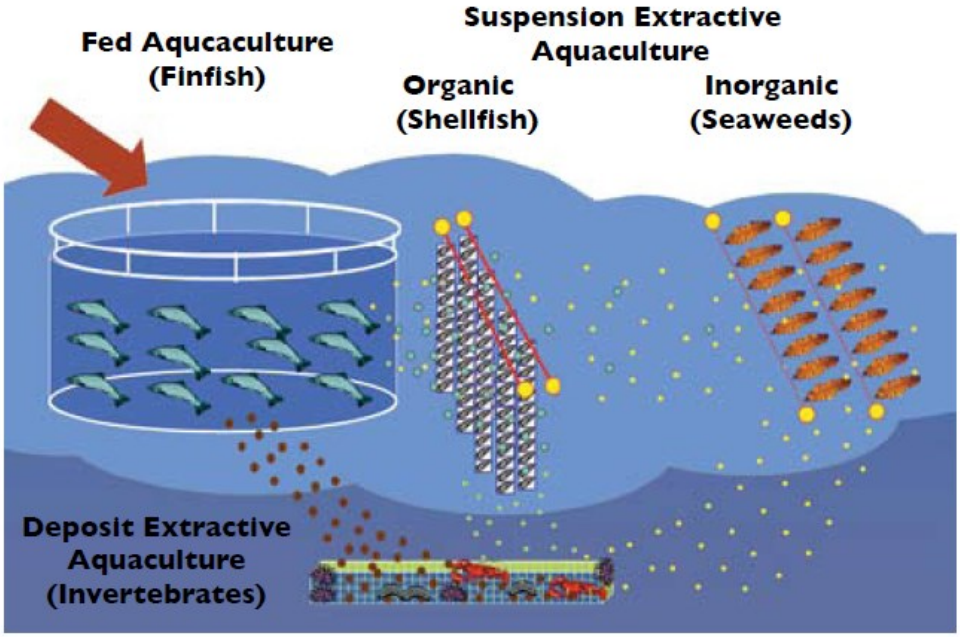


Figure 31**:** Integrated Multi-Trophic Aquaculture (Chopin 2010)

Industry pilot projects in the Bay of Fundy, Canada, have shown promising growth rate increases of 46% for kelps and up to 50% for mussels cultured in close proximity to the fish farms, reflecting increases in food availability and energy. Also, as Table 21 shows, the additional revenues from the mussels and seaweed resulted in a 9.3% higher profitability for IMTA than salmon monoculture (Ridler 2007).

Table 22 Profitability of IMTA vs. salmon monoculture

Operation	Scenario 1: Optimistic (Can $)	Scenario 2: Worst Case (Can $)	Scenario 3: Intermediate (Can $)
IMTA	9,797,078	742,038	3,625,641
Salmon monoculture	8,961,125	55,933	2,930,523

The IMTA concept is fully scalable, with no initial capital investment threshold. The infrastructure is built on rafts, nets, cages and boats for harvesting and transportation. The maintenance requires a balance of feed (fish fry and seed from seaweed), and engages scientists and marine biologists to prevent over feeding. These aquatic farms face a different set of risks than land-based farms. Protecting their livestock from disease is more complex, as the environment can be affected by marine pollution, red tide, green tide and disease from other fish. Much as land-based farms may be damaged by natural disasters, fish farms could be entirely wiped out from wave forcing and tidal drag during big storm events. Additionally, the aquaculture farms are located in open water which can be accessed by other fish. This makes the feeding more difficult, as well as the filtering of the fish at harvest.

The benefits of IMTA are the economic opportunities for business revenue and the creation of high skilled jobs. In contrast to the high risk job of deep-sea fishing, these jobs are all located close to the shore. Also, the multiple species of fish, extractive aquaculture species (e.g. seaweeds) and organic extractive species (e.g. mussels) provides food security and a resource for land-based value added businesses (e.g. preserving, processing, packaging).

Finally, the bio-remediative services of the extractive species of IMTA have beneficial impact to acidification of the marine environment, and early studies indicate the potential for carbon sequestering.

Port

Port plays roles of a logistics hub and transportation. In the case of the logistics hub, the port is a facility for loading and unloading products to/from ships. These products are sold in the market. On the other hand, in the case of transportation, the people can travel by ship. Therefore, the port can provide the people economy and transportation. Smaller ports can attract a wide range of tourism activities, as well as proving a harbour for specialty vessels, such as maintenance ships for off-shore wind farms.

In the concept sketch of the port, we have also identified areas that might be designated for swimming, scuba diving lessons, or boating with kayaks or other small boats.

Market

Traditionally, cities were located on the coast for the benefit of the trade by sea routes. While this is mostly consolidated in containers that are handled in large ports, there is still the opportunity to establish a market location near the Coastal Farm. In the market, the food and items generated by the different activities of the coastal farm can be sold improving the economy of the area. Also the market needs manpower so it can provide jobs to the citizens.

Research Institute

The main objective of this research institution is to connect and control the activities developed in the Coastal Farm. Other objectives of this institute are monitoring the marine environment and developing tools to mitigate the climate change and to conserve the environment. It also can provide education to the citizens for understanding the maritime environment.

Although, currently there are many research institutes developing new technologies, the institute which plays a role of connecting the maritime environments with the people is not still developed. Moreover, the concept of providing this service not only to the company, but also to the people, is considered a new concept of a future research institute.

In the Coastal Farm concept, there are designate pond areas that could be used as holding tanks for research or rehabilitation of marine mammals.

Thus, our concept of Coastal Farm is a fully integrated location with benefits to the people, the economy and the environment.

5 SInRG Tool Application– Analysis

- *Designed to facilitate **collaboration** early in design.*
- *Tool retains **flexibility for customization** of Indicators and Activities.*
- *Tool data can be **normalized** by researchers or user groups.*
- ***User groups retain control** of indicator weighting, design decisions.*

5.1 Users and Implementation

The SInRG Tool is intended to be used in the early planning phase of a project, and was designed to facilitate the collaboration of many stakeholders. We were encouraged that our contacts at the city planners could envision the application of the SInRG Tool in their own planning process. While it was recognized that it might be difficult to gain the participation of the private sector (project constructors), the SInRG Tool was clearly seen as a way to create a common dialogue between residence associations, service providers and other NGOs. However, there are many examples from industry where this type of collaborative design has resulted in greater project clarity and saved time/ money for the contractors, and any initial resistance should not be insurmountable.

5.2 SInRG Tool Customization

The environmental assessment tools were originated in developed countries, but the benchmarks and even the activities may not be equally applicable in all parts of the world. The SInRG Tool has the advantage of cross-cultural transferability, since the activities can be customized by the user groups. The activities of the SInRG Tool are only an example of all the activities that may be developed for sustainability design. These activities may be modified by the people that work with the SInRG Tool.

We also kept the objectives of transferability and customization in mind when selecting indicators. Based on the research, four categories of indicators were identified, in order to cover the types of values that might be identified for a project. We selected indicators that are universally applicable, while the SInRG Tool structure retains the ability to add or modify the indicators.

In working through the prototype and the consistency analysis, we recognized the need for tighter definitions of some of the indicators in order to provide a meaningful scoring of the actions. Also, one indicator was subdivided into sub-divided to reflect a differentiation between responsible parties. Energy efficiency was differentiated as energy savings, as an activity that the residents may be able to implement themselves, and energy generation, which should be implemented experts in this field and is more likely to be financed by the building owner.

The second indicator that needed to be changed was the safety infrastructure indicator. This concept has different meanings for developed and undeveloped countries. Surit (2008) identified for this indicator that the main concepts to explain it are accessibility for school, to hospital, to fire station, to police station, to public phone and to post station. These facilities may be expected in a developed country, and safety would then relate to safety from crime, fire, or personal harm.

5.3 Normalizing the Data

In order for the SInRG Tool to be robust, the tool scoring (magnitude of importance) needs to be normalized. This means that the standard deviation of the different indicators and activities should be low, indicating that the individual scores were consistent for any one cross-cell. In the development of this prototype, we recognized that the degree of consistency between our scores was directly related to the level of understanding of the indicators and the activities. We found the process of discussing the differences in scoring helped us to clarify the definitions, and aligned our scoring.

While the SInRG Tool is provided with the scoring from our research team, it would be highly recommended to submit this scoring process to a larger numbers of people in order to help normalize the data. Also, some of the cross cells are related to combinations of indicators/ activities that are very context dependent. These might be used as part of a tool "customization" process, where the user groups derive their own scores. This scoring activity becomes part of the value management process itself, as it gets people thinking about project values.

5.4 Indicator Weighting

The weight of the indicators must be defined by the users of the SInRG Tool. One of the main advantages of the SInRG Tool is that it can be understood by people of many backgrounds. It does not require and special knowledge or skills.

When a project is going to be developed it is important to include all of the stakeholders. Often, when the project activities are being decided, only the opinion of the immediate design team or planning department is taken into account. But it is necessary to have representation from the user groups, and give them the opportunity of explain their needs and objective. One way of doing this is to include them in the weighting of indicators.

One suggestion approach for gathering the input of all of the involved parties was to ask each individual to weigh the indicators independently, and then calculate the average of everyone's scores. In this way, the activities that are selected by the SInRG Tool will better represent the needs of all these groups, and not only look at the capital costs.

Since there are so many indicators, one approach was derived from some of the decision analysis tools reviewed in this report. First, the indicators which have little of no relationship to the project are discarded. Next the top two or three indicators are identified through group dialogue and consensus. The top one is awarded a 100% weighting, and the significance of the others is determined in relation to the first one. The rest of the weighting is scored as in the first suggestion. This combines an initial dialogue and group consensus to align the highest priorities, but then allows the freedom of expression to individuals for other indicators.

There are no pre-established data outcomes, but there are some formulae that can be programmed to address patterns of data manipulation. For example:

- A community planner wishes to improve certain factors in a community (e.g. food security and social equality), and wishes to know which activities can accomplish this which can be implemented by community volunteers and for the low material costs.
- A landscaper would like to better understand the contributions of the exterior environment activities in the various contribution areas. With a better understanding of how they fit into systems, they can better tailor their project proposals to fit the needs of the community planner or developer.
- A developer would like to offer the maximum benefit for the lowest cost. They decide on the appropriate activities based on the activity items contribution to the criteria (selected by community planners), the cost and legal implications of this activity item, as well as the synergy between activity items that can be harvested as shared savings.

6 Business Model

- *Potential users: current **users of BREEAM**, city planning and developers*
- *Value proposition for BREEAM: shift from **assessment to a design guide.***
- *Cost: **Refine** the SInRG Tool methodology, **adapt** to BREEAM activities, **normalize** the scoring data.*
- *Legal Considerations**: decision guidance** only, responsibility for design decisions and customization remains with user groups.*

6.1 Potential Users

The research had identified the benefit and need for use of the SInRG Tool during the planning phase of a project.

The Sustainability Innovation and Resilience Generator (SInRG)Tool provides several functions:

- Facilitate dialogue about project value
- Correlate project values with sustainability activities
- Guide selection of activities based on value weighting
- Generate innovative thinking for sustainability activities and systems
- Strengthen resilience through systems implementation
- Reduce implementation costs by harvesting synergies of systems

The researchers identified a gap in the existing BREEAM for Communities approach which would be well served by the SInRG Tool. Step 1 of BREEAM is the assessment of resources, while Step 2 is the selection of sustainability actions. The SInRG Tool would provide the link between the two steps, and identify a set of values that can be used throughout the entire project.

6.2 Value Proposition

Developing the SInRG Tool to work within the framework of BREEAM would help reposition BREEAM from an environmental assessment tool to that of a design guidance tool This is consistent with recent reviews of BREEAM, and the increasing awareness in the design community of the opportunity for value creation in the early

design phases. A vocabulary and a structure to guide this discussion is lacking and hence time needs to be devoted to producing this discussion.

The availability of the SInRG Tool through a web portal would be of benefit to many stakeholders: planning departments, resident associations, private industry, and environmental agencies. It can also help to understand the social and cultural benefit of some of the activities, as these can be related to the selected project indicators.

6.3 Cost Considerations

The development of the SInRG Tool for interoperability with BREEAM will require three additional work packages. First, the methodology has been developed to a beta level for the prototype, and will require two weeks of full time research to complete the testing and package the formula for a web-based access. Second, the activities will need to be redefined to align with the existing BREEAM tools. This could be developed by researchers from BRE who were involved in the BREEAM creation. Finally, the SInRG Tool scoring (impact significance) would need to be completed by a larger group of researchers who are familiar with BREEAM activities, in order to normalize the data and make the tool more robust.

6.4 Legal Considerations

We have been careful in the design of the SInRG Tool to emphasize its function as guidance for the alignment of project values. Furthermore, a disclaimer should be included to acknowledge the subjective nature of the tool scoring on the baseline of a rental tower in a developed country. Users in other cultures might need to review the scoring and customize the definitions of the indicators to adapt to their own cultures.

7 Conclusions and Future Work

- ***Future application of the SInRG Tool:*** *Southampton City planning.*
- *Interoperability and future research with* ***BREEAM.***
- ***Academic papers:*** *value management, resilience, and tool methodology.*
- *Opportunities for* ***innovation*** *with fast-track approach.*

The design science methodology is explicitly linked at the beginning to both real world problems and prior theoretical knowledge. Equally, the methodology also calls for a reflection on the design experiment in the form of artefacts that contribute back to the real-world problem and to academic theory. This final chapter will review both areas of contribution, and reflect on the adaptability of the methodology to the short time frame of the Collegium.

7.1 Contributions to Industry

There are several contributions to industry of this project.

Positive Feedback - First of all, in the application of the SInRG Tool to the Weston Towers, the selection of activities is consistent with the activities that were implemented by the city planners. The planners also welcomed the additional activities which were recommended by the case study (social uses of ground floor space). They recognized the opportunity to suggest these activities as part of the Section 106 community contribution, and suggested that the presentation of these social activities as part of a group of related activities could help persuade funding agencies of their merit. The city planners commented that the SInRG Tool could help them to "link sustainability ideas with the indicators" and help to "get everyone on the same page." They also noted that the vocabulary and concepts of the indicators could help the planners to organize their thoughts and communicate the project values in the form of a "value brief."

Case Study Brief - Additionally, with the objective of explaining this success and offering a contribution to industry, the research group will develop a short case study paper for the City Council of Southampton to use in support of the project promotion.

This case study paper will also be used to demonstrate the usefulness of the SInRG Tool, with the intent of introducing the SInRG Tool on future projects.

SInRG Tool Implementation - The city planners discussed the opportunity to implement this tool in upcoming projects of the City Council of Southampton to help define the project values and provide guidance to the selection of the activities. Since the SInRG Tool is still in beta form, this will require further development and testing for user applications. Future research will explore the possibility of a web-based portal.

BREEAM - Finally, the SInRG Tool has an important opportunity to fill the gap in current BREEAM methodology. If the activities included in the SInRG Tool were reworked to align with the activities used by BREEAM, the SInRG Tool could serve to guide the selection of activities. The researchers will explore this opportunity, and identify the additional work necessary for this adaption.

7.2 Academic Contributions

This project lies at the intersection of several academic fields, and provides a solid body of knowledge for contributions in many areas.

Value management – Current research in value management has identified the need to articulate value at the outset of a project, but also the paucity of language to describe the sustainability concepts. This project proposes that quality of life and planetary resilience indicators can be used to shape this discussion. Furthermore, these values are reflected in the sustainability activities, and can be used for value management exercises throughout the design and construction of the project.

SInRG Tool Methodology – The point of departure for the SInRG Tool is the application as decision guidance, and not benchmarking. There are three additional contributions to methodology:

- The separation of the impact significance decisions (tool development) from the impact magnitude decisions (user defined)
- The separation of the subjective (indicators) and the objective (activities)
- The use of numerical activity selection combined with cluster analysis.

Resilience Research – This study builds on the research work by the Stockholm Resilience Research, which juxtaposed the planetary boundaries with social foundation indicators. This research examines a design that puts this concept into practice.

7.3 Fast-Track Approach

The project detailed in this book was developed in a six-week time frame, with five people from different backgrounds. This short working schedule has some benefits and drawbacks that are explained in the following paragraphs.

With a limited time for research, the traditional sequence of research steps were abbreviated and not completed in a sequential manner. The research, tool development and case study application were completed with considerable overlap of the phases. While this caused some level of stress, it also made each action more efficient and directed toward the end deliverable. There was a short-cycling of information feedback that proved to be quite beneficial for the project.

This short period of time also created a conflict between the directive to innovate and the necessity of having a defensible and derivable outcome. This was made even more challenging as the researchers were only given a theme, Coastal Eco-Cities, and were also responsible for scoping and framing the problem and the solution. This further limited the time available for comprehensive topic research, and precipitated a rapid convergence on a research topic. While the depth of the research was limited by the short time frame, we have made every effort to assure the validity of the information in this book.

The last factor that provided a challenge was the differences among the members of the team. The five people involved in this project have different backgrounds, languages and cultures. This caused some communication problems, but also provided a source of new ideas. These differences also provided a rich range of backgrounds to help normalize our tool data, and helped us to gain an understanding of how the SInRG Tool can serve a wide range of people, with different backgrounds and different ideas.

Finally, the design science research methodology was well suited to the interweaving of industry and academic information. The design solution is experimental, so it is intended to be an experiential learning experience. The methodology also supports continuous learning, as the findings from the implementation are related back to academic work, and reviewed by industry.

Overall, this schema of intense work at a fast pace can provide an opportunity for innovation, given the right conditions, facilitation and group membership.

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APPENDIX A. Definitions

BREEAM: An environmental assessment method for new building designs. BREEAM uses a balanced scorecard approach .

City: City is a center of population, commerce and culture; a town of significant size and importance.

Cluster analysis: Statistical classification technique in which data are sub-divided into groups (clusters) such that the items in a cluster are very similar to one another and very different from the items in other clusters.

Coastal: The Location of a place in accordance with its proximity to Sea or Ocean.

Coastal zone:Interface where the land meets the ocean, encompassing shoreline environments as well as adjacent coastal waters. Its components can include river deltas, coastal plains, wetlands, beaches and dunes, reefs, mangrove forests, lagoons, other coastal features.The terrestrial portion of the coastal zone is defined by an area extending 10 km landwards from the coastline.

Coastal Eco-City: The concept of the "Coastal Eco-City" is to make coastal cities more resilient and more adaptive to future weather changes, where a good ecology and sound economy is achieved.

Correlation:a statistical procedure used to determine the degree to which two (or more) variables vary together

Correlation matrix: a matrix giving the correlations between all pairs of data sets

Eco-City:a reconstructed city in balance with nature. This is the original concept of "eco-city" developed by the Urban Ecology group, founded by Richard Register in Berkeley, California. While the term is often used now to refer to a newly built city, the original concept was developed to improve the environmental footprint of Berkeley. For the purpose of our report, we accept this broader definition.

Resilience: Resilience is the ability of the urban poor to withstand the effects of hostile environment especially natural disasters caused by dramatic global weather changes in the future. And the ability to get back to their original status. If urban poor can cope with dramatic weather changes then the whole community will be resilient.

Scaling-weighting method:A method of scoring options against a prioritize requirements list to determine which option best fits the selection criteria.

Significance degree: An interpretation of statistical data that indicates that an occurrence was probably the result of a causative factor and not simply a chance result.

Urban Poor: by urban poor we mean: low and medium-income persons and families who are living in urban areas and they are part of the urban community but they cannot afford the rising expenses of water, food, and housing.

