From Masterplans to Local Strategies - High and Low level Applications of the Ecological Footprint

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ABSTRACT

The Ecological Footprint is a widely used and accepted tool for educating and raising awareness of the environmental impacts associated with consumption. Although initially it was used as an awareness raising tool, the past few years have seen the use of the Footprint as a policy tool become more widespread. This growth has occurred specifically amongst decision makers in local authorities and regional governments where the Footprint has provided information for evidence-based policy decisions. Moreover, its use is now expanding further and the past year has seen its use in a wide variety of other studies. For example, at the masterplanning level the Footprint has been used to asses the sustainability of the proposed new eco-city in China 'Dongtan'. At the micro scale it has been used to look at the relative environmental impacts of different waste management systems. This paper looks at a number of real life examples to demonstrate the wide variety of practical applications of the Ecological Footprint and to assess the appropriateness of its use at each scale.

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1. Introduction:

The ecological footprint provides an aggregated indicator of resource consumption and waste generation. It provides an indication of how global, national, regional or local consumption relates to globally available resources and, through this means, acts as an index of sustainable consumption put within a global context.

Countries, organisations, individuals and institutions the world over have begun to utilised the ecological footprint to asses their ability to live within the ecological limits of the planet. This paper will run through two key real life case studies to assess ways in which the ecological footprint has been used at the macro and micro level. The first will look at the plans for the proposed new eco-city development in China 'Dongtan', which will home an estimated half a million by 2040, and where the ecological footprint has been used to both asses and drive the sustainability of this new development. Secondly a look will be taken at the ecological footprints use at the micro level drawing on an example of its use in assessing the impact of local waste management. In both examples the ecological footprint will be assessed for its appropriateness in use.

2. A Global Context

It is of wide global recognition that with present day consumption levels we are using the world's resources faster that they can be replenished and generating wastes faster than they can be absorbed. The most recent Living Planet Report published in 2006 demonstrated that today's scale of global consumption of resources is exceeding the Earth's capacity to regenerate by 25% and that we have been living beyond the planets ability to support our lifestyles for the past 20 years (WWF, 2006). These worrying statistics are backed up with visible signs of our ever increasing levels of consumption readily seen in the world around us, such as the depletion of fish stocks, the destruction of rainforests and the pollution of waters. The Living Planet Index (LPI) has demonstrated a continual decrease in global biodiversity with, for example, the population of global terrestrial species declining by about a third since 1970 (WWF, 2006).

It has also become evident that the planet is struggling to keep up with the volumes of waste we are producing. Carbon dioxide is the waste gas produced in many industrial systems, energy generation and the burning of petrol. Because the Earths biomass cannot absorb this waste carbon as quickly as it is generated by human activities there has been a build up in carbon dioxide concentrations in the atmosphere since pre-industrial times. Global carbon dioxide concentrations reached 379ppm in 2005 which far exceeds the natural range of 180 – 300 ppm over the past 650,000 years (IPCC, 2007a). As reported in the summary of the fourth report for the UN's Intergovernmental Panel on Climate Change (IPCC) there is now a strong consensus amongst the scientific community that global warming is a result of these anthropogenically derived greenhouse gas emissions. Records have shown that eleven of the past twelve years (1995 – 2006) were amongst the twelve warmest years on record since records began in 1850 (IPCC, 2007a). Climate change is having far and wide reaching effects on the planet. In the IPCC's fourth assessment it has been stated that 'Observational evidence from all continents and most

oceans shoes that many natural systems are being affected by regional climate changes, particularly temperature increases' (IPCC, 2007b).

With global population reaching over 6.5 billion in 2005 and estimated to reach 9.1 billion by 2050 (UN, 2005) and with an ever increasing number of people entering the consumer society, total levels of global consumption are more than likely to continue growing into the foreseeable future which will increase both the total quantity of resources consumed and wastes generated. It is going to be a global challenge, and one that must be led by the developed world, to reduce the impact of our consumption, so that we as a global population can live within the means of the planet. The ecological footprint, a measure of sustainability in the context of the planets ecological limits, may prove to be a key indicator that can help to map out our progress along this path.

