

## Year 1 Progression Report

# The Environmental Sustainability of the Bristol City-Region: Current and Potential Scenarios

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# **PART A**

## **1. Introduction to the Research**

The working title for the research is “The Environmental Sustainability of the Bristol City-Region: Current and Potential Scenarios”. The research is concerned with the sustainability of the Bristol city-region (the county formerly known as Avon), focussing primarily on the environmental pillar of the sustainable development discourse. The key aim is to generate an assessment of the present (and to some extent, historical) sustainability situation for the city-region and examine future possible scenarios including ways in which the most sustainable outcomes can be achieved.

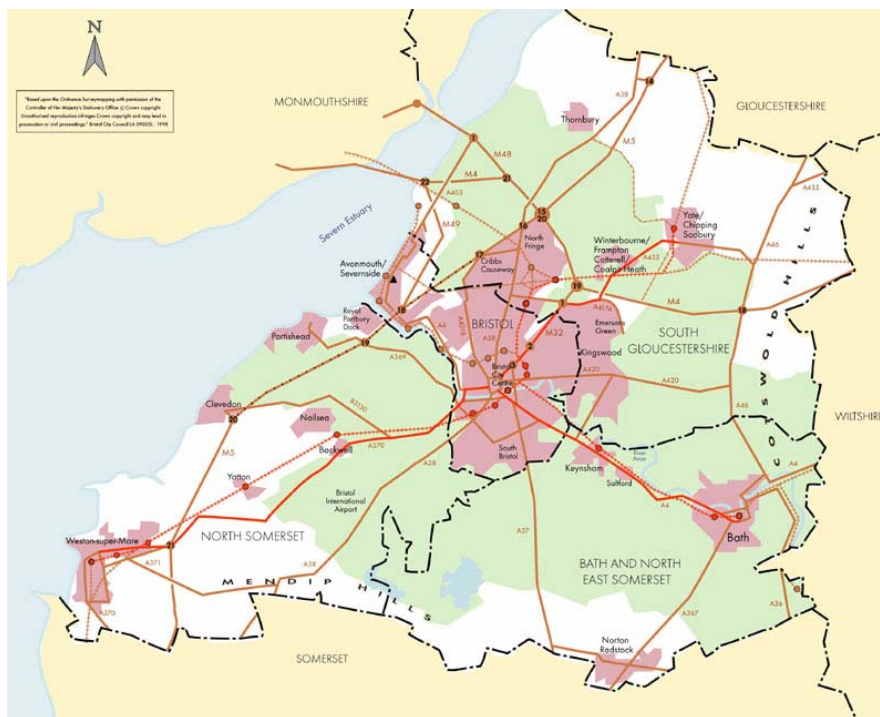
The focus on cities and sustainability is vital for global sustainable development, cities representing intense hubs of human activity and being the main drivers of modern economies (OECD, 2006). According to Girardet (1999), 80 per cent of Europeans live in urban areas, and globally cities use around 75 per cent of the world’s resources and generate most of the world’s waste. Rees (1997) alludes that cities themselves represent great opportunities for sustainable living due to their concentration of activity and potential for collective action, but nonetheless also present a great sustainability risk due to their size, levels of consumption and perceived separateness of the population from the land that feeds them.

The sustainability of cities can be thought of as having two spatial scales – activity and environmental impacts occurring within the city-region, and activity and environmental impacts occurring outside of the city region to which responsibility can be attributed to the city-region itself. Various methods have been devised to measure environmental sustainability at both scales, with one approach emphasising the maintenance of local natural capital assets (ecosystems) whilst the other is concerned with sustainable consumption and production (SCP) with an emphasis on protecting the quality and longevity of ecosystems globally. This research will embrace both approaches. The purpose of this report is to describe the relevance of these approaches and discuss how

they will be used in this project to achieve the sustainability assessment and exploration of scenarios for the Bristol City-Region.