Vulnerability: is referring to the inability to withstand the effects of hostile environment, and by hostile environment we mean – in our research – climate change and economic challenges.

Port: It's the artificial structures located at coastal where ships can keep their safety and transport people, foods, energy, etc to/from land. Ports provide lots of equipment for activities of ships such as container, dry cargo, liquid, oil and gas.

APPENDIX B. SInRG Tool

B.1 SInRG Tool explanation and use

The aim of the research is to develop a systems approach to urban regeneration, wherein environmental and social values drive the project design, within the context of urban poor in a coastal city. Our focus is on the refurbishment of existing housing stock, specifically tower blocks.

The research indicated that the sustainability tools are focused on specific improvement activities (such as BREEAM), housing quality indicators, and cost. Research in this field points to the need for a systems approach to sustainability actions in order to leverage the synergy between systems, but also noted that methods for this approach are still lacking. Additionally, we identified a need for a method that would allow the project indicators (values) to be the determining factor for the selection of the actions.

B.2 About the SInRG Tool

The basis of the selection tool is a database (Excel spreadsheet) that captures the relationship of the indicators with the sustainability actions. There are four areas of indicators: environmental issues (planetary boundaries), quality of life (social foundations), Vitruvian qualities (durability, function, beauty), as well as more traditional project parameters of cost, legal and risk.The sustainability actions are also organized by systems: external environment, built environment, socio-economic, energy/waste, and climate issues. While these are similar to the categories in programs such as BREEAM, this tool is not a benchmarking tool, rather a selection guidance tool based on the degree of relationship between an action and the project indicators.

B.3 How to use the SInRG Tool?

The intended users are the decision-makers of housing refurbishment projects. Perhaps the easiest explanation is an example. Suppose a community planner has identified certain values for a project (e.g. food security and social equality), and wishes to know which actions can be implemented by community volunteers and for low material costs.At the same time, they wish these actions to be environmentally friendly.The planner would select these indicators on the tool, and determine the relative weighting of importance to each of the indicators.The tool would be able to “solve” for this formula and identify the top activities from those in the database.

We believe there is an opportunity to use the activity of indicator selection and weighting as the basis of dialogue between various stakeholders of a project (e.g. city planners, residence association, sustainability planner, developer) to gain an agreement on the desired values (indicators) for the project.This process can help create a unified vision to guide the project decisions.

B.4 Indicators

Economics/ implementation

Community project vs. hired labor

This is the first indicator of cost, and reflects the degree to which the project *could* be organized and carried out by the residents themselves, even if the activity may typically be implemented by hired labor.The primary benefit is the reduced cost of implementation, and possible the opportunity to allocate more funding to materials or equipment, or to enlarge the scope of the project. Also, studies have shown that projects organized by Community Based Organizations can better respond to local needs, make more effective use of resources, and are more likely to be sustainable (World Bank).

Minimal equipment cost

Projects with low equipment needs, are preferable to reduce the cost barrier and improve the ease of implementation.This indicator can also refer to the adaptability of the project to equipment that can be easily leased, or used by volunteer local labor.

Low material cost

Low material cost does not mean a secondary grade or poor quality materials. It only means the choice of the cheaper materials of the existing without losing any of the necessary qualities.

Low maintenance Cost

Maintenance cost is important to the long term use of a project/ activity. The cost considerations include the amount and frequency of the maintenance effort, the amount and skill level of labor, the availability and expense of materials, and the need for equipment. Projects with high maintenance costs are more likely to fall into disrepair and not provide a good long term cost/ benefit ratio.

Legal/ regulatory barriers

Projects that face legal or regulatory barriers can face time delays and costs in order to overcome the barriers.While barriers can be overcome, projects with lower barriers are likely to be implemented quicker.

Risk

Risks are the potential hazards that are harmful for personal health, safety and the environmental. Risk includes social problem (ex. demonstration, equality), accidents (ex. fire, explosion), pollution, etc. Risk need to be defined and managed. This indicator reflects the relative risk of the action item to other actions within the system.

Vitruvian qualities

Vitruvius, a Roman author, architect, and engineer, is famous for asserting in his book *De architectura* that a structure must exhibit the three qualities of *firmitas, utilitas, venustas* – that is, it must be solid, useful, beautiful.This gradation of qualities is equally applicable to measures of Quality of Life. These measures represent the human perspective.

Solid / durable

The durability of a system or object refers to the years the item can provide a useful function. This is relevant to life cycle analysis, which is the calculation of the sum of all of the environmental harms of a product/ system divided by the useful service life. The longer the service life, the lower the annualized impact. Durability may also refer to the ability to repair and maintain an item in order to extend the useful life.

Usefulness

The usefulness of a product or system refers to the ability to fulfill the needs for which it was designed. This degree of usefulness can be increased through versatility and completeness. Versatility refers to the ability to adapt to similar or modified use, while completeness refers to fulfilling all of the elements of the design need.

Beauty/ delight

While durability and usefulness can be somewhat objective, a perspective of beauty or delight is entirely a subjective. Does the item make you smile? This can represent individual sources, or a cultural perspective. In the application of this tool, the citizens/ residents could be asked to rate the proposed selection of actions based on beauty/ delight.

Social foundations resilience indicators

The Social Foundations Indicators represent the human needs and the subjective perception of their fulfillment. Improving these foundation improves the resilience of the urban space.

Food security

The World Health Organization defines three factors of food security as food availability, food access and food use. Food availability is having available sufficient quantities of food on a consistent basis. Food access is having sufficient resources, both economic and physical, to obtain appropriate foods for a nutritious diet. Food use is the appropriate use based on knowledge of basic nutrition and care, as well as adequate water and sanitation. The United Nations adds a fourth facet: the stability of the first three dimensions of food security over time.

Water security

The International Water Association defines water security as the reliable availability of an acceptable quantity and quality of water for health, livelihoods and production, coupled with an acceptable level of water-related risks.

Shelter security

Shelter is one of the basic human needs, as presented by Maslow. The security of shelter has physical, social, financial and legal aspects. The physical considerations are primarily covered by building codes, which are intended to provide for the life safety of the occupants from natural events. Social aspects consider the impact of other humans on the structure (for example, damage to property). Financial and legal security in this application refer stability of the financial and legal parameters of the owner. Will the rent stay stable? Will the property remain as rental or change to other uses?

Job/ income/ economy

This indicator refers to the ability to provide a livelihood for oneself or one's family. This can be a direct revenue generating activity or other activities to supply basic needs, such as growing of one's own food. The indicator reflects the degree to which the action can either directly provide revenue / resource generation or contribute to future provisioning. These may be activities which improve skills, support local shops, or create opportunities for entrepreneurship.

Safety infrastructure

This indicator reflects the degree of personal safety from bodily harm. This indicator is often measured as the accessibility to police station, fire stations, and medical centers. Since the location of these facilities is often already established and not in the control of the redevelopment project, actions items might include the provision of space for travelling health care clinics, training for a neighborhood volunteer fire force, a community safety officer. Safety might also be enhanced by physical elements such as proper lighting, physical barricades and landscaping to support clear lines of sight between points of access. In addition, the safety of a community is also increased when the social support networks is well established, and people start looking out for one another.

Transportation infrastructure

Improved transportation, as it relates both the urban setting and the lower economic demographics, refers to the ability to move about the city without the use of a private automobile. The indicator generally refers to the proximity to points of access to mass transit, but an equal emphasis should be given to bicycle commuting and foot traffic. In addition, action items in this category should be reviewed on the quality of the experience (Vitruvian Delight). For example, does the bus shelter provide adequate protection from the weather and traffic. Is there a safe crossing, and does the path back to the housing complex provide a pleasant experience? Similarly, is the bicycle path inviting and does it link to other paths outside the development?

Health

This indicator concerns the ability to improve the health of the individual and their families. This refers not only to "sick" care but wellness care. Actions may include the proximity to health care, provisions for travelling clinics or for healthcare classes. The wellness care might include the improved food supply of fresh produce or proteins, provisions for exercise or improving indoor air quality.

Energy/ fuel generation/ safety of supply

One of the basic needs for urban dwellers is the accessibility to fuel for heating and cooking. This indicator reflects the contribution toward ensuring the safety of the supply of fuel, either through the improvement or safeguarding of the existing supply chain or by creating alternative fuel generating sources.

Energy saving

The energy saving indicator reflects the contribution of an action toward reducing the utility bills for the residents. Therefore, solar PV panels would contribute to the previous indicator as improving the safety of supply, but would only contribute to this indicator if the utility savings were credited to the residents.

Political voice/ self governance

Community driven development and participatory planning have the potential to increase the power of poor communities to negotiate with public authorities, the private sector, and civil society. This indicator should reflect the degree to which the activity can help the community interact, discuss local issues, and organize themselves. Active participation and empowerment results from citizens gaining rights and responsibilities that go with being citizens.This indicator is linked with the following two, as the community voice should reflect the needs of all the citizens.

Social equity/ gender equality

Activities/ projects that are socially inclusive can give voice and decision making responsibility to women, the elderly, youth, and minorities. The indicator reflects the degree of active involvement that it generates. Activities such as surveys that only ask citizens to express needs and demands, without accepting responsibilities that go with being citizens, does not really empower people.

Planetary boundaries resilience indicators

The concept of planetary boundaries was developed by the Stockholm Resilience Centre (Rockstrom, 2009). Concerned that the anthropogenic pressures on the Earth System have reached a scale where abrupt global environmental change can no longer be excluded, they proposed a new approach to global sustainability. They have identified planetary boundaries within which we expect that humanity can operate safely. Transgressing one or more planetary boundaries may be deleterious or even catastrophic due to the risk of crossing thresholds that will trigger non-linear, abrupt environmental change within continental- to planetary-scale systems. The researchers at the Stockholm Resilience Center have identified nine planetary boundaries and, drawing upon current scientific understanding, proposes quantifications for seven of them.

These planetary boundaries are included as part of the Tool to provide the representation of global environmental concerns. While many of the planetary indicators are not directly

impacted by the action items from residential refurbishment, there is certainly a direct impact in the area of carbon footprint and measures for protection and adaption to the impacts of climate change.

The following explanations are derived from the Stockholm Resilience Centre (02/07/2012).

Stratospheric ozone layer

The stratospheric ozone layer filters out ultraviolet radiation from the sun. If this layer decreases, increasing amounts of ultraviolet radiation will reach ground level and can cause a higher incidence of skin cancer in humans as well as damage to terrestrial and marine biological systems.

Biodiversity

In the Millennium Ecosystem Assessment of 2005, it was concluded that changes in biodiversity due to human activities were more rapid in the past 50 years than at any time in human history, and the drivers of change that cause biodiversity loss and lead to changes in ecosystem services are either steady, show no evidence of declining over time, or are increasing in intensity. These large rates of extinction can be slowed by judicious projects to enhance habitatand build appropriate connectivity while maintaining high agricultural productivity.

Chemicals dispersion

Emissions of persistent toxic compounds such as metals, various organic compounds and radionuclides, represent some of the key human-driven changes to the planetary environment. There are a number of examples of additive and synergic effects from these compounds. These effects are potentially irreversible. Of most concern are the effects of reduced fertility and especially the potential of permanent genetic damage.

Climate change

We have reached a point at which the loss of summer polar ice is almost certainly irreversible. The weakening or reversal of terrestrial carbon sinks is another such interdependent tipping point. Recent evidence suggests that the Earth System, now passing 387 ppmv CO_2, has already transgressed this Planetary Boundary. A major question is how long we can remain over this boundary before large, irreversible changes become unavoidable.

Ocean acidification

Around a quarter of the CO_2 humanity produces is dissolved in the oceans. Here it forms carbonic acid, altering ocean chemistry and decreasing the pH of the surface water. Increased acidity reduces the amount of available carbonate ions, an essential building block used for shell and skeleton formation in organisms such as corals, and some shellfish and plankton species. Compared to pre-industrial times, surface ocean acidity has increased by 30%. The ocean acidification boundary is a clear example of a boundary which, if transgressed, will seriously change ocean ecology and potentially lead to drastic reductions in fish stocks, with ramifications for the whole planet.

Freshwater consumption and the global hydrological cycle

The freshwater cycle is both a major prerequisite for staying within the climate boundary, and is strongly affected by climate change. Human pressure is now the dominating driving force determining the function and distribution of global freshwater systems. The effects are dramatic. Water is becoming increasingly scarce and by 2050 about half a billion people are likely to have moved into the water-stressed category. A water boundary related to consumptive freshwater use has been proposed to maintain the overall resilience of the Earth system and avoid crossing local and regional thresholds ‘downstream´.

Land system change

Land is converted to human use all over the planet. Forests, wetlands and other vegetation types are converted primarily to agricultural land. This land-use change is one driving force behind reduced biodiversity and has impacts on water flows as well as carbon and other cycles. A major challenge with setting a land use-related boundary is to reflect not only the needed quantity of unconverted and converted land but also its function, quality and spatial distribution.

Nitrogen and phosphorus inputs to the biosphere and oceans

Human modification of the nitrogen cycle has been even greater than our modification of the carbon cycle. Human activities now convert more N2 from the atmosphere into reactive forms than all of the Earth´s terrestrial processes combined. A relatively small proportion of the fertilizers applied to food production systems is taken up by plants. A significant fraction of the applied nitrogen and phosphorus makes its way to the sea, and can push marine and aquatic systems across thresholds of their own.

Atmospheric aerosol loading

This is considered a planetary boundary for two main reasons: (i) the influence of aerosols on the climate system and (ii) their adverse effects on human health at a regional and global scale. Without aerosol particles in the atmosphere, we would not have clouds. Most clouds and aerosol particles act to cool the planet by reflecting incoming sunlight back to space. Some particles (such as soot) or thin high clouds act like greenhouse gases to warm the planet. In addition, aerosols have been shown to affect monsoon circulations and global-scale circulation systems. Particles also have adverse effects on human health, causing roughly 800,000 premature deaths worldwide each year. While all of these relationships have been well established, all the causal links (especially regarding health effects) are yet to be determined. It has not yet been possible specific threshold value at which global-scale effects will occur; but aerosol loading is so central to climate and human health that it is included among the boundaries.

Besides these indicators, according with the current environmental problems, one extra indicator was added to this group.

CO_2 emissions

The carbon dioxide makes up the largest share of "greenhouse gases", disturbing the earth's radiative balance. This is leading to an increase of the earth's surface temperature and to related effects on climate, sea level rise and world agriculture.

Global emissions of carbon dioxide have risen by 99% since 1971, and are projected to rise by another 45% by 2030. To try to prevent or at least lessen this growth, various technologies and activities are being developed and promoted worldwide.

B.5 Sustainability improvement activities

Exterior environment

EE-1: Urban garden

Urban gardening is the process of growing plants of all types in an urban environment.

Table B. 1: Potential benefits from urban greening. Source: (Westphal, 2003)

	Passive experience of a green environmental	Active involvement in greening the environment
Individual	Shorter hospital stay, improved cognitive function	Sense of accomplishment, food security
Organization	Stronger business districts	More members, stronger ties to politicians
Community	Reduced crime	More extemal resources

Studies of people with urban gardens identified the top benefits as "creation of a pleasant environment" and "promoting relaxation". (Dunnet and Qasim , 2000), pointing to the therapeutic aspects of contact with plants. Urban gardening also provides an opportunity for creativity and it is good for the health because of the physical exercise everybody has to do in the garden. It is also a good way to contact with nature and to produce food.

I: This kind of activity can be developed by volunteers. This is not an expensive activity. The main cost to implement this is the works to adequate the floor. After this, the seeds and maintenance prices are low and also the water can be collected by a rainwater harvesting system. The risk and legal barriers of this activity are practically nil.

V: An urban garden has high values for the three vitruvian indicators. It may provide food and these urgan gardens can give to the city a "green space".

S: The main benefit of an urban garden is the food security. Furthermore, this food is going to be healthy. It also gives social and gender equality, and it may also provide job to the citizens. With the rainwater harvesting system it can be also an energy saving source.

P: This kind of activity provide high values to the planetary boundaries resilience indicators because it is a natural source of food that is not emitting CO2 and has not impact on climate change. It has no pollution and, although the land uses may change, this change is to a better situation.

Sources: (Westphal, 2003) (Dunnet et al, 2000)

EE-2: Park

An urban park is a park in cities to offer recreation and green space to residents of, and visitors to, the community. The design, operation and maintenance of these parks is usually done by government.

A lot of researches show that the vegetation in urban areas affects to the thermal environment, air quality and noise levels. With these areas the air temperature is reduced and the heat island is mitigated.

Parks and open green spaces are an important strategy for the quality of life of the urbanized society.

The urban parks have physical, social and economical benefits as:

- Physical health benefits: The relationship between parks and physical activities is well known and it is simply shown in this graph.

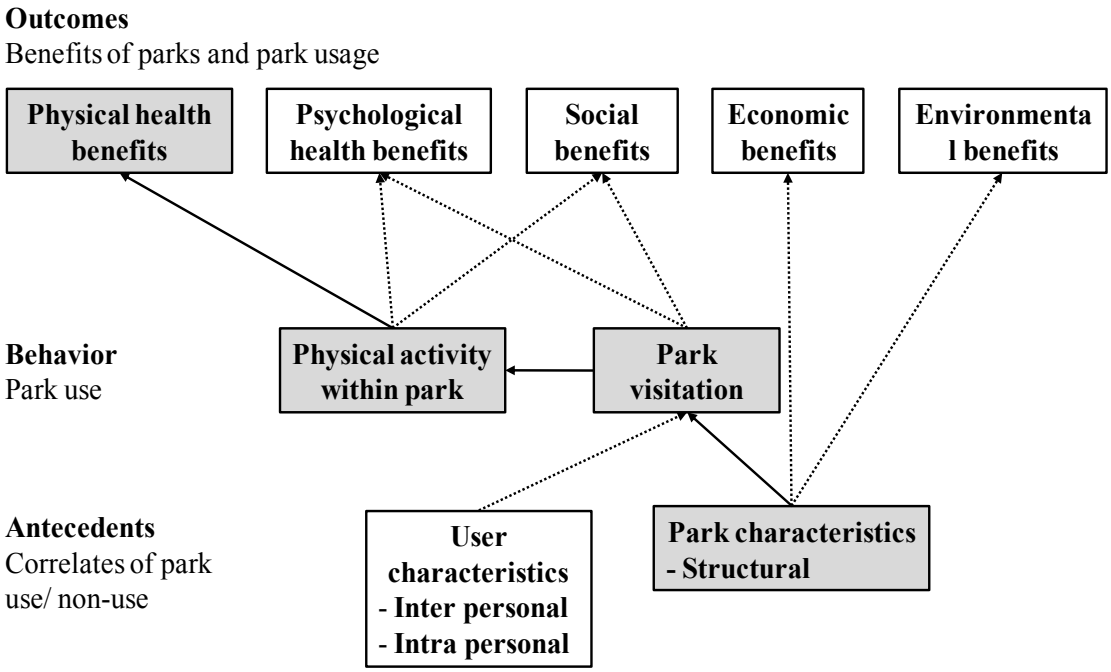

Figure B.1: The relation ship between parks and physical acivity

- Social benefits: The parks may facilitate social interactions that are critical in maintaining community cohesion, pride and social capital.
- Economic benefits: Some studies shows that the proximity to a park is positive related to property value.

Environmental benefits: Parks are important to preserve and purity the environment.

I: Equipment and material for this activity has medium cost, but the maintenance of these parks is cheap. The community members may not develop a park without experts but they can maintain it. A park has no risk but the legal barriers to construct it are highs because it is necessary a large area.