3. The Ecological Footprint

The ecological footprint is the predominant methodology used to highlight the impacts of consumption within the context of ecological limits. The methodology has been increasing in popularity since its initial publication by Mathis Wackernagel and William Rees in the early 1990's. The footprint is a means of measuring a population's level of consumption by calculating the notional and direct land area needed to support them with the resources they consume and absorb the wastes they generate. The ecological footprint is measured in global hectares (gha) which means that the land can be located anywhere in the world and is representative of a standardised unit of average global productivity. In this manner the ecological footprint reallocates the environmental impact to the end user no matter where in the world the impact takes place.

Ecological footprint methodology can take either a bottom up or top down approach, or use a combination of both. The two methodologies which have both been used to conduct ecological footprint calculations in the UK have been widely reported on, see "Sharing Natures Interest" (Chambers et al, 2001) for bottom up and "Allocating ecological footprints to final consumption categories with input-output analysis" (Wiedmann et al, 2006) for the top down for example.

Independent of the methodology used to conduct an ecological footprint study, one of the most important messages that it conveys is that we only have one planet with a finite land area therefore clearly demonstrating that we are constrained by ecological limits. Moreover it takes a different approach from traditional environmental indicators, such as the Kyoto climate change targets, where impacts are measures within a defined boundary such as a country, and instead calculates the impacts of a population no matter where in the world the impact is taking place. The ecological footprint is therefore taking a consumer rather than territorial approach in measuring environmental impacts.

4. How Is The Footprint Being Used?

The ecological footprint is now being widely used in many countries and at many different levels. For example it is being adopted by government authorities and agencies,

organisations, companies and communities the world over. Individuals are also becoming aware of the concept with the advent on numerous on-line ecological footprint calculators (see www.myfootprint.org for example) allowing for the calculation of your own personal ecological footprint. In 2005, a 'Google' internet search registered more that 30,000 hits for the phrase 'ecological footprint' (Barrett et al, 2004), today this has risen to over 1,150,000, representing a near 4 fold increase.

Since the origination of the ecological footprint concept the majority of studies conducted have assessed the impact of a defined population be it an entire country, or part of a country. In the UK a vast number of projects have been carried out working with local, regional and national government bodies. For such projects the ecological footprint has been used to analyse policy and develop scenarios as well as to educate and raise awareness both internally within the government organisation and externally to the general public. Regional projects have included in detail studies of Wales, Scotland, Northern Ireland, London, South East, South West and the North East (see www.regionalsutainability.org and www.bestfootforward.com for more details). Within the Ecological Budget UK project, completed in 2006, a consistent methodology was used to asses the ecological footprint and material flows for every region and devolved country in the UK (WWF, 2006). At the local level numerous Local Authorities in the UK have also conducted an ecological footprint study including York, North and North East Lincolnshire, the ten local authorities that make up Hertfordshire, Bury, Cardiff, Gwynedd and the local authorities that make up Greater Nottingham and Nottinghamshire to name but a few.

Over the past few years there has been a rapid rise in 'non-traditional' ecological footprint studies. Recent projects have involved analysis of businesses, sports events, different diets and specific products. It is not within the scope of this paper to discuss the numerous applications of the ecological footprint and their appropriateness for use. Instead a look will be taken at two specific case studies. The first will look at the generation of the masterplans for the development of a new eco-city in China 'Dongtan', and the second will take a look at its use in assessing localised waste management.

5. Dongtan

5.1 Introduction

China is currently urbanising at a rate never seen before in global history, there are already 90 cities with more than a million residents (Pearce, 2006). The rate of urbanization in China is expected to rise to around 70 percent by 2050 which equates to approximately 10 to 12 million people moving from rural areas into cities every year (Embassy of the people's republic of china, 2003).

Whilst the process of urbanisation and industrialisation in China has led to a booming economy, it has also led to the generation of major pollution problems. However, there has been recognition in China that the only way to sustain this rate of urbanisation combined with long term social and economic vitality is to recognise environmental and

ecological limits and move forward along a path of more efficient and effective use of natures resources.

It is becoming evident that these messages are beginning to inform the decisions of both the government and planners alike. For example when the Chinese Government released their plans for the development of a new eco-city in China called Dongtan, it sent out a clear message that they were willing to find ways of overcoming the challenges of creating sustainable cities in the face of significant climate change, environmental pollution, water shortages and the need for the use of cleaner energy. Ma Cheng Liang who is in charge of the Dongtan development has stated that Dongtan is an experiment for China who are trying to stay within their ecological limits, "We face challenges of shortages of energy and damage to the environment, we need to reduce our ecological footprint. So Dongtan is very significant for Shanghai and our nation" (Pearce, 2006).