## 2. Background Justification

With the latest estimated population being 421,300 inhabitants (Office for National Statistics, 2009) and a population density of around 3942 people per square kilometre in 2001, the City of Bristol is among the top 10 most populous areas in the United Kingdom (Pointer, 2005). Clearly human demands for food, water, energy, materials and products cannot be met by the city alone. Being part of a globalised economy, within the current political and energy climate Bristol is able to import these commodities from around the world. Indeed some commodities can be sourced from closer to home within the city-region, for example water abstracted and treated from the River Avon, local food and timber produced from the surrounding farmland and fisheries, electricity from nuclear energy generated by Oldbury power station and consumer products produced within the city itself and surrounding urban areas. The Bristol City-Region, Greater Bristol or former county of Avon as it can be termed, is shown in Fig. 1.



**Figure 1:** The Bristol City-Region is made up of four unitary authorities: Bristol City, South Gloucestershire, Bath and North East Somerset and North Somerset (Source: Joint Local Transport Plan Team, 2006)

From a sustainability perspective, defined here for simplicity as *the responsible stewardship of the earth and its people through time in order that future generations are able to meet their needs*, the production of these commodities, wherever they occur, will consume natural resources which can have a negative impact on the source environment and reduce the global stock of finite resources. The commodities themselves when consumed can also have a negative impact on the sink environment in terms of pollution from waste. Transporting and trading the commodities also uses energy, which at present largely comes from oil consumption, which in turn causes local air pollution, global warming from carbon dioxide pollution and runs down a finite supply of concentrated energy. It is argued here that the extent of this impact of resource consumption on the environment and finite resource stocks is the main question for managing development sustainably. A separate argument would be that in a less stable political and energy climate, the export of commodities from distant sources may not be possible, and therefore a reliance on the region's own natural capital could be essential. The maintenance of regional natural capital can therefore also be considered as a matter of bioregional resilience, as noted by Larsen (2008) from the Victorian Eco Innovation Lab.

Bristol city has shown a great overall acceptance of the sustainable development paradigm with regular farmers' markets selling local produce and a well implemented household recycling scheme (see Bristol City Council, 2009). The city has gained Fairtrade status through many retailers signing up to the Fairtrade scheme (see Bristol Fairtrade Network, 2009), and the city has been graded as the UK's most sustainable city in an index created by the charity Forum for the Future (Forum for the Future, 2008a). Forum for the Future have also initiated a project to launch Bristol as the UK's first sustainable city-region, working with partners in industry and local government (Forum for the Future, 2008b). This PhD is incorporated into the first stages of this wider project, Forum for the Future being a co-funder.

Whilst Bristol has achieved more than most cities in the UK in terms of becoming more sustainable, there are still many challenges ahead if the city-region is to be sustainable in the truest, deepest sense of the term. The city suffers from much road congestion causing localised air pollution and contributing to global

warming, as well as inefficiently depleting a finite supply of oil. Economic growth pressures from central government threaten the city-region's natural capital with regards to building on virgin agricultural land. The city's consumption as measured by its ecological footprint, that is, the amount of land required to regenerate renewable resources used and sequester carbon dioxide produced, has already been roughly calculated as being 191 times the size of the city, which would equate to three earth's worth of ecological productivity if every person used an equivalent amount of resources per year (Bristol City Council, 2003).

It is apparent that whilst Bristol has been moving towards a more sustainable future, there appears to have been no explicit assessment of the city-region's environmental sustainability, taking into account both urban and rural areas and the local and global impacts of local and global economic activity occurring from within the city-region. There also appears to be no overall guiding directions for sustainable outcomes for the city-region. It is proposed that the focus of this PhD will be to attempt to fill such knowledge gaps.

The following literature review covers some of the conceptual and methodological aspects for measuring the sustainability of city-regions and developing potential scenarios.