V: A park has high level for this indicators because it is a solid, useful and beautiful area.

S: It is a good activity for social issues because it provides shelter and safety infrastructures. The use of a park may provide gender and social equity.Also researches show the benefits of parks on the physical and psychological health of people.

P: This kind of infrastructures are good for these issues as a park is a green space in the middle of the city that acts like a lung of the city.

Sources: (Chiesura, 2004) (Bedimo-Rung et al, 2005)

EE-3: Cool paving

Permeable pavement, also known as pervious or porous paving, is a type of hard surfacing that allows rainfall to percolate to an underlying reservoir base where rainfall is either infiltrated to underlying soils or removed by a subsurface drain.

Permeable pavement can be used instead of standard asphalt and concrete for many types of road surfaces. Standard asphalt and concrete are considered to be "impermeable" because precipitation that falls on or drains to them cannot flow through the surface to the soils below, but runs to the lowest points to be drained away.

Installing cool pavements can be part of an overall strategy to reduce air temperatures, which can result in a wide range of benefits.

Researchers predicted that the air temperature of a city can be reduced by 0.6ºC if the pavement reflectance were increased from 10 to 25 percent. This reduction would result in significant benefits in terms of lower energy use and reduced ozone levels. Similarly when permeable pavements evaporate water and contribute to lower air temperatures, they also provide other energy benefits such as:

- Nighttime illumination: Reflective pavements can enhance visibility at night, potentially reducing lighting requirements and saving money and energy. European road designers often take pavement color into account when planning lighting.
- Comfort improvements: Using reflective or permeable pavements where people congregate or children play can provide localized comfort benefits through lower surface and near-surface air temperatures.

- Safety: Permeable roadway pavements can enhance safety because better water drainage reduces water spray from moving vehicles, increases traction, and may improve visibility by draining water that increases glare.

I: A cool paving is a expensive infrastructure to implement in the city and can not be developed by the community members. The legal barriers to develop this are high if we are trying to do new roads, but not so high if we are trying to re-develop the existing ones.

V: Cool paving is an useful and solid infrastructure but it is not beautiful.

S: It provides a safety infrastructure to the community and energy saving. It may provide also jobs to the community if they can be formed to maintain the roads.

P: In terms of these indicators, a cool paving is not good except for the impact to climate change because of the energy saving. The land use is also changing to a worse situation.

EE-4: Wetlands

A wetland is a land area that is saturated with water, either permanently or seasonally. Wetlands play a number of roles in the environment; principally water purification, flood control, and shoreline stability. Wetlands are a physical entrapment of sediment and contaminants.

The main ecological functions of urban wetlands are;

- Water storage and flood controlling, water purification.
- Protection of biological diversity.
- Adjustment of regional micro-climate and improvement of urban environment.
- Conserving water and supplying water for urban residential uses.
- Beautification of Urban Landscape and Improvement of Residents' Life Quality

Nowadays a lot of wetlands are disappearing due to the construction of buildings in urban areas, and those who still are in the cities a being polluted and their functions cannot be developed. (Nicholls et al, 2004)

It is important for the urban wetlands to improve the 3R's (Zedler et al, 1998): Restoration, Recreation, Research opportunities.

The benefits of wetlands are shown on table B.1.

Table B. 2: Classification of total economic value for wetlands (Boyer et al, 2004)

Use values			Non-use values
Direct use value	Indirect use value	Option value	Existence calue
Fisheries Agriculture Fuel-wood/tumber Recreation ● Hunting ● Fishing ● Birdwatching ● Hiking Transport Wildlife harvestion Peat/energy Water purification	Nutrient retention Flood control Strom protection Groud water recharge External ecosystem support Micro-climate stabilization Water filtration from pollutants	Potential future uses (direct and indirect) Fuure value of information	Biodiversity (habitat) Culture, beritage Bequest valus

I: A wetland has high development costs but after this the maintenance is not expensive. It is difficult to implement this action with the community people. The legal barriers for this activity are high because it is necessary to have enough area.

V: This activity has high values for the Vitruvian indicators because it is durable, useful and beautiful.

S: In terms of social indicators, it does not have strong relationships with them.

P: The highest benefits of wetlands are those related with the planetary boundaries resilience indicators, because with this activity the area is returning to a natural state.

EE-5: Protecting existing habitat

Since 1994 in the UK exists a Biodiversity Action Plan (BAP) that provided detailed plans for conservation of biological resources.

After the implementation of this plan, the UK has worked hardly in this issues and nowadays exists a framework to implement this kind of activities called UK Post – 2010 Biodiversity Framework. It is designed to identify the activities needed to galvanise and complement country strategies. The shared priorities of this framework, divided into different possible activities, are the following:

- Address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society.

- Reduce the direct pressures on biodiversity and promote sustainable use.
- To improve the status of biodiversity by safeguarding ecosystems, species and genetic diversity.
- Enhance the benefits to all from biodiversity and ecosystems.
- Enhance implementation through participatory planning knowledge management and capacity building.

I: This activity involves a lot of possible actions that may have high or low values in this indicators. Some of these actions may be developed by the citizens.

V: If these actions are trying to protect existing habitats it is suppose that they are going to return some spaces to a natural way, so they are going to be useful and beautiful. The durable indicator depends on what kind of activity are we going to develop.

S: This kind of activity are good for the human health because they are based in protecting the nature.

P: As in other activities it is going to reduce the impact change and the CO2 emissions because it is developed on the idea of protect the environment.

EE-6: Reduce exterior lighting

The intent of this activity is to reduce building, canopy, walkway, parking, roadway, signage, landscape and site lighting when it is not needed during times of limited occupancy or non-retail hours.

Some researches show that light at the night may cause cancer, depression and obesity.

Actually at the night all the places are well illuminated an in a lot of cases they are more illuminated than the necessary. Really, only certain areas need to be illuminated so the light must be focused in these places. With this we can obtain some benefits as:

- Saves energy
- Decreases light pollution
- Reduces light trespass
- Increases safety

I: The costs of implementation of this activity depends on the kind of actions to develop. If we are going to switch off the lights of some streets it is going to be cheap, but if we are going to change the bulbs of all the lamppost of our neighbourhood it is going to be expensive.

V: The Vitruvian indicators are not useful for this action.

S: It is going to save energy and it is also good for human health.

P: It is good for this kind of indicators because with this action is possible to save energy, so the impact of the climate change is also decreased, and the CO_2 emissions are also reduced. Additionally with this activity the light pollution is also reduced.

EE-7: Stormwater management

The stormwater management is used to control the quantity of rainwater runoff and the resultant flooding, and the quality of water in rivers, lakes, streams and oceans that receive this runoff. This runoff is higher since the urbanisation of the cities has been cleared of trees and grass in the street and it was replaced by impermeable surfaces.

Bioswales are vegetated open channels specifically designed to attenuate and treat stormwater runoff for a defined water volume that must be installed in green zones.

There are some design variations of the bio-swale, including grassed channels, dry swales and wet swales. These designs may also include an underlying rock reservoir, with or without a perforated underdrain. The specific design features and treatment methods differ in each variation, but all are considered improvements on traditional drainage ditches.

The bio-swales must be installed in green zones, like parks.

I: In terms of costs, it is not an expensive activity comparing with other activities we are speaking about. It has low level of legal barriers and risk.

V: The stormwater management is a useful and durable action.

S: This activity can provide water security to the community, so it is also a security infrastructure.

P: This activity has its high level values in this group, because it is a good action to fight against the climate change and the pollution.

EE-8: Walking path

Making a suitable walking path, plain, flat and easily practicable, can be the only need for people to walk instead of driving their cars around the city.

If there is a walking path that discourse to atractive buildings or areas, like the park or the amphitheatre, community members will start using it more often.

I: The costs associated with the developing of this action are high, but after this the costs are going to decrease for the maintenance. The legal barriers for this action are high, because it is necessary to use public space to develop it if the goal is to connect this walking path with pre-existing paths.

V: A walking path is a useful and durable activity. In terms of beauty, it depends on the kind of material used to make it. It is possible to develop a walking path with materials that don not change the environment, like grass.

S: It is a good activity for human health, because if people have this kind of paths they are going to go walking instead of by car. Because of this also it represents an energy saving reducing the use of cars.

P: The walking path is good for the climate change and it reduces the CO2 emissions, but it changes the land uses to a worse situation than the natural.

EE-9: Bicycle path

One of the most important pollutant in all cities are cars. In all the sustainable cities plans there are plans to reduce this, and one of the most used solutions is to promote the use of bicycles instead of cars.

I: The costs of implementation of this activity are high, but the maintenance costs are going to decrease. The legal barriers are high because it is necessary to use public space.

V: A bycicle path is useful and durable, and it may be also beautiful.

S: This activity should improve human health promoting the use of bycicles instead of cars.

P: The bycicle path is good for the environment because it promotes not using the car, but the change on land uses is not good.

EE-10: Outdoor amphitheatre

Traditionally, an amphitheatre is an open, circular or oval building with a central space for the presentation of dramatic or sporting events surrounded by tiers of seats for spectators.

Nowadays, the term amphitheatre is used for a space where people can represent different kind of spectacles for the sace entertainment.

The benefit of the amphitheatre in this public space is that all the people can go to see those spectacles and promote the social life and the social equity among different people.

I: In terms of these indicators, this action is not good because it has high costs and legal barriers. It cannot be developed by community members, it is necessary experts.

V: The values for the Vitruvian indicators depend on the kind of infrastructure to develop. It may be a solid and beautiful infrastructure according to the general aspect of the environment.

S: With the activities that can be developed in this infrastructure, the social and gender equality are going to improve because all community members can participate.

P: The outdoor amphitheatre is not a good actions for this indicators because it is an infrastructure that don not add to the natural state land.

EE-11: Pond

Wet ponds are constructed basins that have a permanent pool of water throughout the year. They are a good source to storage rainwater and decrease the effects of runoff. Moreover, they have a good effect to the health because these areas returned to a more natural state.

The main problem with this kind of infrastructure is that they need a relatively large area.

I: The costs of implementation of a pond are high and it has also high legal barriers because of the area necessary to implement it. It is not possible to develop a pond without experts, so only the community members are not sufficient.

V: It is a durable, useful and beautiful infrastructure.

S: It may provide food and water security. It also is healthy and safety and can provide job to the community if they are formed to this.

P: With this activity an area of the city is going to return to a more natural state, so it has good effect on the climate change, in the pollution and in the CO2 emissions. Furthermore, the land uses are going to change with this implementation, but this change is going to be beneficial for the environment.

Source :http://cfpub.epa.gov/npdes/stormwater/menuofbmps/index.cfm?action=factsheet_results&view=specific&bmp=68

EE-12: Shade trees

The benefits of green areas into the urban city are well known. But the benefits of shade trees in the streets to provide shadows are not very studied yet.

The general benefits of trees are: it combat the greenhouse effect, clean the air, provide oxygen, cool the streets and the city, conserve energy, save water, help prevent water pollution, help prevent soil erosion, provide shield children from ultraviolet rays, provide food, reduce violence, it marks the seasons, create economic opportunities, trees are teachers and playmates, it bring diverse groups of people together, adds unity, provides a canopy and habitat for wildlife, provides wood, increase property values, and increase business traffic.

To have trees into the streets and the parking providing shadow to the asphalt may cause a decrease in the degradation of this asphalt which translates as a large money saving.

I: The costs for planting these trees may be high because the soil must be changed from asphalt. After this, the costs of maintenance are not so high. The risks of this activity are not important, but the legal barriers may be high because it is necessary to use public roads to develop it.

V: The highest value for this indicators is that it is a beautiful activity. It also may be useful and durable.

S: It may is healthy and safety and the maintenance of these trees can provide job to the citizens.

P: The urban area is going to return to a more natural situation, and trees are beneficial for the climate change, the pollution and the CO2 emissions.

Sources: http://www.treepeople.org/top-22-benefits-trees

http://www.fs.fed.us/psw/programs/uesd/uep/products/cufr_673_WhyShadeStreets_10-06.pdf

EE-13: Plant nut / fruit Trees / berry Bushes

The idea is to plant fruit trees, berry bushes and nut trees in the street where citizens are able to pick it. With this, it is possible to provide some sort of food security to citizens.

The urban trees are used to contribute with the fisiological, sociological and economical welfare of the urban society. If these urban trees are fruit trees it may help because it can provide direct subsistence food products. If besides these trees, plant nuts and berry bushes are planted, the citizens access to this food source greatly increases

I: As in the case of shade trees, the costs for planting these trees and plants may be high but the costs of maintenance are not so high. There is no risk in this activity, and the legal barriers can be high if it is necessary to use public space.

V: This is a useful and beautiful activity that should be also durable.

S: It provides food security to the citizens and also is good for the human health because this is natural food. It may provide also jobs for maintaining them.

P: This activity is good for all the planetary boundaries resilience indicators, because the trees and plants are supposed to have a more natural.

Built environment

BE-1:Seal and insulate building skin (Thermal envelope)

Reducing air infiltration into a building is the first step in improving building efficiency to reduce the heat loss. It includes sealing the attic space of all interior wall cavities, sealing any openings in the ceiling from light fixtures or around chimneys, and sealing around electrical receptacle and windows. The aim is to have a continuous air tightness layer.

Once the air sealing is completed, a continuous layer of insulation can be added to all exterior walls and ceiling, extending down into the ground to the frost level.The best practice is for this insulation to be adjacent to the air barrier, or that any material in between the two layers are not susceptible to moisture damage.The thickness and composition if the insulation is dependent on the needs of the local climate.

I: The activity of air sealing should be conducted under the guidance of a certified energy rater.This job requires training and initial outlay of equipment of around 5,000 Euro.The activity of air sealing has a low equipment and material cost, and can be easily learned and implemented by local labor. Equally, adding insulation can be learned and requires minimal equipment, but can be costly for material.While there are no legal obstacles,there is a risk of the energy improvements causing problems with mold and moisture if not done under the supervision of a trained rater.

V: Improving the thermal envelope, when done properly, can be very durable and provide the use of reducing energy needs for many years. Since it is essentially invisible, it cannot be considered to be beautiful, but one might consider that it brings delight in the added levels of comfort and the lower utility bills..

S: This activity is correlated to a few of the Social Foundation Indicators.It can improve the security of the shelter, by protecting it from deterioration from weather;the improvements can improve the interior temperatures to contribute to personal health, and it reduces the consumption of energy.

P: The lower use of fuel also reduces the related carbon emissions.Air sealing and insulation materials needs to selected to avoid materials that contribute to atmospheric aerosol, CO2 emissions, or chemical pollution.

Source: Energy Savings Trust Improving airtightness in dwellings and Insulation

BE-2: Improving efficiency of windows

Improving the energy efficiency of windows refers to the sealing against air infiltration and increasing the thermal barrier by increasing the layers of glazing. Sealing around old windows can greatly help reduce air leakage. The least disruptive approach, with the lowest implementation cost, is the addition of a secondary level of glazing either on the interior or the exterior of the building. This approach can often be done with recycled glazing material which can be resized and fitted to bespoke frames. The disadvantage of this method is the inability to have open windows for air circulation. Also, the existing windows might be broken or no longer functioning and will need to be replaced. In this case, new windows can be installed.

I: The implementation of window replacement has a low equipment cost, relatively high material costs, but typically low legal barriers and no risk.

V/S/P New windows can also bring great delight, particularly if they have been selected to provide the best use for the particular need. The choices for new windows are concerned primarily with improved energy efficiency, and thus the reduction of carbon. However, the oft neglected consideration is the durability and the impact on other planetary indicators.The choice of windows is often driven by cost, but low cost windows may not be very durable.If the window frame is not sufficiently robust, the seal between the frame and the glazing will be ruptured and they may be just as leaky as the original windows.The materials used in window frames are vinyl, wood, metal and fiberglass with different expectations of service life and need for maintenance.These have varying degrees of impact on planetary boundaries, such as air pollution and land use (e.g. from mining activities and lumber harvesting).

Sources: Sinha and Kutnar (2012) Carbon Footprint versus Performance of Aluminum, Plastic, and Wood Window Frames from Cradle to Gate

Sustainability Analysis of Window Frames (2005)
http://bse.sagepub.com/cgi/content/abstract/26/1/71

BE-3:Water efficiency

Water efficiency of a building can be improved by reducing the demand for water, improving the system of delivery (the pipework) or the increasing the efficiency of water delivery at the fixtures. Reducing demand can be accomplished by installing more water efficient washing machines, dishwashers, or other appliances that use water.Water delivery systems can be improved during building reconstruction by bringing the fixtures and the water heaters closer together, the installation of manifold delivery systems, or the installation of on-demand hot water heaters. This reduces the wasted water from waiting for the water at the tap to get hot.

I: This action will typically have high material costs (appliances, low-flow fixtures, new piping), low equipment costs, and requires a skilled plumber for implementation.However, there are no legal restrictions and this action carries a low risk.

V: Improving water efficiency can be very durable and provide a long useful life, if installed well and with quality materials.

S:It can improve the water supply and personal health by replacing old corroded lead water pipes with clean piping that does not contaminate the water.This action will also save energy from the improved efficiency of water heating appliances.

P: Reducing energy is linked to reduced CO2 emissions, but the reduced waste also contributes to the most efficiency use of water.

BE-4: Rainwater harvesting system

Rainwater can be collected and stored on property, for uses in irrigation or other non-potable uses. Rain collected from rooftops by rerouting the gutter downspouts into rain barrels, which can be re-used barrels from any food-grade use. It can also be routed into swales, or large underground containers.

I:The cost of implementation can range from very low for simple schemes and smaller water storage containers, to a higher expense for more complex schemes such as underground water storage.The legal barriers can be considerable since rainwater are often considered to belong to the collective whole, or the government agencies.There may be limits placed on the size of the water collection.The pollution risk from standing water can be mitigated through design.

V: Rainwater harvest systems can be very durable with suitable materials and design.The usefulness of this rainwater harvesting is linked with the availability of uses for non-potable water, such as gardens.Finally, rainwater harvesting systems can be designed to bring delight both in the collection of the water and in the redistribution of this water to other systems.

S: Harvesting of rainwater can increase water security, and can also contribute to food security.In areas of scarce water, the ability to gather water at no cost may also

P: The harvesting of rainwater can improve the best use of freshwater by replaces some of the uses of domestic water, which also reduces the handling costs of this water.In dry climates that are experiencing increasing drought from climate change, the harvesting of rainwater can provide a reserve to help equalize the supply.The availability of water could also be used to increase vegetation in the urban environment, and help reduce the heat island effect and even reclaim empty urban lots for garden and natural use.

BE-5: Electrical system efficiency

Improving the electrical system efficiency refers to the improvement of the distribution system as well as the point of delivery. Buildings that were built before WWII will often need to be entirely rewired and new circuits added as a safety precaution against fire and in order to upgrade the systems for today's expectation of power needs. Big savings in electrical can be achieved by higher efficiency applications for heating, refrigerators and lighting.

I: The cost of implementation can range from low cost measures such as switched receptacles outlets to turn off phantom loads, changing out lightbulbs a few at a time for LED or fluorescent, and putting a motion sensor on lights in public spaces such as hallways. In these activities licensed electricians should be hired when dealing with any rewiring. They are all low-risk and have no legal barriers, though may be governed by Electrical Codes as well as Green Building criteria. More extensive projects, such as the rewiring, come at a greater cost of labor, but can alleviate future risk.