This section of the paper will discuss how Arup have used the ecological footprint as a tool to feed into the designs for the Dongtan masterplan and discuss its suitability for use in the application.

5.2 The Dongtan Project

The Shanghai Industrial Investment Corporation (SIIC) commissioned Arup to design the world's first sustainable city which is to be situated close to Shanghai on China's third largest island situated in the mouth of the Yangtze River. Arup have used a system of integrated masterplanning in the design of Dongtan to develop a dynamic, liveable and eco-friendly city that has the lowest achievable ecological footprint and is as close to being carbon neutral as possible within economic constraints.

The city of Dongtan is estimated to be 86km2 in size and to house half a million people by 2040. It will be a place where people can both live and work in a high quality environment. The designs are based on the principal that all of its citizens can be in close contact with green open spaces, lakes and canals. The population of Dongtan will live in three compact districts separated by green land such as parks and lakes and leisure facilities. The development will be low rise consisting of 6-8 storey blocks which will avoid the "heat island" effect which is felt in neighbouring Shanghai where night time temperatures can be elevated by 6C. The buildings will be highly energy efficient and the city will be largely powered by renewable energy.

Due to Arup being responsible for masterplanning the entire built environment from urban design, energy management and renewable implementation, waste management, economic and business planning, sustainable building design, infrastructure and community and social structures, it was possible for a holistic and integrated approach to be taken in achieving the goal of reducing the overall environmental impact of the city.

5.3 Integrating the Ecological Footprint into the Design Philosophy

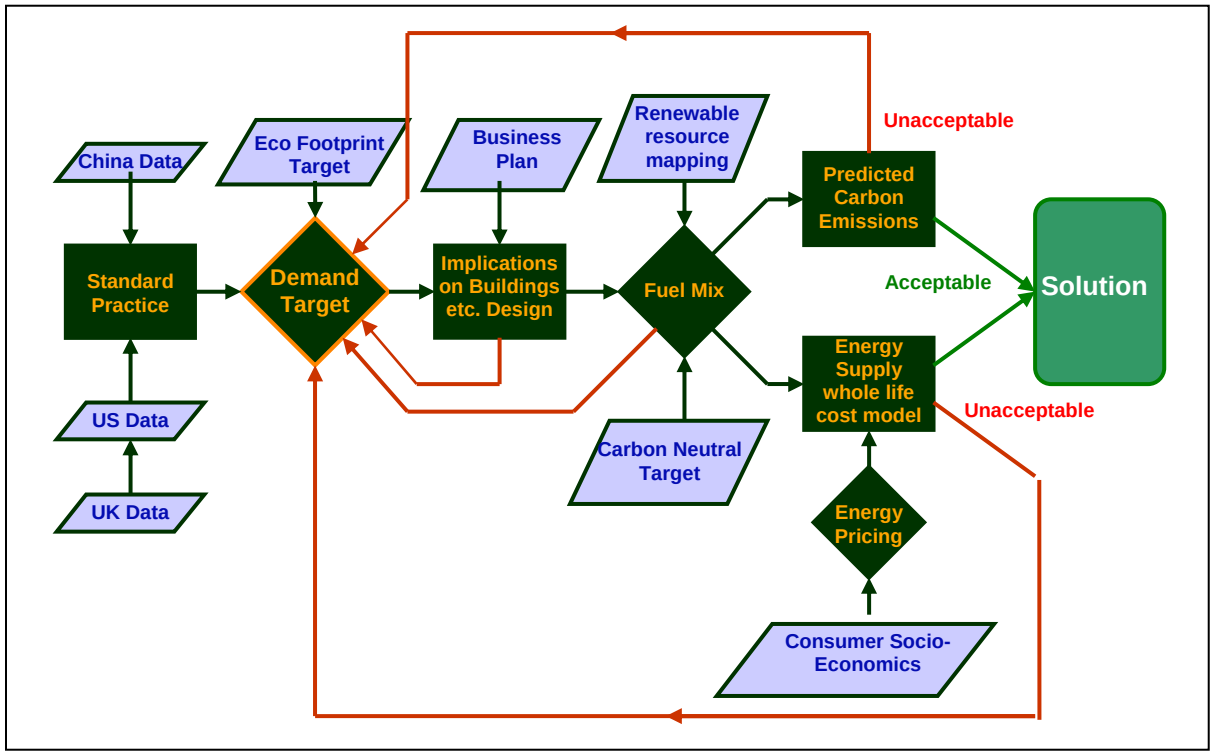
The average footprint in rural China currently stands at 1.6 gha per capita and that of an individual living in Shanghai is already around 7gha per capita. In a country that is