V: Durability and functionality are very important when dealing with electrical refurbishment. Thoughtful design of the electric circuits may provide opportunities for future adaptive use. Beauty is not often a criteria that is associated electrical,but lighting fixtures and bulbs can bring delight.

S: Electrical improvements can also increase the security of a building.Motion sensors that are remotely linked to lighting fixtures can improve functionality and also safety.For

example, a motion sensor at the entry to a walkway can cause light affixed to the building to turn on. Motion sensors, located at windows and doors, can be linked to security cameras to help alert security guards, and of course the openings can be alarmed against breaking and entering.

P:If the net result of the electricity improvements are lower need for electricity, than this savings has also reduced CO2 emissions.

BE-6: Improve energy efficiency heating/ cooling

The approach to heating and cooling differs greatly between countries, and even within demographics of a community. However, the actions to improving comfort are based on building science and can be generalized.The first step is to reduce the need for supplemental heating and cooling. This can be achieved through insulation, shading of the building, and passive solar gain.A key element is reducing air infiltration and draftiness.This action refers to the next step, which is improvement of the efficiency of the heating or cooling equipment. Simple actions by tenants can improve the circulation of the heat, keeping radiators or heat vents clean from dust, and not blocked by furniture. Equipment with filters will need regular exchanging, both for air quality and to not overtax the motor. Annual maintenance can also improve efficiency and safety of the equipment.Replacing old equipment is more expensive, but may be a more cost-effective option with the higher efficiency units. When replacing equipment, the whole delivery system should also be considered for efficiency upgrades. Insulating the exterior building shell should decrease the demand,and smaller sizing might be appropriate. Also, there may be options for shared or centralized units for improved cost/ benefit.

I: The cost and benefits are directly correlated, with low cost and do-it-yourself improvements able to improve only up to the efficiency of old equipment. New equipment installation is governed by regulations for life and safety, but present no legal barrier.The risk is limited to the building owner, as it is born by the equipment manufacturers.

V: Improving energy efficiency should be highly functional and selected for durability. The beauty is not obvious, but it can bring comfort.

S/P: Improving energy efficiency contributes to energy savings (S), and reducing CO_2.

BE-7: Renewable energy - solar PV or thermal

This action refers to the procurement of renewable energy generation at the building site. In the case of electricity generation from PV or wind turbines,this energy is typically fed

back into the grid in a feed-in tariff scheme. These tariffs are fixed by government, and are often unstable and unreliable revenue in a business model. The implementation costs are high capital costs (equipment), but generally low legal barriers or risk. However, there are maintenance issues with PV panels, both in keeping them clean from debris and also monitoring to ensure that the inverter is functioning properly. Small wind turbines have not proven to be very efficient, and are thus not considered here.In addition to the storage of energy as electricity,energy can be stored in the form of heat. For example, solar thermal panels can transfer heat from the sun to heat up a tank of water. This can be used for radiant heating and also for domestic water.The implementation costs can be much less than for PV panels,with much longer durability.

I: PV panels initial cost is always high, the capital expense cost on this action is high for unites and the whole system.

V: Due to the high capital costs of this action, the durability and continued functionality of the solution should be key decision issues.Solar panels were once considered to be ugly and unwelcome additions to a home, but are now often a source of community pride.Generating power on site can contribute to a sense of energy security, and reduce CO2 by providing an alternative to fossil fuel.

S/P: This action will result in energy saving, and thus reduced CO_2.

BE-8: Install individual metering and payment

Installing individual metering for utilities at each residence unit can result in energy savings from conservation efforts. Payments methods can be adapted to accommodate the economic means of the residence. In some schemes, pre-payment is made at the metering station or at a point of collection. This removes the landlord's risk of unpayed bills, and it also avoids any paperwork interaction if the payment is not made. The meter simply shuts off the electricity, and stars up again when the payment is made.

I: The capital expense costs on this action is not high per units, rather in sum of all apartments.

V /S/ P: High functionality, durability.This action will typically result in energy savings, and thus reduced CO2.

BE-9: Install home energy dashboard in each unit

Installing an Energy Dashboard is the next level to individual metering.Energy Dashboard controllers and electricity sensors can provide real-time feedback on the electrical

consumption in the house. Residents can use this information to monitor their patterns of consumption.

I: The key obstacle to this implementation is the high capital expense of materials, and the problem of aligning the cost with the beneficiary. In some schemes, the utility company or 3rd party financing may underwrite the initial capital cost and receive compensation from savings or a surcharge allocated to each months' bill.The difficulty is the transient nature of the rental population who would be quite unwilling to pay extra for something for which they might not ever benefit during their stay.

V/S/P: Highly functional.This action will typically result in energy savings, and thus reduced CO_2.

BE-10: Improve air quality

Air quality generally refers to the amount of particles in the air. Improving this quality can be achieved through dilution, source removal, or filtration. Air pollutant sources that are generated within the building can generally be controlled. Some low-cost options are installing exhaust fans in kitchens and bathroom, and increasing air flow with fans and open windows. However, in urban areas, the outdoor air is often polluted and the strategy is changed to one of filtration and protection. In severe cases, whole building filtration can effective, but carries a risk of creating a "sick-building" syndrome if not designed for adequate air flow. Also, tenants are likely to open the windows and doors to balconies and thus introduce unfiltered outdoor air. Another option is the introduction of plants into the common areas of the building, to provide natural ventilation, as well as encourage the tenants to have greenery within their dwellings.

I: The implementation cost of this action could reach to zero if preventive actions are taken. A low cost material such a plant may help improving air quality inside buildings.

V/S/P: The importance of improving air quality is directly related to personal health.

BE-11: Optimize daylight

Optimizing daylight can be accomplished at several levels. Daylight can be introduced into the building through is typically by means of common spaces with a lot of glazing, such as central staircases or interior corridors lit through clerestory or glass roofs.For new construction, the geometry of a building can greatly affect the amount of interior lighting. Daylight can also be introduced to individual units by strategically introducing the amount of glazing on outside walls, and also introducing transom windows above doorways to

allow the light to pass into the interior.Brightly colored reflective surfaces can also optimize the daylighting.

I: Most of these solutions involve construction, and a high cost of labor and often materials (though not equipment).There are few legal implications, and only the risk related to heat gain (see below). However, this indicator of daylighting should be included within energy refurbishment schemes, as the added cost of work may be far outpaced by the added value to quality of life.

V/S/P: The importance of daylight is directly related to personal health.Not only can the presence of sunlight in a building generate delight, but the absence of daylight has been linked with depression and SAD disorders. It can also reduce the electricity use by reducing the time that interior lighting is needed.However,the design of windows should consider the effects of added solar heat into the building, and provide shading to protect from the summer sun heat. Also,increasing window glazing should be done with consideration to the relative lower thermal and safety protection than can be provided by a solid exterior wall. However, exterior windows can contribute to safety if the building occupants gain a better view of events on the exterior of the building, but people on the outside gain no information about the activities on the interior.

BE-12: Interior green spaces

Improving interior green spaces is closely linked to the indicators of improving air quality and increasing interior daylighting. Similarly, these can be implemented at a whole building level or at the individual flats.Stairwells with large landings and interior gathering areas can serve as greenspaces. There are many opportunities to balconies / Stairwells - "Green" wall/ garden

I: Interior green-spaces within common areas are typically maintained by exterior contractors and represent a maintenance cost.However, in a residential complex, this labor could be supplied by the community. Once the planting structures are constructed, material costs are relatively low, and could be paid by a tenant collective.The legal limitations are related to egress and not blocking the clear passage on the stairs or hallways. This action can also be connected with that of urban gardens. The interior space can serve as a greenhouse to start vegetables in the early spring, and also provide shelter for plants that need to be overwintered.

V/S/P: Green spaces in common areas can bring great delight (V), and bring neighbors together in a common activity that can support gender and social equality (S).

Additionally, greenspaces in common areas and within tenant units can be used to grow fruits and vegetables for increased food security (S). The plants can also mitigate some of the air pollution, and contribute positively to the reduction of CO_2. The benefits of having both common greenspace and individual tenant gardens is the exchange of information, both informal and supported by garden expertise.

BE-13: Exterior green wall

Exterior greenwalls have become a popular feature in "green buildings" but the concept of using vegetation as shade for a building has long been practiced. There are many variations of this concept, including rows of tall trees planted very near the exterior wall, plants growing up trellis attached or near the building wall or even hanging gardens growing from the building rooftops. Considerations in design include the protection of the building foundation from tree roots, the impact of the moisture captured by the greenery on the structure of the structural wall, and the maintenance of the plants.

I: As there are many options, the capital costs can vary considerable. In all cases, a greenwall will require ongoing maintenance and labor.If this space has been used for growing food (grapes, columnar fruit trees), then this ongoing cost can become part of the responsibility of the persons benefiting from the food.There should be no legal barriers, and the risk would be related to the safety of the workers.

V/S/P: The functionality of a greenwall is based on the ability to cool the building and possibly provide food. The durability is dependent on the growing conditions created by the design and installation. The beauty of a greenwall is very much dependent on the level of maintenance. A greenwall can contribute to food security, and can reduce energy consumption and therefore CO_2 emissions.

Social-economic needs

SE-1: Community kitchen

With this kind of kitchens is possible to combine a way to reduce food waste with an excuse to bring a community together. Furthermore, it may be possible that if one person (or family) is not able to pay its own food, his neighbors may pay for it.

I: The costs of implementation of this action may be high if it is necessary to build a kitchen in a building. After this, the cost of maintenance are not so high, and it is possible that the same people that is cooking in the kitchen pay for the food they are using. In terms of legal barriers, there are not problems in this case, and the risk is nil. The people that cook in this kind of installations may be the community members and it is not necessary to involve experts and other people.

V: It is a very useful and solid infrastructure.

S: It provides food security for the community members and also can be a way to save energy because all the people is cooking in the same place. Furthermore, it promotes the gender and social equality.

P: In terms of planetary boundaries resilience indicators, this kind of activities do not influence at them.

Sources: http://www.cagoxfordshire.org.uk/news-archive/236-community-kitchen-brings-oxfordshire-together

http://www.cagoxfordshire.org.uk/news-archive/236-community-kitchen-brings-oxfordshire-together

comedorespopulares in Peru:
http://www.ifpri.org/sites/default/files/publications/ib9_peru.pdf

Community Kitchens in Australia: http://www.communitykitchens.org.au/

http://docs.health.vic.gov.au/docs/doc/52B54F7C83AC8224CA25788B001B05FA/$FILE/CommunityKitchens.pdf

Handbook for Community Kitchens:
http://www.wrha.mb.ca/healthinfo/prohealth/nutrition/files/Nutrition_3.pdf

Guidelines on Remodelling Community Kitchens:
http://www.extension.iastate.edu/publications/pm2071.pdf

Community Kitchen Toolkit Newfoundland:
http://www.foodsecuritynews.com/Publications/Community_Kitchen_Best_Practices_Toolkit.pdf

Community Food and Health Scotland: http://www.communityfoodandhealth.org.uk/about-us/

Aberdeen city centre community kitchen plan: http://hi-netgrampian.org/hinet/file/6875/CommunityKitchenOptionAppraisal.pdf

Greater Vancouver Food Bank Society - Community Kitchen Program: http://www.freshchoicekitchens.ca/community-kitchens

http://www.nada.ca/wp-content/uploads/26.pdf

SE-2: Book crossing

The idea is to share the books with your neighbours. It is a good idea because normally when you have read a book you are not going to read it again, but also you don't need this space in your house to storage the books

I: The costs of implementation of this action are not going to be so high if in the building exists a big room to develop this action, and the materials and maintenance of it are also going to be low. There are no risk or legal barriers to develop this activity.

V: It is a very useful and solid infrastructure

S: It provides gender and social equality. It also can provides job to people of the community to undertake this activity.

P: In terms of planetary boundaries resilience indicators, this kind of activities do not influence at them.

Source: http://www.deskunion.co.uk/why-coworking/

SE-3: Coworking

It is based in the idea of use empty spaces in the buildings as spaces for working. Everyone can work together and everybody can work to the other people.

I: The costs of implementation of this action are not going to be so high if in the building exists a big room to develop this action, and the materials and maintenance of it are also going to be low. There are no risk or legal barriers to develop this activity.

V: It is a very useful and solid infrastructure

S: It provides gender and social equality.

P: In terms of planetary boundaries resilience indicators, this kind of activities do not influence at them.

Source: http://www.deskunion.co.uk/why-coworking/

SE-4: Urban barter

An urban barter is based on the idea that everybody have in their homes clothes and staffs that are new or semi-new buty thery are not using. All these things can be sell to other people that may need it cheaper. With this activity people is going to have less things not used in theris house and they can buy things at lower price.

I: The cost of implementation of this activity is low, only it is necessary an empty space to develop it and buy some materials that may be cheap. The maintenance costs are not going to be high to. The risk and legal barriers does not exist in this activity.

V: It is a useful and durable infrastructure that may be also beautiful.

S: It can provide job and social and gender equality to the citizens.

P: This activity has not relationships with the planetary boundaries resilience indicators.

SE-5: Bike kitchen

Bike kitchens are non-profit repair shops set up for the purpose of supporting the use of bicycles. They are generally organized as a cooperative or a non-profit association, and are supported by volunteer labor and donations. The repair centers can be open to the public for a fee, or volunteers might be trained to help people fix their bikes. Some of the outreach functions of these centers may also be bike repair clinics, support of local efforts for bicycle paths, and safety riding lessons for the public. Bike kitchens do not compete with for-profit bike shops, as they are serving a different clientele. In fact, for-profit shops will often participate with bike kitchens.

I: Bike kitchens are low cost implementation, since many of the bicycle and bike parts are donated. However, there is a cost of space leasing and the initial repair equipment. Some creative approaches include the shop space being established within another store, or warehouse. There are few legal barriers, but the boundary of risk does need to be established for the protection of the volunteers. This is typically accomplished through the formation of the legal entity of non-profit organization.

V: This action is particularly effective in bringing delight to the population it serves, as it provides transportation to people with limited income. It can also bring delight to children who may not otherwise ever experience the pleasure of bicycle riding. Also, the benefit of a bike kitchen is the access to skilled technicians and the right tools to make the bicycle repairs more durable.

S: Having access to a bicycle directly improves the transportation infrastructure of a community. Bicycles can help link to existing infrastructure, such as busses and trains. They can also support gender and social equity. Bicycle riding can also improve health.

P: Commuting by bicycle and public transport saves on fuel and reduces CO_2.

SE-6: Public transportation

According to UK government improving local transportation policy, two-thirds of all journeys are under 5 miles and that many of these trips could be walked, or made by bike or public transport. Plus, encouraging the public to use mass transportation and leave their cars home will reduce their carbon footprint and helps UK reach its climate change goals.

I: The costs of implementation of this action are not going to be so high if there is already a good public transportation network in the area. There are some risksand legal barriers to develop this activity.

V: It is a very useful and solid infrastructure.

S: It provides gender and social equality.

P: In terms of planetary boundaries resilience indicators, this kind of activities influence directly and indirectly the planetary boundaries in terms of carbon footprint and CO_2 emissions.

SE-7: Education space

Creating an educational space within a community can serve all age groups of the population, from children to adults. It can be developed for formal children's education, crèche, or part-time children's crafts or recreation. This same space can be re-used in the evenings for adult education, for outreach programs by community education or specialty training. An indoor gathering space can be used for young adult after school activities.

I: The initial costs of building an educational space should be high if the instalations are not prepared for it, but if it is available an empty space it is only necessary to buy some items that are not very expensive. Also it requires low maintenance.

V: It has the three Vitruvian attributes, it is useful, solid and beautiful.

S: It provides gender and social equality.

P: It does not contribute directly to the planetary boundaries resilience indicators, but in some cases the use of recycled materials and the recycling education can help with this.

Energy/ waste

EW-1: Waste to energy plant

Waste-to-energy (WtE) or energy-from-waste (EfW) is the process of generating energy in the form or electricity or heat from the incineration of waste. It is a form of energy recovery that may produce electricity and/or heat directly through combustion or produce a combustible fuel as methane, methanol, ethanol or synthetic fuels.

Most of WtE plants have incinerations to combust the waste for energy recovery and modern incinerators can reduce the volume of waste more than 90%. The incinerators have electric efficiency of 14 to 28%. For preventing the energy losing, it can be also used with cogeneration for district heating. Even if, WtE plants have great efficiency, it is relate to big global issue as air pollution.

According to International Solid Waste Association (ISWA), the number of WtE plants in Europe is 431 and 89 plants in United States are existed in 2004 (ISWA, 2006).

I: Even though it needs lots of money to build the facility, maintainance cost is low because it uses the waste for material to generate the power. But it has some risks such as fire, explosion and accident.

V: It is solid/durable and useful to provide heat and electric. But it is not beautiful.

S: It is not related with social foundation.

P: It is too deeply invelved with plantary boundaries. It can reduce the waste to landfill,but it makes chemical and air pollution by buring the waste.

Sources: B&W.(2010). Waste to energy plant, Amager Bakke, Copenhagen, Denmark.

ISWA. (2006). Energy from waste, State of the Art Report Statistics 5th Edition, International Solid Waste Association, Denmark.

EW-2: Biomass

Biomass, mainly in the form of wood, is the oldest type of energy used by humans. Traditionally, biomass has been utilized through direct combustion, and this process is still widely used in many parts of the world (Balat, 2006). Biomass (Biofuel) is the organism for generating biological energy. It includes firewood, charcoal, gas from organism, etc. It usually mentions plants or derive materials as called lignocellulosic biomass, but biomass

can apply to material derived by both plants and animal (Biomass Energy Centre,http://www.biomassenergycentre.org.uk)

It is eco-friendly, low cost and it can be used in anywhere. But it makes bad smell from waste and needs ground for structure.

I: This kind of activities represents a large investment of money both when making facility as when maintain. The legal barriers to implement this activity are not so high, because nowadays all governments try to develop this kind of renewable energies.

V: Biomass plants are solid and useful but they don not have any beuty.

S: If a biomass plant is ubicated in a city, it may provide jobs and income to the people that lives there. It may also provides an energy production and saving. Finally, it also can be considered as a safety infrastructure.

P: A biomass plant improve the planetary boundaries resilience indicators because this is a renewable activity and it means less damages to the environment. The negative part of this activity is that the land uses has to change to a worse situation.

Sources: Balat, M.(2006). Biomass energy and biochemical conversion processing for fuels and chemicals, *Energy Sources*. Part A, **28**. 517-525.

Biomass Energy Centre.(2013) http://www.biomassenergycentre.org.uk, United Kingdom.

EW-3: Waste management-recycling

The waste recycling is the process for recovering waste products as inputs or resources. It is a part of waste management process.

The main benefits of the recycling process are the following:

- Reduces the amount of waste sent to landfills and incinerators.
- Conserves natural resources such as timber, water and minerals.
- Prevents pollution by reducing the need to collect new raw materials.
- Saves energy.
- Reduces greenhouse gas emissions.
- Helps sustain the environment for future generations.
- Helps create new well-paying jobs in the recycling and manufacturing industries.

I: The implementation of the waste recycling is expensive if there is no plant pre-existing. After the construction of the plant, the costs of maintenance are not so high. The legal barriers and the risk of this activity are very low.

V: A waste recycling plant is a useful and durable infrastructure but it is not beautiful.

S: It may provide job and income to the community people and it also provide an energy saving. This activity is also good for the political voice.

P: This activity should make a beneficial contribution to the planetary boundaries resilience indicators because the main benefit of this activities is beneficial to the climate change, pollution and CO_2 emissions. The construction of a recycling plant may be harmful to the land uses, but the benefits are higher than this.