urbanising as rapidly as China it is important to try and significantly reduce the impact of all new cities. With the vision of being an eco-city it was decided that the Dongtan development would aim to have the lowest possible ecological footprint.

Through using the ecological footprint as a key indicator throughout the entire design phase of the eco-city it encouraged the use of innovative technologies and forced members of the project team who where involved in designing different components of the masterplan to collaborate with the ambition of identifying new ways to collectively reduce the ecological footprint of Dongtan by the absolute maximum possible.

Figure 1 below demonstrates the process that was put in place to achieve a low ecological footprint in the masterplan development for Dongtan. Initially the baseline ecological footprint for a new city development in China was derived from existing data. The masterplan could then be analysed to determine the ecological footprint of the design and then continually reiterated to reduce the ecological footprint to the absolute minimum.

Figure 1: Schematic of integrated approach to developing a low ecological footprint in the Dongtan masterplanning process.



Source: Arup

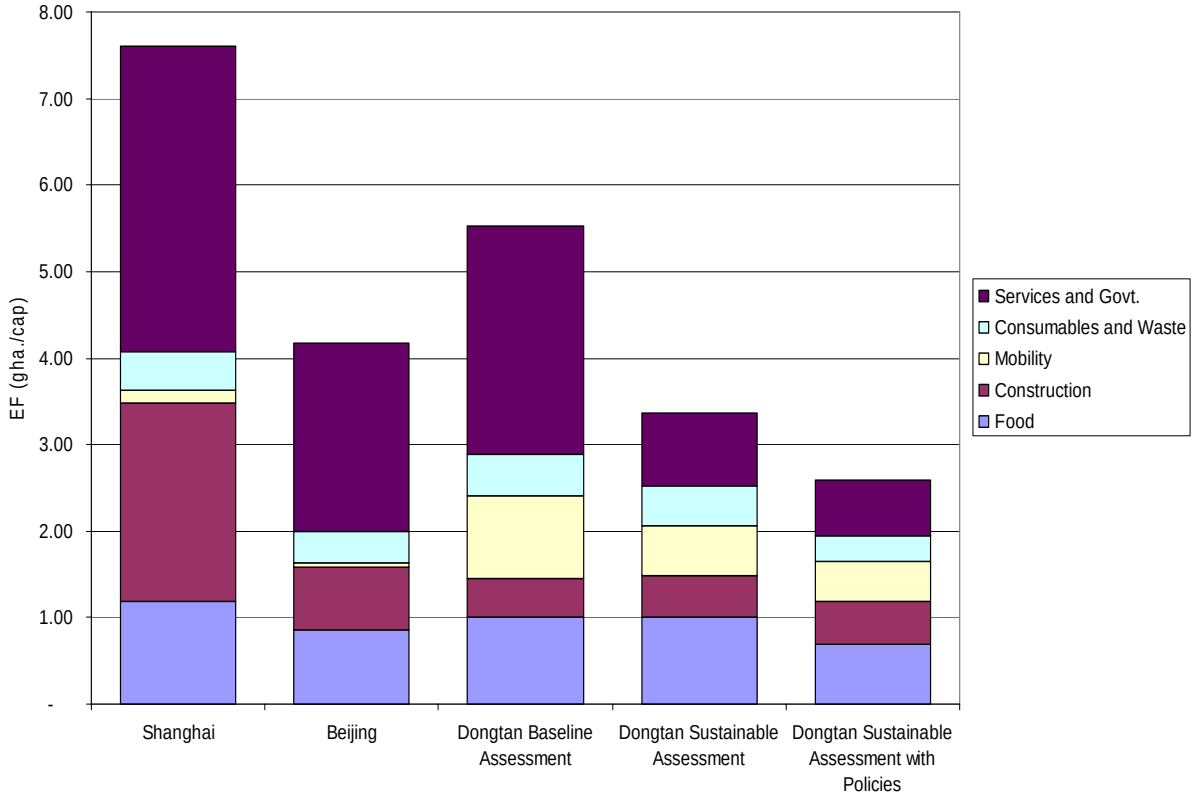
Through this process the masterplan was in a constant state of flux with new interventions from all members of the design team being implemented into the plans until the project team felt that they had achieved an acceptable end result.