Source: http://www2.epa.gov/recycle/recycling-basics

EW-4: Waste management-reuse

Reuse is using an object or material again, either for its original purpose or for a similar purpose, without significantly altering the physical form of the the object or material. The main difference between recycling and resue is that the first activity alters the physical form of the waste, and it consumes more energy and resources than reuse. Reuse is considered a form of waste prevention.

The waste management reuse has several benefits as:

- Environmental benefits. The US Environmental Protection Agency has recently identifies waste reuse as an important method of reducing grennhouse gas emissions.
- Community benefits. Reuse may provide a way in which to get people the food, clothing, building materials, business equipment, medical supplies and other items.
- Economic benefits. Reuse is an economical way for people of all socio-economic circles to acquire the items they need.

I: The waste reuse may be a cheap action if the population is aware of this necessity. It is not necessary to have infrastructures for this action, because people themselves can resuse their waste. There are not risks or legal barriers with this kind of activity.

V: This kind of activity may generate solid, useful and beautiful outcomes.

S: The main benefit of the waste reuse is the energy saving because it is not necessary to create so many new products.

P: It is a good activity for the planetary boundaries resilience indicators. With this activity it is possible to benefit the environment without producting so many things.

Sources: http://www.calrecycle.ca.gov/reducewaste/define.htm#Reuse

http://loadingdock.org/redo/Benefits_of_Reuse/body_benefits_of_reuse.html

EW-5: Waste management-minimization

The waste minimization is the reduction of waste at its source to minimize the quantity required to be treated and disposed of, achieved usually through better product design and/or process management.

A well organized waste minimization program can produce many benefits for a facility:

- Lower operating costs from the substitution of less expensive raw materials.
- Lower end disposal costs.
- Lower energy costs through the use of newer, more efficient equipment.
- Increased health and safety of your staff from reduced exposure to hazardous materials.
- Reduced concerns about penalties, liabilities, and regulatory burdens.
- Improved public image promotes positive public relations with client, customers, and the local community

I: The cost of implementation of this kind of activities is low. It should be a good idea to do some courses or seminars to the community people to become aware with this kind of activities. It may be done by the people of the buildings, and it has no risk or legal barriers.

V: It is no relationship between these indicators and the waste minimization.

S: The waste minimization provides a energy saving in the water management process, if a population is generating less waste, the energy used to manage this waste is also less.

P: With this activity the impact on the climate change will be lower, and the pollution and emissions are also going to be decreased.

Sources: http://www.businessdictionary.com

EW-6: Waste management-prevention

The term waste prevention includes all the actions performed in order to prevent the generation of waste. Waste reuse is a kind of waste prevention but it does not include all the actions of waste prevention. Examples of other actions are avoiding the use of disposal utensils, napkins and paper towels or buying durable items.

The environmental benefits of this activity are the following:

- Conservation of natural resources.
- Reduced environmental impact from raw material extraction.
- Reduced energy usage and pollution from manufacturing.

- Reduced burden on landfills and combustors.

This activity also has economic benefits like:

- Reduce waste management costs.
- Savings in material and supply costs.
- Saving from more efficient work practices.
- Potential revenues from selling unwanted or reusable materials.

I: The waste prevention may be an action that the population of the community can develop alone. It is not necessary a large investment. There are no risk or legal barriers in the development of this action.

V: These indicators are not useful for this action.

S: The energy saving is the main benefit of this group of indicators. If the people become aware with this action, the necessity of waste management would be lower, so the energy employed on it should decrease too.

P: This action has huge benefits in this group of indicators, because it improves the climate change, the pollution and the emissions.

Source: http://www.calrecycle.ca.gov/reducewaste/define.htm#WastePrev

http://www.epa.gov/wastes/conserve/pubs/spotlght.pdf

Coastal/ climate change

CC-1: Make local port/harbor for access/independences

A port or harbor is defined as an artificial structure in coastal for protecting ships from wave, wind, etc. This structure is necessary to upload and offload products to/from ships.

Sometimes, ports are constructed with multiple functions and it provide benefits to the coastal cities, as jobs, goods and energy. It also has some disadvantages like the ocean pollution produce by the waste from the ships. So, it is necessary to build an eco friendly and sustainable port/harbor.

I: A port is a expensive infrastructure that also needs regular maintainance. It takes much money to build the ports. And it needs regular maintainance. But it can provide a lot of jobs and shelter for ships.

V: This infrastructure is useful because it is economically necessary and in these days, they aremade with materials which confers durability andbeauty.

S: A port can provide food, water, job, income and transportation through the ships. It also can provide social and gender equality.

P: In terms of the planetary boundaries resilience indicators, a port is only related with the land uses changes, as a port changes the structure of the sea to a worse situation.

CC-2: Create coastal forest

Coastal forests are planted in coastal boundariesfor protecting against a natural coastal disaster, such as tsunami or storm surge. A coastal forest can absorb the energy of wave soit decreases the damage of the disaster.

I: The cost of planting trees in the coastal boundary is not high and this activity may be developed by the citizens. The risk is no big, but the legal barriers are higher than in other cases because it should be built in a public space.

V: This activity is a solid, useful and beautiful activity.

S: The maintenance of the coastal forest should provide long-term jobs and sources of food and wood to the population.

P: Coastal forests minimize the impact of climate change, because the trees have function of the carbon capture and nature preservation. The land uses are going to change but to a better situation because it is going to be a natural space.

Sources

Braatz, S., Fortuna, S., Broadhead,J. and Leslie, R. (2006). Coastal protection in the aftermath of the indian ocean tsunami: what role for forests and trees?.*Proceedings of the Regional Technical Workshop*. KhaoLak, Thailand.

Forbes, K. and Broadhead, J. (2007). The role of coastal forests in the mitigation of tsunami impacts, *Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific Bangkok*.

Harada, K. and Imamura, F. (2005). Effects of coastal forest on tsunami hazard mitigation - apreliminary investigation.*Tsunamis Advances in Natural and Technological Hazards Research* .**23**, 279-292.

CC-3: Building a seawall

A seawall is a structure separating land and water areas. The objective of this infrastructure is to prevent coastal erosion and other damages due to wave action and storm surge. Seawalls need a maintenance and replacement for an effective long term use. In the construction of seawalls, a range of environmental problems and issues may arise.

I: The implementation and maintenance costs to implement this action are high. It should be constructed by expert people and not by the community people. It also may have big legal barriers because sometimes is difficult to build inside the sea.

V: This infrastructure may be a solid and useful infrastructure, that also can be beautiful depending on the materials used to build it.

S: The function of a seawall is to protect the coastal cities from several damages, so this action improve the safety and the healthy of the population.

P: The construction of this infrastructure may cause marine pollution and harmful effects in the marine ecological system. It also changes the land uses making a less natural area.

Sources: Shore Protection Manual. USACE. (1984).

Design of Revetments. Seawalls and Bulkheads. USACE.(1995).

CC-4: Fish farming

Fish farming involves the planned growth and cultivation of fish for harvesting as food. The positive effects of this activity are due to the availability of making food and jobs. It has to be carefully developed because an improperly planned fish farm can destroy valuable portions of a local ecosystem.

I: The cost of construction of fish farm is low, but the maintenance costsare high. It has a medium risk and medium legal barriers problems.

V: A fish farm is a useful activity because it provides food.

S: This activity creates jobs and incomes to the population, but the main advantage is that it provides food security.

P: The pollution created into the fish farm can be transferred to the sea. It implies the change of land uses to a less natural situation.

Sources: Economic Sustainability of Marine Aquaculture. (2007).*Report of the Marine Aquaculture Task Force*, 2007

Sustainable Marine Aquaculture. (2007). Fulfilling the promise managing the risks.*Report of the Marine Aquaculture Task Force*.

Tisdell, C. (2008). Overview of environmental and sustainability issues in aquaculture.*Aquaculture Economics & Management*.

CC-5: Seaweed harvesting system

In this system, seaweed is harvested and cultivated under controlled conditions and provides the people the foods.This farm is constructed with rafts and ropes for growthing of seaweed. A risk of seaweed farming is very low, because it utilize the nature of the seaweed. A initial cost of seaweed farming is high. It needs some raft and rope for seaweed cling.

I: The initial cost to implement a seaweed farm is high, like the maintenance costs. It can provides job to the people of the community. The risk is low because it employs the nature of seaweed, but the legal barriers should be highs if it has to be developed in a public space.

V: This farm is a solid and useful activity. The beaty of the seaweed farm depends on the materials employed to develop it.

S: It may provide job and income to the community. It is also a safety infrastructure because it helps to the maintenance of the sea. The collected seaweeds can be selled and provide an economical improvement to the society.

P: It should be benecial for the sea because a large amount of seaweed is harmful and pollutant.

Sources: Crawford, B. (2002). Seaweed farming: an alternative livelihood for small-scale fishers?.*Coastal Resources Center*. University of Rhode Island.

Environmentally Sustainable Seaweed Harvesting in Northern Ireland. (2007).*Environment & Heritage Service.*

Farming of Seaweeds (Eucheuma).http://bizfil.com/farming-of-seaweeds-eucheuma/.

CC-6: Generate power offshore

The power plants on the ocean (Offshore power plant) involve the generation of power using renewable energy including wind, tidal and wave.

I: Building and maintainance cost of the power plants using renewable energy are cheaper than other plant such as nuclear, gas, oil etc. But they needs high technology,floating system and auto-position system. Also the maintenance costs are high because all the materials may be transported from the land. The risk of this kind of plants are high like the legal barriers to develop it.

V: Due to infinite renewable energy, offshore power plant is durable and sustainable. But sometimes, is makes bad view on the ocean.

S: The advantage that show this action in this group of indicators is that they generate energy.

P: Offshore renewable power plant do not use chemical materials for generating the power. So, they don’t make any pollution and they are eco-friendly.Also, energy from plants is limitless.

APPENDIX C. Statistics Analysis

C.1 Exterior environment

Urban garden

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	3	3	3	3	3	3	3	3	4	4	0	0	2	0	0	3	0	0	0	4	2	3	0	0	0	0	0	4	4	4
Maximum	5	4	4	5	4	5	5	5	5	5	3	5	3	3	0	4	1	4	5	5	5	5	4	5	4	4	5	5	5	5
Mean	4.2	3.6	3.8	4.2	3.8	4.2	3.8	4.2	4.8	4.6	1.2	1.8	2.4	1.2	0	3.6	0.2	2.2	3.2	4.8	4.2	4	2.6	3	1.4	2.2	2	4.6	4.4	4.4
Median	4	4	4	4	4	5	4	4	5	5	0	1	2	1	0	4	0	3	4	5	5	4	3	3	0	3	0	5	4	4
Deviation	0.8	0.5	0.4	0.8	0.4	1.1	0.8	0.8	0.4	0.5	1.6	2.2	0.5	1.3	0.0	0.5	0.4	2.0	1.9	0.4	1.3	1.0	1.5	1.9	1.9	2.0	2.7	0.5	0.5	0.5

Park

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	2	2	2	2	3	3	3	4	0	0	0	0	0	0	3	0	0	0	1	1	4	0	0	0	0	0	4	3	4
Maximum	3	4	5	5	4	5	5	5	5	3	3	5	3	5	0	4	0	3	5	5	5	5	4	5	5	5	5	5	5	5
Mean	2.4	3.2	3.2	3.6	3	4.2	4	4.2	4.8	1.2	0.6	2.6	1.6	2	0	3.8	0	0.6	2.4	4.2	4.2	4.4	1.8	2.4	1.6	3.2	2.2	4.4	4.2	4.4
Median	3	3	3	4	3	4	4	4	5	0	0	3	2	1	0	4	0	0	3	5	5	4	1	3	0	4	2	4	4	4
Deviation	0.9	0.8	1.3	1.1	1.0	0.8	0.7	0.8	0.4	1.6	1.3	2.5	1.1	2.3	0.0	0.4	0.0	1.3	2.3	1.8	1.8	0.5	1.6	1.9	2.3	1.9	2.3	0.5	0.8	0.5

Cool paving

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	2	2	3	2	2	3	3	0	0	-1	0	0	0	0	0	0	0	0	0	0	3	0	-1	0	-1	-1	0	0	-1
Maximum	3	3	4	5	4	5	5	5	4	0	1	3	2	4	5	3	1	4	4	5	5	5	0	0	3	3	3	3	4	4
Mean	1.8	2.6	2.8	4	3	3.6	3.8	4	1.8	0	0	0.6	1	0.8	1.8	1.6	0.2	2.75	1.2	2.4	3	3.6	0	-0.2	0.6	0.8	1	2	1.2	0.8
Median	2	3	3	4	3	3	4	4	2	0	0	0	1	0	0	2	0	3.5	0	2	5	3	0	0	0	0	0	3	1	0
Deviation	0.8	0.5	0.8	0.7	1.0	1.3	0.8	1.0	1.5	0.0	0.7	1.3	1.0	1.8	2.5	1.1	0.4	1.9	1.8	2.5	2.7	0.9	0.0	0.4	1.3	1.6	1.9	1.4	1.6	1.9

Wetlands

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	2	4	2	2	3	0	3	0	0	0	0	0	0	2	0	0	0	0	0	2	0	0	0	0	0	2	4	4
Maximum	4	3	5	4	4	5	4	5	5	3	4	5	2	4	0	4	0	3	4	5	5	5	5	5	5	5	5	5	5	5
Mean	2.2	2.4	3.6	4	3	3.2	3.6	3.2	3.8	0.6	2.4	1.6	1	1	0	2.8	0	1.2	1.4	3.8	3	3.6	2.8	2.2	1.8	2	1.8	3.4	4.6	4.6
Median	2	3	4	4	3	3	4	4	4	0	3	0	1	0	0	3	0	0	0	5	5	4	3	3	1	2	1	3	5	5
Deviation	1.1	0.9	1.1	0.0	1.0	1.3	0.5	1.9	0.8	1.3	1.5	2.3	1.0	1.7	0.0	0.8	0.0	1.6	1.9	2.2	2.7	1.1	1.9	2.2	2.2	2.1	2.2	1.1	0.5	0.5

Protecting existing habitat

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	3	3	3	3	3	0	3	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Maximum	4	4	4	4	4	5	4	5	5	3	3	2	3	0	0	3	0	2	4	5	5	4	3	3	1	3	3	4	5	5
Mean	3.4	3.6	3.8	3.6	3.6	2.8	3.4	3.6	3.8	0.6	0.6	0.4	1.4	0	0	1.8	0	0.4	1.2	2.8	2.8	2.8	0.6	1.2	0.2	1.2	0.6	2.8	3.6	4.8
Median	3	4	4	4	4	3	3	4	4	0	0	0	1	0	0	3	0	0	0	4	4	4	0	0	0	0	0	3	4	5
Deviation	0.5	0.5	0.4	0.5	0.5	1.9	0.5	2.1	0.8	1.3	1.3	0.9	1.5	0.0	0.0	1.6	0.0	0.9	1.8	2.6	2.6	1.8	1.3	1.6	0.4	1.6	1.3	1.6	2.1	0.4

Reduce exterior lighting

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	3	2	2	0	0	0	2	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	4	5	4	4	4	5	3	5	3	0	0	2	3	5	3	3	5	5	4	5	5	4	0	0	0	3	5	4	4	2
Mean	2.6	3.4	2.8	3.2	2.8	3	2.2	3.4	2.2	0	0	0.4	1.2	1.6	0.6	1.6	1.4	3.6	0.8	2.6	3	2.2	0	0	0	0.6	1	1.2	1.4	0.6
Median	2	3	3	3	3	3	3	3	3	0	0	0	1	0	0	1	0	4	0	3	5	3	0	0	0	0	0	0	1	0
Deviation	1.3	0.9	0.8	0.8	1.6	1.9	1.3	1.1	1.3	0.0	0.0	0.9	1.3	2.3	1.3	1.3	2.2	1.1	1.8	2.5	2.7	1.6	0.0	0.0	0.0	1.3	2.2	1.8	1.7	0.9

Rainwater management system

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	0	3	2	3	2	0	3	3	0	0	4	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	4	5	4	5	4	3	5	0	3	4	1	5	0	4	4	5	5	5	5	0	3	3	0	3	3	5
Mean	2.6	3.6	3.2	3.6	3	2.6	3.6	4	2.4	0.8	4.6	0	1.4	1	0.2	1.8	0	1.2	0.8	2.6	3	4.2	3.8	0	1	0.8	0	0.6	1.4	1.8
Median	2	3	3	3	3	3	4	4	3	0	5	0	1	0	0	1	0	0	0	3	5	4	5	0	0	0	0	0	1	0
Deviation	1.9	0.9	1.3	0.9	1.0	1.8	0.5	0.7	1.5	1.3	0.5	0.0	1.1	1.7	0.4	2.2	0.0	1.8	1.8	2.5	2.7	0.8	2.2	0.0	1.4	1.3	0.0	1.3	1.5	2.5

Walking path

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	2	2	2	2	2	2	4	1	0	0	0	0	0	1	3	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
Maximum	3	4	4	5	4	4	5	5	5	0	1	5	2	4	5	4	1	5	5	5	5	4	0	0	0	3	0	4	3	3
Mean	1.8	2.6	3	3.8	3.2	3	3.8	4.4	2.8	0	0.2	1	1	2.2	3.6	3.6	0.2	1.6	2.8	3.8	3.8	2.2	0	0	0	0.6	0	2.2	1	1.2
Median	2	2	3	4	3	3	4	4	3	0	0	0	1	3	4	4	0	0	3	5	5	2	0	0	0	0	0	2	0	2
Deviation	0.8	0.9	1.0	1.3	0.8	0.7	1.1	0.5	1.5	0.0	0.4	2.2	1.0	2.0	1.5	0.5	0.4	2.3	2.3	2.2	2.2	1.8	0.0	0.0	0.0	1.3	0.0	1.8	1.4	2.0

Bicycle path

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	2	2	2	2	2	2	4	1	0	0	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
Maximum	3	4	4	5	4	4	5	5	5	0	1	5	2	4	5	4	2	5	5	5	5	4	0	3	0	3	0	4	3	3
Mean	1.8	2.6	3	3.8	3.2	3	3.8	4.4	2.8	0	0.2	1	1	2.2	4	3.6	0.4	3	2.6	3.8	3.8	2.2	0	0.6	0	0.6	0	2.6	1	1.2
Median	2	2	3	4	3	3	4	4	3	0	0	0	1	3	4	4	0	3	3	5	5	2	0	0	0	0	0	3	0	2
Deviation	0.8	0.9	1.0	1.3	0.8	0.7	1.1	0.5	1.5	0.0	0.4	2.2	1.0	2.0	1.2	0.5	0.9	1.9	2.5	2.2	2.2	1.8	0.0	1.3	0.0	1.3	0.0	1.7	1.4	2.0

Outdoor amphitheathre

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	1	2	2	4	3	0	0	0	1	0	0	0	-1	-1	0	3	4	-1	0	0	0	0	0	0	0	-1
Maximum	3	3	4	5	4	5	5	5	5	0	3	5	5	5	1	4	0	4	5	5	5	3	0	0	3	3	3	2	3	3
Mean	1.8	2.6	2.8	3	2.4	3	3.8	4.2	4.2	0	0.6	2.2	2.6	1.6	0.2	2	-0.2	1	3.8	4.4	4.8	0.8	0	0	0.6	0.6	0.6	0.6	1.2	0.6
Median	2	3	3	3	2	3	4	4	4	0	0	3	2	0	0	3	0	0	5	5	5	0	0	0	0	0	0	0	0	0
Deviation	0.8	0.9	1.3	1.6	1.1	1.2	1.1	0.4	0.8	0.0	1.3	2.2	1.5	2.3	0.4	1.9	0.4	2.0	2.2	0.9	0.4	1.6	0.0	0.0	1.3	1.3	1.3	0.9	1.6	1.5