5.4 The Ecological Footprint of Dongtan

To calculate the ecological footprint of Dongtan, Arup teamed up with the Stockholm Environment Institute (SEI), who assisted in the adaptation of Chinese Input-Output tables to generate a model for calculating the ecological footprint. The final results demonstrated that the new development could achieve an ecological footprint of 2.6gha per capita. Although this is an increase from the average Chinese rural resident it is significantly lower than the average Chinese urban resident as well as being one of the best examples of a sustainable urban environment to date.

The final results for the ecological footprint of Dongtan are detailed below in Figure 2. The 'Dongtan Baseline Assessment' indicates the predicted ecological footprint of Dongtan if current trends continue and existing legislative requirements were met with no interception to improve sustainability. The 'Dongtan Sustainability Assessment' provides an indication of the ecological footprint of the eco-city on implementation of all the planned sustainability measures. The 'Dongtan Sustainability Assessment with Policies' explores the likely further reduction in the ecological footprint that can be achieved with the inclusion of policy measures to achieve higher levels of sustainability.

Figure 2: The Ecological Footprint of Dongtan



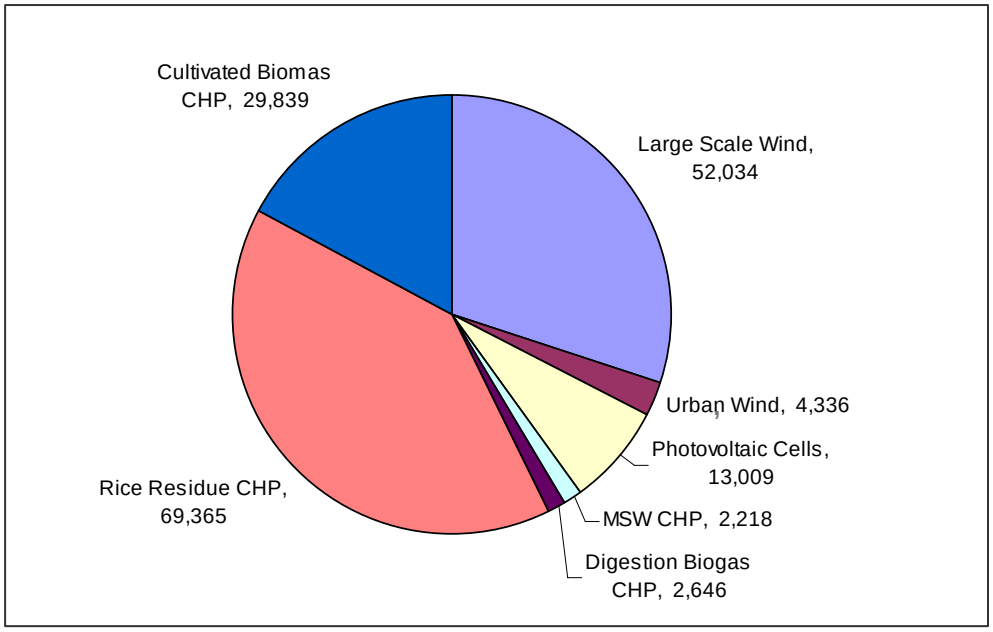
Source: Arup and SEI

This paper will now go on to talk through two specific categories in more detail to provide information on how the ecological footprint has been reduced in the Dongtan masterplan.

5.4.1 Energy use in Dongtan

Dongtan's energy consumption will be derived from 100 percent renewable sources. Energy will be generated from both solar power and wind turbines combined with an anaerobic digestion plant on the edge of the city that will convert organic waste, including sewerage, into biogas that can be used for cooking, heating and power generation. Buildings will have photovoltaic solar panel cells, there will be large wind turbines outside the city area with smaller ones on the side of buildings. Combined heat and power systems will provide the technology to source clean and reliable energy from waste products such as rice husks (the outer shell of a rice plant) which would otherwise be thrown away.