Pond

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	1	1	3	2	2	3	0	3	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Maximum	4	3	4	4	4	4	5	5	5	4	4	3	3	3	0	4	0	3	5	5	5	4	4	3	3	3	0	4	5	5
Mean	2.6	2.4	3	3.6	3.2	3.4	3.8	3	4.4	2.4	2.8	0.6	1.8	1	0	2.8	0	0.6	1.8	3	3	2.4	1.8	0.6	0.6	1.6	0	1.6	4.2	3.8
Median	2	3	3	4	3	4	4	3	5	2	3	0	2	0	0	3	0	0	0	5	5	3	2	0	0	2	0	1	4	4
Deviation	0.9	0.9	1.2	0.5	0.8	0.9	0.8	1.9	0.9	1.7	1.3	1.3	1.1	1.4	0.0	1.3	0.0	1.3	2.5	2.7	2.7	1.5	1.8	1.3	1.3	1.5	0.0	1.8	0.8	0.8

Shade trees

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	3	3	3	2	1	3	0	3	0	0	0	0	0	0	1	0	0	0	0	0	3	0	0	0	0	0	2	4	3
Maximum	4	4	4	5	5	5	5	5	5	3	3	5	2	4	0	5	2	4	5	5	5	5	1	4	3	3	3	5	5	5
Mean	3	3.6	3.8	4.4	3.4	3.6	4	3.2	4.2	1.2	0.6	1.6	1.2	1	0	3.2	0.4	0.8	1.8	3	3	4.2	0.4	1.4	0.6	1.4	1.4	3.6	4.4	3.8
Median	3	4	4	5	3	4	4	4	4	0	0	0	2	0	0	3	0	0	0	5	5	4	0	0	0	1	1	4	4	4
Deviation	0.7	0.5	0.4	0.9	1.1	1.7	0.7	1.9	0.8	1.6	1.3	2.3	1.1	1.7	0.0	1.5	0.9	1.8	2.5	2.7	2.7	0.8	0.5	1.9	1.3	1.5	1.5	1.1	0.5	0.8

Plant nut/ fruit trees and berry bushes

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	3	4	4	2	1	3	3	3	4	-1	0	0	0	0	2	0	0	0	0	0	3	0	0	0	0	0	3	4	3
Maximum	4	5	4	5	5	5	5	5	5	5	3	5	3	1	0	4	0	3	5	5	5	5	1	5	3	3	3	5	5	5
Mean	3	4	4	4.2	3.6	3.6	3.8	4	4.2	4.6	0.4	1.6	2	0.2	0	3.2	0	0.6	1.8	3	3	3.6	0.6	2	0.6	1.6	1.6	3.8	4.2	4
Median	3	4	4	4	4	4	4	4	4	5	0	0	2	0	0	3	0	0	0	5	5	3	1	2	0	2	2	4	4	4
Deviation	0.7	0.7	0.0	0.4	1.1	1.7	0.8	0.7	0.8	0.5	1.5	2.3	1.2	0.4	0.0	0.8	0.0	1.3	2.5	2.7	2.7	0.9	0.5	2.1	1.3	1.5	1.5	0.8	0.4	0.7

C.2 Built envitonment

Improve thermal envelop

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	2	2	2	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	3	4	3	5	5	5	5	5	5	2	0	5	4	5	0	5	0	5	5	5	5	4	0	0	0	3	0	4	3	0
Mean	1.8	2.2	2	3.4	3.8	3.2	3.4	3.8	2.6	0.4	0	2.8	1.6	1.8	0	3.4	0	4	2	2.4	3	2.2	0	0	0	0.6	0	2.4	0.6	0
Median	2	2	2	3	4	3	4	5	3	0	0	4	1	0	0	4	0	4	0	2	5	3	0	0	0	0	0	4	0	0
Deviation	0.8	1.3	1.0	1.1	1.1	1.1	2.1	2.2	2.5	0.9	0.0	2.6	1.5	2.5	0.0	2.1	0.0	1.0	2.7	2.5	2.7	2.0	0.0	0.0	0.0	1.3	0.0	2.2	1.3	0.0

Replace windows

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	3	3	2	0	2	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	4	4	4	5	5	5	5	5	5	0	0	5	4	5	0	5	0	5	5	5	5	4	0	0	0	3	0	4	3	0
Mean	2.4	2.8	2.2	4	4.2	3.6	3.4	4	2.8	0	0	3.4	1.6	3	0	3.4	0	4	2	2.4	3	2.4	0	0	0	0.6	0	2.2	0.6	0
Median	2	3	2	4	5	3	4	4	4	0	0	4	1	3	0	4	0	4	0	2	5	3	0	0	0	0	0	3	0	0
Deviation	1.5	1.1	1.3	0.7	1.1	1.3	1.9	1.2	2.6	0.0	0.0	2.1	1.8	1.9	0.0	2.1	0.0	1.0	2.7	2.5	2.7	1.5	0.0	0.0	0.0	1.3	0.0	2.0	1.3	0.0

Water

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	2	3	1	3	3	0	0	5	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	0	0	0	0
Maximum	4	4	4	4	5	5	5	5	3	3	5	5	2	5	0	5	0	5	3	5	5	4	5	0	3	3	0	4	3	0
Mean	2.2	2.8	2.4	3.2	4.6	3.4	4	4.4	1.2	1	5	3.4	1.2	1	0	3	0	3.2	0.8	3	3	2	4	0	0.6	0.6	0	1	0.6	0
Median	2	3	2	3	5	3	4	5	0	0	5	4	1	0	0	3	0	3	0	5	5	3	4	0	0	0	0	0	0	0
Deviation	1.3	1.1	1.1	0.8	0.9	1.7	0.7	0.9	1.6	1.4	0.0	2.1	0.8	2.2	0.0	1.9	0.0	1.1	1.3	2.7	2.7	1.9	1.0	0.0	1.3	1.3	0.0	1.7	1.3	0.0

Rainwater harvesting system

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	1	1	2	2	1	3	3	0	0	4	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0
Maximum	3	4	4	5	5	5	5	5	4	4	5	3	4	4	0	3	0	4	3	5	5	4	5	2	3	3	0	4	3	0
Mean	2.4	2.8	2.6	3.2	3.6	3.2	3.8	4.2	1.4	1.4	4.6	1.2	1.4	0.8	0	1	0	2.4	0.8	3.2	3.8	2.8	4.4	0.4	0.6	0.6	0	0.8	0.6	0
Median	2	3	3	3	3	3	4	4	0	0	5	0	1	0	0	0	0	3	0	4	5	3	5	0	0	0	0	0	0	0
Deviation	0.5	1.3	1.1	1.3	1.3	1.5	0.8	0.8	1.9	1.9	0.5	1.6	1.7	1.8	0.0	1.4	0.0	1.5	1.3	2.2	2.2	1.6	0.9	0.9	1.3	1.3	0.0	1.8	1.3	0.0

Electrical

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	2	3	1	3	3	0	0	0	0	1	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	5	4	4	4	5	5	5	5	3	0	0	5	3	5	0	5	0	5	3	5	5	4	0	0	0	0	2	4	3	0
Mean	2.2	2.8	2.4	3.4	4	3.2	4	4.4	1	0	0	3.2	2	3.2	0	2.4	0	4	0.6	2.4	3	1.8	0	0	0	0	0.4	2	0.6	0
Median	2	3	2	4	4	3	4	5	0	0	0	3	2	4	0	3	0	4	0	2	5	2	0	0	0	0	0	2	0	0
Deviation	1.6	1.3	1.1	0.9	1.0	1.5	0.7	0.9	1.4	0.0	0.0	2.0	1.0	1.9	0.0	2.3	0.0	0.7	1.3	2.5	2.7	1.8	0.0	0.0	0.0	0.0	0.9	2.0	1.3	0.0

Improve energy efficiency

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	2	3	1	3	3	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	4	3	4	4	5	4	5	5	4	0	0	5	3	5	0	5	5	5	3	5	5	4	0	0	0	0	3	4	3	0
Mean	2.2	1.8	2	3.2	4	3	4	4.4	1.4	0	0	3.2	1.6	2.2	0	2.4	1	4.4	0.6	2.4	3	3.2	0	0	0	0	1	2.4	0.6	0
Median	2	2	2	3	4	3	4	5	0	0	0	3	2	3	0	3	0	5	0	2	5	4	0	0	0	0	0	4	0	0
Deviation	1.3	0.8	1.2	0.8	1.0	1.2	0.7	0.9	1.9	0.0	0.0	2.0	1.1	2.2	0.0	2.3	2.2	0.9	1.3	2.5	2.7	1.8	0.0	0.0	0.0	0.0	1.4	2.2	1.3	0.0

Solar PW or thermal

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	3	1	2	0	0	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	3	3	5	4	5	4	5	5	4	0	0	3	3	3	0	3	5	5	3	5	5	4	0	0	0	3	0	5	3	2
Mean	1.8	2	2.2	2.8	3.8	3.2	3.8	3.2	1.8	0	0	1.4	1.6	1.2	0	0.6	4.8	2.8	0.8	2.8	3	3.2	0	0	0	0.6	0	2.6	0.6	0.4
Median	2	2	2	3	4	4	4	3	2	0	0	2	2	0	0	0	5	4	0	4	5	4	0	0	0	0	0	4	0	0
Deviation	0.8	0.7	1.6	1.3	0.8	1.3	1.1	2.0	1.8	0.0	0.0	1.3	1.1	1.6	0.0	1.3	0.4	2.6	1.3	2.6	2.7	1.8	0.0	0.0	0.0	1.3	0.0	2.4	1.3	0.9

Install undividual metering and payment

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	2	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	4	4	4	4	5	5	5	5	3	0	3	2	4	2	0	3	0	5	4	5	5	4	4	0	0	0	0	4	3	0
Mean	2.2	3	2.4	2.6	3.6	3	4	4	1.4	0	0.6	0.8	1.4	0.6	0	0.8	0	2.4	0.8	3.2	3.6	1.8	1.4	0	0	0	0	1.4	0.6	0
Median	2	3	2	2	4	3	4	4	2	0	0	0	1	0	0	0	0	3	0	3	5	2	0	0	0	0	0	0	0	0
Deviation	1.1	1.2	1.1	1.3	1.1	1.6	1.0	1.0	1.3	0.0	1.3	1.1	1.7	0.9	0.0	1.3	0.0	2.3	1.8	2.0	2.2	1.8	1.9	0.0	0.0	0.0	0.0	1.9	1.3	0.0

Install startboard in each flat

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	3	1	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	3	4	4	4	5	5	5	5	4	0	3	4	4	5	0	3	0	5	4	5	5	4	4	0	0	0	0	4	3	0
Mean	2.2	3	2.6	3	4.4	3.6	3.6	3.8	2.2	0	0.6	1.2	1.4	2.4	0	1	0	2.6	1.4	3.2	3.6	2	1.6	0	0	0	0	1.6	0.6	0
Median	2	3	2	4	5	4	4	4	3	0	0	0	1	3	0	0	0	3	0	3	5	3	0	0	0	0	0	0	0	0
Deviation	0.8	1.2	1.3	1.4	0.9	1.7	1.1	0.8	2.0	0.0	1.3	1.8	1.7	2.3	0.0	1.4	0.0	2.5	1.9	2.0	2.2	1.9	2.2	0.0	0.0	0.0	0.0	2.2	1.3	0.0

Air quality

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	3	1	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	5	4	4	4	5	5	5	5	3	0	0	5	2	5	0	5	0	5	4	5	5	3	0	0	3	3	3	4	4	0
Mean	2.8	2.8	2.6	2.6	4	3.4	3.8	4.4	1.2	0	0	2.2	0.6	1.6	0	3.2	0	2.6	1	2.8	3	1.2	0	0	0.6	0.6	1	1.4	1.4	0
Median	3	3	3	3	4	3	4	5	0	0	0	3	0	0	0	3	0	3	0	4	5	0	0	0	0	0	0	0	0	0
Deviation	1.5	1.3	1.1	1.1	0.7	1.7	0.8	0.9	1.6	0.0	0.0	2.2	0.9	2.3	0.0	2.0	0.0	1.8	1.7	2.6	2.7	1.6	0.0	0.0	1.3	1.3	1.4	1.9	1.9	0.0

Optimize daylight

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	3	1	3	3	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	4	5	5	4	5	5	5	5	5	2	0	5	2	5	0	4	0	4	4	5	5	4	0	0	0	0	0	4	3	0
Mean	2	3.2	3.2	3.2	4.2	3.6	4	4.2	3.2	0.4	0	3	0.6	2.2	0	3	0	2.8	0.8	2.8	3	1.4	0	0	0	0	0	1.6	0.6	0
Median	2	4	4	4	4	4	4	4	4	0	0	3	0	2	0	4	0	3	0	4	5	0	0	0	0	0	0	0	0	0
Deviation	1.2	1.6	1.6	1.3	0.8	1.7	1.0	0.8	1.9	0.9	0.0	2.1	0.9	2.3	0.0	1.7	0.0	0.8	1.8	2.6	2.7	1.9	0.0	0.0	0.0	0.0	0.0	2.2	1.3	0.0

Balconies

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	3	3	3	1	3	0	2	2	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	5	4	3	4	3	4	0	4	0	3	4	5	5	5	3	4	3	3	3	5	4	5
Mean	4.2	4.2	4.2	3.4	4.2	3	3.2	3.6	3.6	1.4	0.6	2	1.2	1.2	0	2.8	0	1.6	1.2	3.2	3.4	2.6	1.4	0.8	0.6	0.6	0.6	2.8	2.8	1.6
Median	5	4	4	4	4	3	3	4	4	0	0	3	1	0	0	3	0	2	0	4	5	3	2	0	0	0	0	4	3	0
Deviation	1.1	0.8	0.8	1.5	0.8	1.9	1.3	1.1	2.1	1.9	1.3	1.9	1.3	1.8	0.0	1.1	0.0	1.1	1.8	2.2	2.3	1.8	1.3	1.8	1.3	1.3	1.3	2.6	1.6	2.3

Exterior green wall

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	3	3	1	3	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	5	3	3	3	3	4	0	4	0	3	4	5	5	5	3	4	3	3	3	5	4	5
Mean	3.8	4.2	4.2	3.4	3.8	3	3	3.4	3.6	1	0.6	1.4	1.2	1	0	2.4	0	1.8	1	2.8	3	2.6	1.4	0.8	0.6	0.6	1	3.2	2.2	1.8
Median	5	4	4	3	4	3	3	3	4	0	0	1	1	0	0	3	0	2	0	4	5	3	2	0	0	0	0	4	3	1
Deviation	1.8	0.8	0.8	1.7	0.8	1.9	1.2	0.9	2.1	1.4	1.3	1.5	1.3	1.7	0.0	1.8	0.0	1.1	1.7	2.6	2.7	1.8	1.3	1.8	1.3	1.3	1.4	2.2	2.0	2.2

Middle park

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	3	3	1	3	0	2	0	0	0	0	0	0	0	0	2	0	0	0	4	4	0	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	5	3	0	4	3	4	0	4	0	3	5	5	5	5	3	4	3	3	3	5	4	5
Mean	3.6	3.8	3.6	3.2	4	3	3.4	3.6	3.6	1.6	0	2	1.2	1	0	3.2	0	0.8	2.6	4.8	4.8	2.4	1.6	0.8	0.6	1	1	3.4	2.2	2
Median	4	4	3	3	4	3	3	4	4	2	0	3	1	0	0	3	0	0	4	5	5	2	2	0	0	0	0	4	3	2
Deviation	1.1	0.8	0.9	1.5	0.7	1.9	1.1	2.1	2.1	1.5	0.0	1.9	1.3	1.7	0.0	0.8	0.0	1.3	2.4	0.4	0.4	1.8	1.1	1.8	1.3	1.4	1.4	2.1	2.0	2.1

C.3 Social – economic needs

Community kitchen

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	4	1	1	3	2	2	3	4	3	0	0	0	0	0	0	1	0	0	5	3	3	0	0	0	0	0	0	0	0	0
Maximum	5	4	5	5	5	5	5	5	5	5	2	5	4	5	0	5	0	4	5	5	5	3	3	0	0	0	0	3	3	0
Mean	4.4	2.4	3.4	4	3.4	3.6	4	4.6	3.8	3.8	0.4	2.4	2.4	2	0	3.4	0	2	5	4.4	4.2	0.6	1.6	0	0	0	0	1	0.6	0
Median	4	3	4	4	4	3	4	5	3	5	0	3	3	2	0	4	0	3	5	5	5	0	2	0	0	0	0	0	0	0
Deviation	0.5	1.3	1.5	0.7	1.3	1.3	0.7	0.5	1.1	2.2	0.9	2.3	1.8	2.1	0.0	1.5	0.0	1.9	0.0	0.9	1.1	1.3	1.5	0.0	0.0	0.0	0.0	1.4	1.3	0.0

Book crossing

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	4	3	3	3	4	0	0	0	3	0	0	0	0	0	0	0	0	0	3	4	5	0	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	4	5	5	5	0	4	4	3	0	4	0	3	5	5	5	0	0	0	0	0	0	0	3	0
Mean	4.8	4	4.4	4	4.4	3.6	2.8	3.6	3.6	1	0	0.8	2	0.6	0	1.8	0	0.6	4.4	4.8	5	0	0	0	0	0	0	0	0.6	0
Median	5	4	5	4	4	5	3	4	3	0	0	0	3	0	0	2	0	0	5	5	5	0	0	0	0	0	0	0	0	0
Deviation	0.4	1.0	0.9	0.7	0.5	2.2	1.6	2.1	0.9	2.2	0.0	1.8	1.9	1.3	0.0	1.8	0.0	1.3	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	0.0

Coworking

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	4	3	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	4	0	0	4	5	4	2	5	0	3	5	5	5	0	0	0	0	0	0	2	3	0
Mean	4.8	4.2	4.4	4	3.8	3.6	3.2	3.4	2.6	0	0	0.8	3.2	1.8	0.4	2.4	0	1.6	3.4	4.2	4.6	0	0	0	0	0	0	0.4	0.6	0
Median	5	5	5	4	4	5	4	4	3	0	0	0	4	2	0	3	0	2	5	5	5	0	0	0	0	0	0	0	0	0
Deviation	0.4	1.1	0.9	0.7	1.1	2.2	1.9	2.1	1.5	0.0	0.0	1.8	1.9	1.8	0.9	1.9	0.0	1.5	2.3	1.1	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.3	0.0

Urban barter

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	4	3	3	4	2	3	0	0	0	0	0	0	0	0	0	0	0	0	2	3	4	0	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	4	0	0	5	5	5	0	5	0	3	5	5	5	0	0	0	0	0	0	2	3	0
Mean	4.8	4.4	4.6	4.2	4	4.2	3	3.4	2.6	0	0	1.8	2.6	1	0	2.4	0	0.6	3.8	4.4	4.8	0	0	0	0	0	0	0.4	0.6	0
Median	5	5	5	4	4	4	3	4	3	0	0	0	3	0	0	3	0	0	4	5	5	0	0	0	0	0	0	0	0	0
Deviation	0.4	0.9	0.9	0.4	1.2	0.8	1.9	2.1	1.5	0.0	0.0	2.5	2.1	2.2	0.0	1.9	0.0	1.3	1.3	0.9	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.3	0.0

Bike kitchen

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	3	3	3	2	2	2	3	3	3	0	0	0	0	0	0	1	0	0	2	4	4	0	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	5	1	0	5	5	5	5	5	0	5	5	5	5	4	2	0	3	0	0	4	3	0
Mean	4.4	4	4	4	3.8	3.6	4	4.2	3.4	0.2	0	1.4	2.4	2	2.6	3	0	3.2	4.2	4.8	4.8	1.4	0.4	0	0.6	0	0	1.4	0.6	0
Median	5	4	4	4	4	4	4	4	3	0	0	0	3	2	3	3	0	3	5	5	5	0	0	0	0	0	0	0	0	0
Deviation	0.9	1.0	1.0	1.2	1.1	1.1	0.7	0.8	0.9	0.4	0.0	2.2	1.9	2.1	2.1	1.4	0.0	2.0	1.3	0.4	0.4	1.9	0.9	0.0	1.3	0.0	0.0	1.9	1.3	0.0

Public transportation

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	0	1	1	1	2	2	0	0	0	0	0	0	0	2	4	1	0	3	0	5	5	0	0	0	0	-1	0	-1	0	0
Maximum	3	3	4	4	4	4	4	5	4	2	0	5	3	5	5	5	0	5	5	5	5	3	0	2	3	3	0	4	3	0
Mean	1.6	2	2.8	2.6	3	3	2.8	3.8	2.6	0.6	0	1.8	2.4	3.2	4.6	2.8	0	3.6	3.6	5	5	0.8	0	0.4	0.6	0.4	0	1.2	1	0
Median	2	2	3	3	3	3	3	5	3	0	0	0	3	3	5	3	0	3	4	5	5	0	0	0	0	0	0	0	0	0
Deviation	1.1	1.0	1.3	1.1	1.0	0.7	1.6	2.2	1.5	0.9	0.0	2.5	1.3	1.1	0.5	1.8	0.0	0.9	2.1	0.0	0.0	1.3	0.0	0.9	1.3	1.5	0.0	2.2	1.4	0.0

Education space

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	3	3	3	3	2	3	3	3	3	0	0	0	3	2	0	1	0	0	3	3	3	0	0	0	0	0	0	0	0	-1
Maximum	5	5	5	5	4	5	5	5	5	2	0	5	5	5	2	5	0	3	5	5	5	0	0	0	0	0	0	2	3	0
Mean	3.8	3.6	3.6	4	3.4	3.6	4.2	4.4	3.6	0.4	0	1.8	4	3.8	0.4	3	0	0.8	4.4	4.6	4.6	0	0	0	0	0	0	0.4	0.6	-0.2
Median	3	3	3	4	4	3	4	5	3	0	0	0	4	4	0	3	0	0	5	5	5	0	0	0	0	0	0	0	0	0
Deviation	1.1	0.9	0.9	0.7	0.9	0.9	0.8	0.9	0.9	0.9	0.0	2.5	1.0	1.3	0.9	1.6	0.0	1.3	0.9	0.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.9	1.3	0.4

C.4 Energy/ waste

Waste to energy plant

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	0	1	1	1	1	1	3	3	-1	0	-1	-1	4	0	0	-1	4	0	0	0	0	2	0	0	0	0	0	-1	0	-1
Maximum	4	3	4	3	3	2	5	5	3	0	3	0	5	5	3	3	5	5	5	5	5	5	4	4	4	4	4	4	4	2
Mean	1.6	1.4	1.6	1.8	1.6	1.2	4	4.4	1	0	0.8	-0.2	4.4	2	0.6	0.8	4.8	3.8	2.2	2	2	3.4	1.6	2.4	1.8	2.2	2.4	2.4	2.4	-0.2
Median	1	1	1	2	1	1	4	5	1	0	0	0	4	1	0	0	5	5	2	0	0	4	2	3	1	3	2	4	3	-1
Deviation	1.5	0.9	1.3	0.8	0.9	0.4	1.0	0.9	1.4	0.0	1.6	0.4	0.5	2.3	1.3	1.6	0.4	2.2	2.3	2.7	2.7	1.3	1.7	1.5	1.6	1.6	1.7	2.3	1.8	1.3

Biomass

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	0	1	1	1	1	1	3	3	-1	0	0	0	3	0	0	0	3	0	0	0	0	3	0	0	0	0	0	3	0	-1
Maximum	3	1	4	3	3	4	5	5	3	3	3	3	5	3	3	3	5	5	5	5	5	5	3	5	5	5	5	5	3	2
Mean	1.4	1	1.6	2	1.8	1.8	3.8	4.6	1	0.6	1	0.6	4.2	1.4	0.6	1.2	4.4	3.2	2.4	2	2	3.6	1.2	3	3	3	2.8	3.8	1.6	-0.4
Median	1	1	1	2	1	1	4	5	1	0	0	0	4	1	0	1	5	4	2	0	0	3	0	3	3	3	3	4	2	-1
Deviation	1.1	0.0	1.3	1.0	1.1	1.3	0.8	0.9	2.0	1.3	1.4	1.3	0.8	1.5	1.3	1.3	0.9	1.9	2.5	2.7	2.7	0.9	1.6	2.1	1.9	1.9	1.8	0.8	1.5	1.3

Waste management - recycling

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	1	1	2	2	2	0	0	-1	0	0	0	2	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	-1
Maximum	5	3	5	4	5	5	5	5	3	3	4	3	5	0	0	4	0	4	5	5	5	4	4	4	4	4	4	4	4	2
Mean	4	2.2	4.2	2.6	3	3.2	2.8	2.8	0.8	0.6	1.4	0.6	3.8	0	0	1.2	0	2.8	2.8	3	2	2.8	1.8	2.8	2.8	2.6	2.4	1.8	2.4	0.2
Median	4	2	5	2	3	3	3	3	0	0	0	0	4	0	0	0	0	3	4	5	0	3	2	3	3	3	3	2	3	0
Deviation	1.2	0.8	1.8	0.9	1.2	1.3	1.9	1.9	1.6	1.3	1.9	1.3	1.1	0.0	0.0	1.8	0.0	1.3	2.6	2.7	2.7	1.3	1.8	1.6	1.6	1.7	1.5	1.8	1.5	1.1

Waste management - reuse

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	1	1	2	2	2	0	0	-1	0	0	0	2	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	3	3	4	3	5	0	0	5	4	4	5	5	5	5	4	4	4	4	4	4	4	5
Mean	3.8	3.4	3.2	2.8	3.2	3.4	2.8	3	1	1	2	0.6	3.6	0	0	1.4	0.8	3	2.8	3	2	3.2	2.2	2.8	2.6	3	2.6	2	2.4	1.4
Median	4	4	3	2	3	3	3	3	0	0	3	0	4	0	0	0	0	3	4	5	0	4	3	3	4	4	3	2	3	0
Deviation	1.3	1.8	1.8	1.3	1.3	1.5	1.9	1.9	1.9	1.4	1.9	1.3	1.1	0.0	0.0	2.2	1.8	1.0	2.6	2.7	2.7	1.6	2.0	1.6	1.9	1.7	1.7	2.0	1.8	2.2

Waste management - minimization

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	3	1	1	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	3	0	4	4	5	0	0	4	0	4	5	5	5	5	5	5	5	5	5	5	5	2
Mean	4.2	3.8	4.2	3.8	4.4	4	3.2	2.8	1	0	1.8	1.2	2	0	0	2	0	2.4	2.6	3	2	3.4	2.2	2.8	3	3	2.8	2.2	2.6	0.4
Median	4	5	5	4	5	5	4	3	0	0	2	0	1	0	0	2	0	3	3	5	0	3	3	3	3	3	3	3	3	0
Deviation	0.8	1.8	1.8	1.3	0.9	1.4	1.9	1.9	1.4	0.0	1.8	1.8	2.3	0.0	0.0	2.0	0.0	1.5	2.5	2.7	2.7	1.5	2.2	1.8	1.9	1.9	1.9	2.2	2.1	0.9

Waste management - prevention

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	3	1	1	2	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
Maximum	5	5	5	5	5	5	5	5	3	0	3	2	5	0	0	2	0	4	5	5	5	5	5	5	5	5	5	5	5	2
Mean	4.2	4.2	4.2	3.8	4.4	4.2	2.4	2.6	1	0	0.8	0.4	1.2	0	0	0.6	0	2.4	2.4	3	2	3	1.8	2.4	2.6	2.6	2.4	1.8	2.2	0.4
Median	4	5	5	4	5	5	3	3	0	0	0	0	0	0	0	0	0	3	2	5	0	2	1	3	3	3	2	1	1	0
Deviation	0.8	1.8	1.8	1.3	0.9	1.3	2.3	1.8	1.4	0.0	1.3	0.9	2.2	0.0	0.0	0.9	0.0	1.5	2.5	2.7	2.7	1.9	2.2	1.9	2.1	2.1	2.1	2.2	2.2	0.9

C.5 Coastal/ climate issues

Port

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	1	1	2	4	3	0	0	0	3	3	5	0	0	-1	0	0	0	-1	-1	0	0	-1	-1	-1	-1	-1
Maximum	4	3	3	4	2	3	5	5	4	5	4	5	5	5	5	3	3	1	5	5	5	3	3	3	3	1	1	1	2	3
Mean	2.8	1.6	2	2.4	1.8	1.8	4.2	4.8	3.4	2.6	1.6	2.2	4.4	4	5	1.4	1.2	0	2.8	4	3.6	1.4	0.8	0.8	1.4	-0.2	0	0	0.2	0.6
Median	3	1	2	2	2	2	5	5	3	4	1	3	5	4	5	2	0	0	3	5	5	1	0	0	1	0	0	0	0	0
Deviation	1.1	0.9	1.0	1.1	0.4	0.8	1.3	0.4	0.5	2.4	1.8	2.2	0.9	0.7	0.0	1.3	1.6	0.7	1.9	2.2	2.2	1.7	1.6	1.3	1.5	0.8	0.7	0.7	1.3	1.5

Coastal protection

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	2	3	2	2	2	0	1	0	0	0	3	2	0	2	0	0	0	0	0	2	0	0	0	0	0	3	4	4
Maximum	5	4	4	4	4	4	4	5	5	4	5	5	4	5	0	5	0	5	5	5	5	5	5	5	5	5	5	5	5	5
Mean	3.6	2.8	3.2	3.4	2.8	3.2	3.4	3.2	3.6	2.6	1.6	2.6	3.2	4	0	3.6	0	1.8	2.4	4	3.2	4.2	2.4	1.2	2.2	2	2.4	4.6	4.6	4.6
Median	4	3	3	3	3	4	4	4	4	3	0	3	3	5	0	4	0	0	2	5	3	5	2	0	1	0	2	5	5	5
Deviation	1.5	1.3	0.8	0.5	0.8	1.1	0.9	1.9	1.7	1.7	2.3	1.8	0.4	1.4	0.0	1.1	0.0	2.5	1.8	2.2	2.0	1.3	2.5	2.2	2.6	2.7	2.5	0.9	0.5	0.5

Seawall

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	2	1	1	2	3	-1	0	0	0	0	2	0	0	0	0	0	0	0	0	-1	0	0	0	0	0	0	-1
Maximum	3	3	3	4	3	3	5	5	3	3	3	5	5	5	3	4	3	1	5	5	5	5	3	0	2	2	2	3	1	4
Mean	1.6	1.6	1.8	2.8	2.4	2	3.8	4	1.8	0.6	0.6	2.4	2.6	4.2	0.6	1.4	0.6	0.4	2	3.2	3.6	2.4	0.4	0	1	0.6	0.6	1	0.6	1.4
Median	1	1	2	3	3	2	4	4	3	0	0	3	3	5	0	0	0	0	2	5	5	2	0	0	1	0	0	0	1	1
Deviation	0.9	0.9	0.8	0.8	0.9	0.7	1.1	1.0	1.8	1.3	1.3	2.3	1.8	1.3	1.3	1.9	1.3	0.5	2.1	2.5	2.2	1.8	1.5	0.0	1.0	0.9	0.9	1.4	0.5	1.8

Fish farm

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	1	2	2	2	2	0	0	0	4	0	0	3	0	0	2	0	0	0	0	0	-1	-1	0	0	0	0	0	-1	-1
Maximum	5	5	5	5	5	5	5	5	4	5	2	0	5	0	0	5	0	0	5	5	5	3	3	3	4	3	0	0	4	5
Mean	3.6	3.2	3.8	3	3.4	3.2	2.4	2.4	2.8	4.8	0.4	0	4.2	0	0	3.4	0	0	2.8	3.4	3	0.4	0.4	0.6	1.4	0.6	0	0	1	1.4
Median	3	3	4	3	4	3	2	3	3	5	0	0	5	0	0	3	0	0	3	5	3	0	0	0	0	0	0	0	0	0
Deviation	1.3	1.8	1.3	1.2	1.3	1.1	1.8	2.3	1.6	0.4	0.9	0.0	1.1	0.0	0.0	1.1	0.0	0.0	1.9	2.3	2.1	1.5	1.5	1.3	1.9	1.3	0.0	0.0	2.3	2.5

Harvesting seaweed system

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	2	1	1	1	2	2	2	0	1	4	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1	0
Maximum	5	4	4	4	4	4	5	5	3	5	4	2	5	0	0	3	0	0	5	5	5	5	4	5	4	3	3	4	5	5
Mean	3	2.8	2.8	2.6	3.2	2.8	3.6	3.4	2	4.6	1.4	0.4	4.2	0	0	1.6	0	0	2.8	3.6	3.2	2.6	1.2	1	2.2	0.6	0.6	0.8	2.8	1.6
Median	3	3	3	3	3	3	4	4	2	5	0	0	5	0	0	2	0	0	3	5	3	4	0	0	3	0	0	0	3	0
Deviation	1.2	1.3	1.3	1.1	0.8	0.8	1.5	2.1	1.0	0.5	1.9	0.9	1.1	0.0	0.0	1.5	0.0	0.0	1.9	2.2	2.0	2.4	1.8	2.2	2.0	1.3	1.3	1.8	2.3	2.3

Offshore

Indicator	I-1	I-2	I-3	I-4	I-5	I-6	I-7	I-8	I-9	I-10	I-11	I-12	I-13	I-14	I-15	I-16	I-17	I-18	I-19	I-20	I-21	I-22	I-23	I-24	I-25	I-26	I-27	I-28	I-29	I-30
Minimum	1	1	1	1	1	1	2	4	1	0	0	0	2	0	0	0	4	0	0	0	0	0	0	0	-1	0	0	0	0	-1
Maximum	4	1	1	3	2	2	5	5	3	4	1	4	5	3	4	3	5	5	5	5	5	4	3	3	3	3	3	4	3	1
Mean	1.8	1	1	1.8	1.4	1.2	3.4	4.6	1.8	1.6	0.2	1.6	4.2	1.2	2	0.6	4.8	2	2	2.2	2.4	1.6	1	0.8	0.6	1.4	0.8	1.6	0.8	-0.2
Median	1	1	1	2	1	1	4	5	2	0	0	1	5	0	3	0	5	1	2	1	1	1	0	0	0	1	0	1	0	0
Deviation	1.3	0.0	0.0	0.8	0.5	0.4	1.3	0.5	0.8	2.2	0.4	1.8	1.3	1.6	1.9	1.3	0.4	2.3	2.1	2.6	2.4	1.8	1.4	1.3	1.5	1.5	1.3	1.8	1.3	0.8

APPENDIX D. Correlation Matrix

	EE-1	EE-2	EE-3	EE-4	EE-5	EE-6	EE-7	EE-8	EE-9	EE-10	EE-11	EE-12
EE-1		0.8	0.5	0.8	0.8	0.4	0.4	0.4	0.4	0.5	0.8	0.8
EE-2	0.8		0.5	0.9	0.8	0.4	0.4	0.5	0.4	0.6	0.7	0.9
EE-3	0.5	0.5		0.5	0.6	0.9	0.6	0.8	0.8	0.6	0.5	0.7
EE-4	0.8	0.9	0.5		0.8	0.4	0.6	0.4	0.3	0.4	0.8	0.8
EE-5	0.8	0.8	0.6	0.8		0.6	0.6	0.5	0.5	0.5	0.8	0.9
EE-6	0.4	0.4	0.9	0.4	0.6		0.5	0.7	0.7	0.6	0.4	0.6
EE-7	0.4	0.4	0.6	0.6	0.6	0.5		0.4	0.4	0.4	0.7	0.5
EE-8	0.4	0.5	0.8	0.4	0.5	0.7	0.4		1.0	0.8	0.5	0.6
EE-9	0.4	0.4	0.8	0.3	0.5	0.7	0.4	1.0		0.7	0.4	0.5
EE-10	0.5	0.6	0.6	0.4	0.5	0.6	0.4	0.8	0.7		0.6	0.5
EE-11	0.8	0.7	0.5	0.8	0.8	0.4	0.7	0.5	0.4	0.6		0.8
EE-12	0.8	0.9	0.7	0.8	0.9	0.6	0.5	0.6	0.5	0.5	0.8	
EE-13	0.9	0.8	0.5	0.7	0.9	0.5	0.4	0.4	0.4	0.5	0.8	0.9
BE-1	0.5	0.5	0.8	0.3	0.4	0.8	0.4	0.8	0.8	0.7	0.4	0.5
BE-2	0.4	0.5	0.8	0.3	0.4	0.8	0.4	0.7	0.8	0.7	0.4	0.5
BE-3	0.2	0.2	0.5	0.3	0.3	0.5	0.8	0.4	0.4	0.5	0.4	0.2
BE-4	0.3	0.2	0.5	0.4	0.3	0.5	0.9	0.4	0.4	0.5	0.5	0.3
BE-5	0.3	0.4	0.8	0.3	0.4	0.8	0.4	0.7	0.7	0.6	0.3	0.5
BE-6	0.3	0.4	0.8	0.3	0.4	0.8	0.4	0.7	0.7	0.6	0.3	0.5
BE-7	0.3	0.3	0.7	0.2	0.4	0.7	0.3	0.5	0.5	0.5	0.2	0.4
BE-8	0.5	0.5	0.8	0.4	0.6	0.8	0.7	0.7	0.7	0.7	0.5	0.6
BE-9	0.5	0.5	0.8	0.4	0.5	0.8	0.6	0.7	0.7	0.8	0.5	0.5
BE-10	0.5	0.5	0.8	0.4	0.5	0.8	0.5	0.8	0.7	0.7	0.4	0.6
BE-11	0.5	0.5	0.8	0.4	0.5	0.8	0.5	0.8	0.8	0.8	0.5	0.6
BE-12	0.8	0.7	0.7	0.6	0.8	0.7	0.6	0.6	0.6	0.7	0.7	0.8
BE-13	0.8	0.7	0.7	0.7	0.8	0.8	0.6	0.6	0.6	0.6	0.7	0.8
BE-14	0.8	0.8	0.7	0.6	0.8	0.6	0.5	0.7	0.6	0.8	0.7	0.8