Figure 3: Sources of electrical energy in Dongtan (MWh/annum)

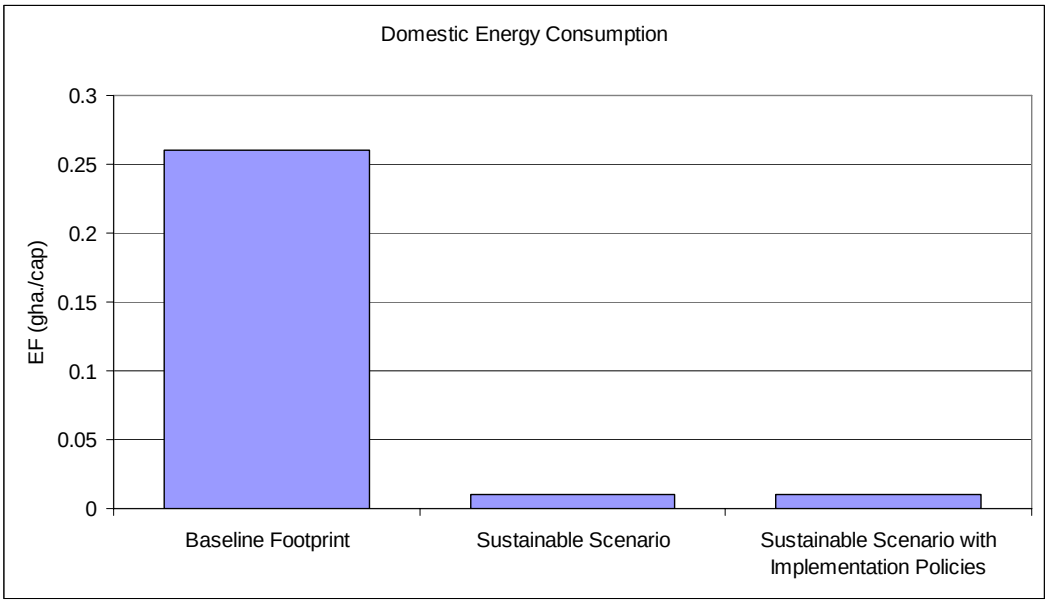


Source: Arup

The design of the buildings and the cities infrastructure will also help reduce energy use by an estimated 64% from 1,650 GWh/year to 600 GWh/year. For example natural ventilation will be utilised which minimises the need for air conditioning systems.

The results of the ecological footprint analysis are shown below in Figure 4. The analysis demonstrated that Dongtan is likely to have a 95 percent reduction in its ecological footprint of energy use compared to the baseline scenario in which energy is predominantly generated through the combustion of coal.

Figure 4: The ecological footprint of domestic energy consumption



Source: Arup and SEI

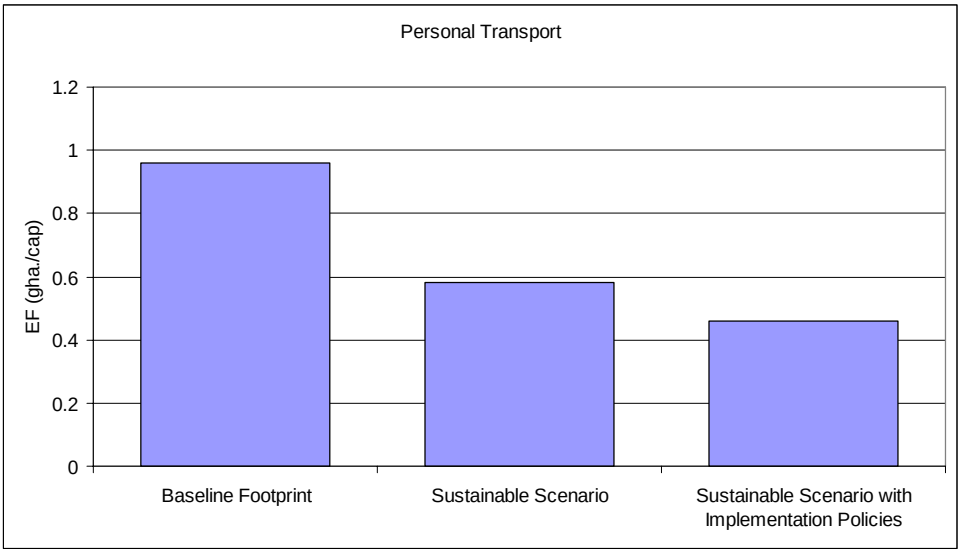
5.4.3. Travel in Dongtan:

Through the design layout of the city the need for transportation has been minimised by having an appropriate mix of facilities within walking distance of residential areas and village centres. The use of cars in Dongtan is going to be strongly discouraged. Although there is a bridge to be built creating a direct connection between Dongtan and Shanghai's central business district, the idea is that residents and visitors will leave their vehicles at the edge of the city and then walk, cycle or use public transport. All public transport will run on Hydrogen or electricity generated from renewable sources and it is suggested that if any car is to enter Dongtan it too must run on electricity or Hydrogen. Not only will this significantly reduce pollution in the city but it will also cut down on noise making Dongtan a quiet and tranquil place to work and live.

The proposed village centres will be designed around pedestrian and also served by public transport both road and water based. Each of Dongtan's neighbourhoods will be designed to prevent through traffic. There will be a continuous network of walking and cycling routes throughout Dongtan which are connected to canals and green parks. There will be a continuous loop served by public transport circulating the city. It is estimated that it will take 7 minutes at most for a pedestrian to reach a bus or tram stop.

The masterplan has the ability to significantly reduce the ecological footprint through both reducing the need to travel and encouraging the use of cycling and walking. The final results of the ecological footprint analysis are shown in Figure 3 below. It is estimated that the ecological footprint could be reduced by 56% from the baseline scenario.

Figure 5: The Ecological Footprint of Transport



Source: Arup and SEI

5.5 Appropriateness of use:

The Dongtan masterplan has proved to be an immensely important application of the ecological footprint as it has clearly demonstrated that cities do not have to have to have a large impact on the environment.

One of the key successes has been the involvement of environmental scientist's right from stage one in the planning process, before the city has been built. This has enabled a two way iteration process to be developed whereby designs have been drawn, the ecological footprint calculated and then the designs altered and improved to further reduce the footprint. In this manner it has also allowed all member of the design team to collaborate and work together towards a common goal in designing the optimum transport, energy, water and waste disposal systems for the city. Through running a number of scenarios of different options it was also possible to determine the optimal population spreads and densities to reduce the footprint to an absolute minimum.

The use of the footprint has enable the plans for the proposed eco-city to have an estimated ecological footprint of only 2.6 gha per resident, which is an enormous achievement given that the average footprint of a resident of neighbouring Shanghai is around 7 gha.

5.6 Conclusions:

Dongtan is a local project with a global perspective, designed to contribute to the emergence of a world of ecologically and economically sustainable human settlements. It is becoming clear that the planet will not be able to deal with the current levels of global urbanisation and its associated consumption of resources and pollution. Therefore the key significance of Dongtan is in that it has demonstrated that international cities can achieve

sustainability and do not have to follow the route of development of all other cities worldwide. Dongtan can now set an example of how to achieve a low urban ecological footprint. It will be a pioneering eco-city that could become a template for sustainable urban development, in China itself and elsewhere in the world.

6. Waste Management

6.1 Introduction

Merseyside Waste Disposal Authority has commissioned Arup and SEI to conduct an analysis of the ecological footprint of their waste management. At time of writing this paper the project is incomplete and so no results have been detailed in the following section for confidentiality reasons. However due to the uniqueness of this project it has been used as a case study to demonstrate a new and novel application of the ecological footprint at the local level.

The overall objective of this project is to develop the ecological footprint indicator (and carbon footprint) to raise awareness of the impact that household waste and waste deposited at Household Waste Recycling Centres in the North West have on sustainable development and climate change.

6.2. Waste and Climate Change

When waste biodegrades in the absence of air at a landfill site both methane and carbon dioxide are generated. In Europe, 60-70% of municipal waste is biodegradable and 65% of this is sent to landfill (EC, 2003). In the UK landfill sites are responsible for 22% of UK methane which has a global warming potential 23 times that of carbon dioxide (Jardine et al, 2006). It is estimated that one tonne of biodegradable waste generates 200 – 400m^3 of landfill gas (DEFRA, 2006).

Greenhouse gases are produced at every stage in the lifecycle of a product the extraction of raw materials, transport, manufacturing, use, to final treatment of waste and its disposal. Waste prevention is the most important management technique in terms of greenhouse gases as it prevents emissions at every stage in a products life cycle. Although recycling and composting do not avoid greenhouse gases, if managed well both options offer significant advantages. Whilst recycling demands energy the associated greenhouse gases are often much lower in comparison to those offset from both the production of raw materials and the disposal of materials to landfill. For example copper recycling reduces average energy requirements by 85% and plastic recycling by 80% (BIR, 2007). Composting also reduces greenhouse gases as it is largely aerobic and produces carbon dioxide instead of methane with the majority of the carbon remaining in the compost.

Surprisingly there has been limited documentation linking waste to climate change and other environmental indicators such as the ecological footprint. It is therefore not surprising that although many people are aware that they should recycle and compost

their waste they are unaware as to the significance of their actions in a broader environmental context.

6.3 Project Aims

The key aim of this project is to forge the link between waste management and the wider environment impacts, predominantly climate change, in the minds of those who manage waste and those who generate it. The project will conduct an ecological footprint and carbon footprint analysis of current waste management practices in the Merseyside Waste Authority. On completion of the analysis the results will be used as an awareness raising tool to respond to the needs of specific audiences. Initially there will be a series of 5 workshops held to disseminate the results to the regional stakeholders and it is anticipate that this will follow on to local awareness raising material being developed to spread the message to residents within the area.

6.4 Appropriateness of use

As an awareness raising tool in this context the ecological footprint is a highly appropriate indicator to utilise. It has regularly been reported that the ecological footprint conveys an easy to understand message linking the impacts of consumption to ecological sustainability. In an analysis of applications of the ecological footprint, it was stated that the predominant role of the ecological footprint has been one of creating public awareness and education (Barrett et al, 2005). Its success stems from its easy to understand concepts and the undisputable notion that we only have one planet allowing people to relate to the message that it identifies. Angus Council have utilised the ecological footprint for internal promotion in a similar manner as is to be done in Mearsyside Waste Authority. For Angus Council the experience was very positive and they stated that ‘people were interested in the project just because it was unusual – they hadn’t heard of the ecological footprint before. The concept is easier to understand than sustainable development – that term just switches people off’ (Barrett et al, 2005). In the context of waste management, recycling and composting the ecological footprint can serve to make the link between individual consumption habits and the wastes that this generates with the ecological limits of the planet in a manner that no other indicator is able to do. The results can also be used to help encourage increased recycling and composting levels and more sustainable waste management practices.

6.5 Conclusions

The Merseyside Waste Disposal Authority waste management assessment will prove to be a very interesting project as it is striving to place the issues of waste management within a global context. With the issues of climate change currently sat high up within the UK political agenda this project will provide a timely assessment of current waste management practises within the area in terms of both the ecological and carbon footprints. In addition, the indicators will be used to influence attitude and behaviour toward waste in a way that is readily and easily understood by individuals responsible for managing waste and the general public alike. The success is likely to be in the fact that

the project relates to clearly defined concepts of which individuals are easily able to identify with.

7. Conclusions

The ecological footprint is a versatile tool that can be used to clearly convey the messages of sustainability. In a climate where as a global population we are consuming an ever increasing quantity of resources and generating more wastes than ever before it is imperative that we gain an understanding of how this is impacting the world around us. The ecological footprint serves as the vital link in addressing these issues.

In terms of its application, it has been demonstrated that they can be both at the macro and micro level. At the macro level, the use of the ecological footprint in developing a masterplan for the new eco-city in China 'Dongtan' the ecological footprint has been used to assist all member of the project team in achieving a common goal and helped to highlight the interdependencies between different aspects of the design. At the micro level, the ecological footprint is being used to demonstrate the wider environmental impacts of waste management. At this scale it is a highly valuable educational tool that can help individuals at all levels of understanding make the important links between individual actions in a global environmental context.

As an important end note, the ecological footprint is still one of the only indicators to provide a comprehensive indication of human impacts on the planet in an easily comprehendible manner. The coming years are more than likely to see numerous new and novel examples of its application worldwide.

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