	EE-1	EE-2	EE-3	EE-4	EE-5	EE-6	EE-7	EE-8	EE-9	EE-10	EE-11	EE-12
SE-1	0.6	0.4	0.5	0.2	0.4	0.6	0.4	0.7	0.6	0.8	0.5	0.4
SE-2	0.6	0.4	0.6	0.3	0.6	0.7	0.5	0.7	0.6	0.9	0.6	0.5
SE-3	0.5	0.4	0.7	0.3	0.6	0.8	0.5	0.7	0.7	0.8	0.5	0.5
SE-4	0.5	0.4	0.6	0.3	0.6	0.7	0.5	0.7	0.7	0.9	0.5	0.5
SE-5	0.4	0.4	0.8	0.2	0.5	0.8	0.4	0.9	0.9	0.9	0.4	0.5
SE-6	0.2	0.2	0.6	0.0	0.2	0.6	0.2	0.8	0.9	0.7	0.2	0.2
SE-7	0.4	0.4	0.6	0.2	0.5	0.7	0.4	0.8	0.7	0.9	0.5	0.4
EW-1	-0.1	-0.1	0.3	-0.1	0.0	0.3	0.1	0.1	0.1	0.1	-0.2	0.0
EW-2	-0.1	0.0	0.2	-0.1	-0.1	0.2	-0.1	0.0	0.1	0.1	-0.3	-0.1
EW-3	0.4	0.3	0.4	0.3	0.4	0.4	0.4	0.2	0.2	0.4	0.2	0.3
EW-4	-0.1	-0.1	0.3	-0.1	0.0	0.3	0.1	0.1	0.1	0.1	-0.2	0.0
EW-5	-0.1	0.0	0.2	-0.1	-0.1	0.2	-0.1	0.0	0.1	0.1	-0.3	-0.1
EW-6	0.4	0.4	0.6	0.4	0.5	0.6	0.5	0.3	0.3	0.4	0.3	0.5
CC-1	0.0	0.0	0.3	-0.2	0.1	0.2	0.2	0.5	0.5	0.6	0.2	0.0
CC-2	0.0	-0.1	-0.2	-0.1	-0.3	-0.2	0.0	-0.3	-0.3	0.0	-0.2	-0.3
CC-3	0.3	0.5	0.6	0.3	0.4	0.5	0.4	0.7	0.6	0.8	0.4	0.4
CC-4	0.6	0.3	0.3	0.2	0.5	0.4	0.4	0.4	0.3	0.6	0.6	0.5
CC-5	0.7	0.4	0.4	0.4	0.5	0.3	0.5	0.3	0.2	0.5	0.7	0.5
CC-6	-0.1	-0.2	0.3	-0.3	-0.1	0.3	0.0	0.3	0.3	0.3	-0.1	-0.1

	BE-1	BE-2	BE-3	BE-4	BE-5	BE-6	BE-7	BE-8	BE-9	BE-10	BE-11	BE-12	BE-13	BE-14
EE-1	0.5	0.4	0.2	0.3	0.3	0.3	0.3	0.5	0.5	0.5	0.5	0.8	0.8	0.8
EE-2	0.5	0.5	0.2	0.2	0.4	0.4	0.3	0.5	0.5	0.5	0.5	0.7	0.7	0.8
EE-3	0.8	0.8	0.5	0.5	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.7	0.7	0.7
EE-4	0.3	0.3	0.3	0.4	0.3	0.3	0.2	0.4	0.4	0.4	0.4	0.6	0.7	0.6
EE-5	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.6	0.5	0.5	0.5	0.8	0.8	0.8
EE-6	0.8	0.8	0.5	0.5	0.8	0.8	0.7	0.8	0.8	0.8	0.8	0.7	0.8	0.6
EE-7	0.4	0.4	0.8	0.9	0.4	0.4	0.3	0.7	0.6	0.5	0.5	0.6	0.6	0.5
EE-8	0.8	0.7	0.4	0.4	0.7	0.7	0.5	0.7	0.7	0.8	0.8	0.6	0.6	0.7
EE-9	0.8	0.8	0.4	0.4	0.7	0.7	0.5	0.7	0.7	0.7	0.8	0.6	0.6	0.6
EE-10	0.7	0.7	0.5	0.5	0.6	0.6	0.5	0.7	0.8	0.7	0.8	0.7	0.6	0.8
EE-11	0.4	0.4	0.4	0.5	0.3	0.3	0.2	0.5	0.5	0.4	0.5	0.7	0.7	0.7
EE-12	0.5	0.5	0.2	0.3	0.5	0.5	0.4	0.6	0.5	0.6	0.6	0.8	0.8	0.8
EE-13	0.4	0.4	0.2	0.2	0.3	0.3	0.3	0.5	0.4	0.5	0.5	0.8	0.8	0.8
BE-1		1.0	0.6	0.5	0.9	0.9	0.7	0.8	0.8	0.9	0.9	0.7	0.7	0.7
BE-2	1.0		0.6	0.5	0.9	0.9	0.6	0.8	0.9	0.9	0.9	0.7	0.7	0.6
BE-3	0.6	0.6		0.9	0.7	0.6	0.4	0.7	0.7	0.7	0.7	0.5	0.5	0.4
BE-4	0.5	0.5	0.9		0.5	0.5	0.4	0.8	0.7	0.5	0.6	0.5	0.5	0.5
BE-5	0.9	0.9	0.7	0.5		1.0	0.7	0.8	0.9	0.9	0.9	0.7	0.7	0.6
BE-6	0.9	0.9	0.6	0.5	1.0		0.8	0.8	0.8	0.9	0.9	0.6	0.6	0.6
BE-7	0.7	0.6	0.4	0.4	0.7	0.8		0.7	0.7	0.6	0.7	0.5	0.5	0.5
BE-8	0.8	0.8	0.7	0.8	0.8	0.8	0.7		1.0	0.9	0.8	0.8	0.8	0.8
BE-9	0.8	0.9	0.7	0.7	0.9	0.8	0.7	1.0		0.9	0.9	0.8	0.8	0.7
BE-10	0.9	0.9	0.7	0.5	0.9	0.9	0.6	0.9	0.9		0.9	0.8	0.8	0.7
BE-11	0.9	0.9	0.7	0.6	0.9	0.9	0.7	0.8	0.9	0.9		0.8	0.8	0.8
BE-12	0.7	0.7	0.5	0.5	0.7	0.6	0.5	0.8	0.8	0.8	0.8		1.0	0.9
BE-13	0.7	0.7	0.5	0.5	0.7	0.6	0.5	0.8	0.8	0.8	0.8	1.0		0.9
BE-14	0.7	0.6	0.4	0.5	0.6	0.6	0.5	0.8	0.7	0.7	0.8	0.9	0.9	

	BE-1	BE-2	BE-3	BE-4	BE-5	BE-6	BE-7	BE-8	BE-9	BE-10	BE-11	BE-12	BE-13	BE-14
SE-1	0.7	0.7	0.5	0.5	0.6	0.6	0.4	0.7	0.7	0.7	0.7	0.7	0.6	0.8
SE-2	0.6	0.6	0.4	0.5	0.6	0.5	0.5	0.8	0.8	0.7	0.7	0.8	0.7	0.8
SE-3	0.7	0.7	0.5	0.5	0.7	0.6	0.5	0.8	0.8	0.8	0.8	0.8	0.7	0.8
SE-4	0.7	0.7	0.5	0.5	0.7	0.6	0.5	0.8	0.8	0.8	0.8	0.8	0.7	0.8
SE-5	0.8	0.8	0.5	0.5	0.7	0.7	0.5	0.8	0.8	0.8	0.8	0.7	0.7	0.7
SE-6	0.7	0.7	0.3	0.3	0.6	0.6	0.4	0.6	0.7	0.6	0.7	0.4	0.4	0.5
SE-7	0.7	0.7	0.4	0.4	0.7	0.6	0.5	0.7	0.8	0.7	0.8	0.7	0.6	0.7
EW-1	0.2	0.1	0.0	0.1	0.3	0.4	0.5	0.3	0.2	0.2	0.1	-0.1	0.0	-0.1
EW-2	0.2	0.1	0.0	0.0	0.2	0.3	0.5	0.2	0.1	0.1	0.0	-0.1	-0.1	-0.1
EW-3	0.3	0.3	0.3	0.4	0.3	0.3	0.2	0.5	0.4	0.4	0.3	0.4	0.4	0.4
EW-4	0.2	0.1	0.0	0.1	0.3	0.4	0.5	0.3	0.2	0.2	0.1	-0.1	0.0	-0.1
EW-5	0.2	0.1	0.0	0.0	0.2	0.3	0.5	0.2	0.1	0.1	0.0	-0.1	-0.1	-0.1
EW-6	0.4	0.4	0.4	0.5	0.4	0.4	0.4	0.6	0.6	0.6	0.5	0.6	0.6	0.5
CC-1	0.3	0.3	0.2	0.3	0.3	0.2	0.2	0.4	0.4	0.3	0.3	0.2	0.1	0.3
CC-2	-0.1	-0.1	0.2	0.2	-0.1	-0.1	-0.3	0.0	-0.1	-0.1	-0.1	-0.2	-0.2	-0.1
CC-3	0.6	0.7	0.4	0.4	0.7	0.7	0.5	0.7	0.7	0.6	0.7	0.5	0.4	0.6
CC-4	0.4	0.4	0.3	0.3	0.3	0.2	0.2	0.5	0.4	0.4	0.5	0.6	0.6	0.7
CC-5	0.3	0.2	0.3	0.5	0.3	0.2	0.2	0.5	0.4	0.4	0.3	0.6	0.5	0.6
CC-6	0.3	0.2	0.1	0.2	0.3	0.4	0.6	0.4	0.3	0.2	0.2	0.0	0.0	0.0

	SE-1	SE-2	SE-3	SE-4	SE-5	SE-6	SE-7	EW-1	EW-2	EW-3	EW-4	EW-5	EW-6
EE-1	0.6	0.6	0.5	0.5	0.4	0.2	0.4	-0.1	-0.1	0.4	-0.1	-0.1	0.4
EE-2	0.4	0.4	0.4	0.4	0.4	0.2	0.4	-0.1	0.0	0.3	-0.1	0.0	0.4
EE-3	0.5	0.6	0.7	0.6	0.8	0.6	0.6	0.3	0.2	0.4	0.3	0.2	0.6
EE-4	0.2	0.3	0.3	0.3	0.2	0.0	0.2	-0.1	-0.1	0.3	-0.1	-0.1	0.4
EE-5	0.4	0.6	0.6	0.6	0.5	0.2	0.5	0.0	-0.1	0.4	0.0	-0.1	0.5
EE-6	0.6	0.7	0.8	0.7	0.8	0.6	0.7	0.3	0.2	0.4	0.3	0.2	0.6
EE-7	0.4	0.5	0.5	0.5	0.4	0.2	0.4	0.1	-0.1	0.4	0.1	-0.1	0.5
EE-8	0.7	0.7	0.7	0.7	0.9	0.8	0.8	0.1	0.0	0.2	0.1	0.0	0.3
EE-9	0.6	0.6	0.7	0.7	0.9	0.9	0.7	0.1	0.1	0.2	0.1	0.1	0.3
EE-10	0.8	0.9	0.8	0.9	0.9	0.7	0.9	0.1	0.1	0.4	0.1	0.1	0.4
EE-11	0.5	0.6	0.5	0.5	0.4	0.2	0.5	-0.2	-0.3	0.2	-0.2	-0.3	0.3
EE-12	0.4	0.5	0.5	0.5	0.5	0.2	0.4	0.0	-0.1	0.3	0.0	-0.1	0.5
EE-13	0.5	0.5	0.4	0.5	0.4	0.1	0.4	-0.1	-0.1	0.3	-0.1	-0.1	0.4
BE-1	0.7	0.6	0.7	0.7	0.8	0.7	0.7	0.2	0.2	0.3	0.2	0.2	0.4
BE-2	0.7	0.6	0.7	0.7	0.8	0.7	0.7	0.1	0.1	0.3	0.1	0.1	0.4
BE-3	0.5	0.4	0.5	0.5	0.5	0.3	0.4	0.0	0.0	0.3	0.0	0.0	0.4
BE-4	0.5	0.5	0.5	0.5	0.5	0.3	0.4	0.1	0.0	0.4	0.1	0.0	0.5
BE-5	0.6	0.6	0.7	0.7	0.7	0.6	0.7	0.3	0.2	0.3	0.3	0.2	0.4
BE-6	0.6	0.5	0.6	0.6	0.7	0.6	0.6	0.4	0.3	0.3	0.4	0.3	0.4
BE-7	0.4	0.5	0.5	0.5	0.5	0.4	0.5	0.5	0.5	0.2	0.5	0.5	0.4
BE-8	0.7	0.8	0.8	0.8	0.8	0.6	0.7	0.3	0.2	0.5	0.3	0.2	0.6
BE-9	0.7	0.8	0.8	0.8	0.8	0.7	0.8	0.2	0.1	0.4	0.2	0.1	0.6
BE-10	0.7	0.7	0.8	0.8	0.8	0.6	0.7	0.2	0.1	0.4	0.2	0.1	0.6
BE-11	0.7	0.7	0.8	0.8	0.8	0.7	0.8	0.1	0.0	0.3	0.1	0.0	0.5
BE-12	0.7	0.8	0.8	0.8	0.7	0.4	0.7	-0.1	-0.1	0.4	-0.1	-0.1	0.6
BE-13	0.6	0.7	0.7	0.7	0.7	0.4	0.6	0.0	-0.1	0.4	0.0	-0.1	0.6
BE-14	0.8	0.8	0.8	0.8	0.7	0.5	0.7	-0.1	-0.1	0.4	-0.1	-0.1	0.5

	SE-1	SE-2	SE-3	SE-4	SE-5	SE-6	SE-7	EW-1	EW-2	EW-3	EW-4	EW-5	EW-6
SE-1		0.9	0.8	0.8	0.8	0.7	0.9	0.0	-0.1	0.3	0.0	-0.1	0.3
SE-2	0.9		1.0	1.0	0.9	0.7	0.9	0.0	-0.1	0.5	0.0	-0.1	0.6
SE-3	0.8	1.0		1.0	0.9	0.7	0.9	0.1	0.0	0.5	0.1	0.0	0.6
SE-4	0.8	1.0	1.0		0.9	0.7	0.9	0.0	-0.1	0.5	0.0	-0.1	0.6
SE-5	0.8	0.9	0.9	0.9		0.9	0.9	0.1	0.0	0.4	0.1	0.0	0.5
SE-6	0.7	0.7	0.7	0.7	0.9		0.8	0.1	0.0	0.2	0.1	0.0	0.2
SE-7	0.9	0.9	0.9	0.9	0.9	0.8		0.1	0.0	0.4	0.1	0.0	0.4
EW-1	0.0	0.0	0.1	0.0	0.1	0.1	0.1		0.9	0.4	1.0	0.9	0.2
EW-2	-0.1	-0.1	0.0	-0.1	0.0	0.0	0.0	0.9		0.4	0.9	1.0	0.2
EW-3	0.3	0.5	0.5	0.5	0.4	0.2	0.4	0.4	0.4		0.4	0.4	0.8
EW-4	0.0	0.0	0.1	0.0	0.1	0.1	0.1	1.0	0.9	0.4		0.9	0.2
EW-5	-0.1	-0.1	0.0	-0.1	0.0	0.0	0.0	0.9	1.0	0.4	0.9		0.2
EW-6	0.3	0.6	0.6	0.6	0.5	0.2	0.4	0.2	0.2	0.8	0.2	0.2	
CC-1	0.6	0.5	0.5	0.4	0.6	0.6	0.6	0.0	0.0	-0.1	0.0	0.0	-0.2
CC-2	0.0	-0.1	-0.2	-0.1	-0.1	-0.1	-0.1	-0.1	0.0	0.2	-0.1	0.0	0.1
CC-3	0.6	0.6	0.6	0.6	0.7	0.6	0.8	0.2	0.2	0.1	0.2	0.2	0.2
CC-4	0.8	0.8	0.7	0.7	0.6	0.4	0.7	-0.1	-0.1	0.4	-0.1	-0.1	0.4
CC-5	0.6	0.6	0.6	0.6	0.5	0.2	0.5	0.1	0.0	0.5	0.1	0.0	0.4
CC-6	0.3	0.2	0.3	0.2	0.3	0.3	0.4	0.7	0.7	0.1	0.7	0.7	-0.1

	CC-1	CC-2	CC-3	CC-4	CC-5	CC-6
EE-1	0.0	0.0	0.3	0.6	0.7	-0.1
EE-2	0.0	-0.1	0.5	0.3	0.4	-0.2
EE-3	0.3	-0.2	0.6	0.3	0.4	0.3
EE-4	-0.2	-0.1	0.3	0.2	0.4	-0.3
EE-5	0.1	-0.3	0.4	0.5	0.5	-0.1
EE-6	0.2	-0.2	0.5	0.4	0.3	0.3
EE-7	0.2	0.0	0.4	0.4	0.5	0.0
EE-8	0.5	-0.3	0.7	0.4	0.3	0.3
EE-9	0.5	-0.3	0.6	0.3	0.2	0.3
EE-10	0.6	0.0	0.8	0.6	0.5	0.3
EE-11	0.2	-0.2	0.4	0.6	0.7	-0.1
EE-12	0.0	-0.3	0.4	0.5	0.5	-0.1
EE-13	0.1	-0.3	0.3	0.6	0.7	-0.1
BE-1	0.3	-0.1	0.6	0.4	0.3	0.3
BE-2	0.3	-0.1	0.7	0.4	0.2	0.2
BE-3	0.2	0.2	0.4	0.3	0.3	0.1
BE-4	0.3	0.2	0.4	0.3	0.5	0.2
BE-5	0.3	-0.1	0.7	0.3	0.3	0.3
BE-6	0.2	-0.1	0.7	0.2	0.2	0.4
BE-7	0.2	-0.3	0.5	0.2	0.2	0.6
BE-8	0.4	0.0	0.7	0.5	0.5	0.4
BE-9	0.4	-0.1	0.7	0.4	0.4	0.3
BE-10	0.3	-0.1	0.6	0.4	0.4	0.2
BE-11	0.3	-0.1	0.7	0.5	0.3	0.2
BE-12	0.2	-0.2	0.5	0.6	0.6	0.0
BE-13	0.1	-0.2	0.4	0.6	0.5	0.0
BE-14	0.3	-0.1	0.6	0.7	0.6	0.0

	CC-1	CC-2	CC-3	CC-4	CC-5	CC-6
SE-1	0.6	0.0	0.6	0.8	0.6	0.3
SE-2	0.5	-0.1	0.6	0.8	0.6	0.2
SE-3	0.5	-0.2	0.6	0.7	0.6	0.3
SE-4	0.4	-0.1	0.6	0.7	0.6	0.2
SE-5	0.6	-0.1	0.7	0.6	0.5	0.3
SE-6	0.6	-0.1	0.6	0.4	0.2	0.3
SE-7	0.6	-0.1	0.8	0.7	0.5	0.4
EW-1	0.0	-0.1	0.2	-0.1	0.1	0.7
EW-2	0.0	0.0	0.2	-0.1	0.0	0.7
EW-3	-0.1	0.2	0.1	0.4	0.5	0.1
EW-4	0.0	-0.1	0.2	-0.1	0.1	0.7
EW-5	0.0	0.0	0.2	-0.1	0.0	0.7
EW-6	-0.2	0.1	0.2	0.4	0.4	-0.1
CC-1		-0.2	0.7	0.4	0.4	0.5
CC-2	-0.2		-0.1	-0.2	-0.1	-0.2
CC-3	0.7	-0.1		0.4	0.4	0.4
CC-4	0.4	-0.2	0.4		0.9	0.1
CC-5	0.4	-0.1	0.4	0.9		0.2
CC-6	0.5	-0.2	0.4	0.1	0.2	