### **3. Literature Review**

#### ***3.1. Introduction: Definitions and Main Principles***

The potential danger of the now widespread use of the terms *sustainability* and *sustainable development* is that they can mean many different things to many different people and in the worst case, render the sustainable development paradigm redundant as just another term for good environmental management and civic planning (see Bell and Morse, 2008, p. 79). Taylor (2003) suggests that a narrower environmental definition of sustainable development relates more to the concept's origins and therefore gives it a clearer focus. As Plant (2001) describes in reference to Marx (1954), societies are fundamentally subordinate to nature, and it could be argued that our fair management of nature for current and

future generations is the most critical aspect of maintaining the longevity of the human race.

Drawing on systems theory, Robèrt (2000) gives a very specific definition of sustainability and sustainable development in relation to the environment. He argues for a semantic difference between principles of *sustainability* and principles of *sustainable development*. The principles for sustainability are given by four system conditions that determine a “favourable outcome” in the systems under study (2000:248), whilst the principles for sustainable development relate to the process, or strategy, to achieve the principles for sustainability. The four system conditions are as follows, later becoming patented by Robèrt as The Natural Step toolkit:

1. Substances extracted from the lithosphere [earth’s crust] must not systematically accumulate in the ecosphere [earth’s ecosystems].
2. Society-produced substances [i.e. anthropogenic chemicals] must not systematically accumulate in the ecosphere.
3. The physical conditions for production and diversity within the ecosphere must not systematically be deteriorated.
4. The use of resources must be efficient and just with respect to meeting human needs.

(Homberg, Robèrt *et al.*, 1996)

For clarity within this project, these system conditions will be taken as the definition for sustainability and the process or strategy to achieve them is defined as sustainable development. For a more detailed exploration of the values and origins behind sustainable development, see the essay in Part B, Appendix 3.

### **3.2. Systems Thinking: Industrial Metabolism**

The principles of sustainability can be applied to a city-region using systems thinking (as described by Bell & Morse, 2008, p.110-114), with boundaries drawn up in order to define and explain the interactions of the city-region with the rest of the world. Various authors such as Rees (1997), Girardet (1999), Ravetz (2000) and Newman & Jennings (2008) call for a city’s ‘industrial metabolism’ to move

away from a linear throughput of resources and energy to a more circular metabolism where resources and energy are sourced locally and reused and recycled as far as possible. Figure 2 depicts a city-region with a linear metabolism whilst Figure 3 shows the same system with a more sustainable, circular metabolism. Figure 2 is effectively an exaggeration of the unsustainable nature of cities; since environmental concerns have become part of the public agenda, the present day situation already incorporates elements of Figure 3. However the diagram is valuable for the illustration of how a city can be unsustainable.

The inputs in Figure 2 consumed by households, industry, agriculture and public services in rural and urban areas of the city-region (or *bioregion*) are largely sourced from outside the city-region, as is generally the case when the city-regional economy is operating mainly at the global scale<sup>1</sup>. The useful properties of final use commodities are used up within the bioregion and output as waste, whilst other materials / chemicals are utilised to make products, food or other materials for industry and consumers, all of which are largely exported. Some solid waste is dumped in local landfills and sewage sludge incinerated, or is exported for treatment outside of the bioregion. Other waste escapes from the region as atmospheric or water pollution. The finance link towards the bottom of the diagram shows external regional production occurring in the rest of the world (ROW, external to the region) which is being financed by the bioregional economy. This could be through investment or retail. It is likely that if this production is occurring in the developing world, environmental standards will be poorer than if the same production took place within the developed world (or equally as poor as that being depicted in the bioregion in Figure 2). The sustainability link with financial investment has been suggested by Girardet (1999) and is discussed in more detail by Schmidheiny & Zorraquín (1996).

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<sup>1</sup> The general exception to this rule is that water has historically been abstracted and treated locally in the UK due to economic efficiency and convenience, and the situation only tends to change in conditions of drought. Treatment of water however does tend to involve inputs of chemicals from global sources.

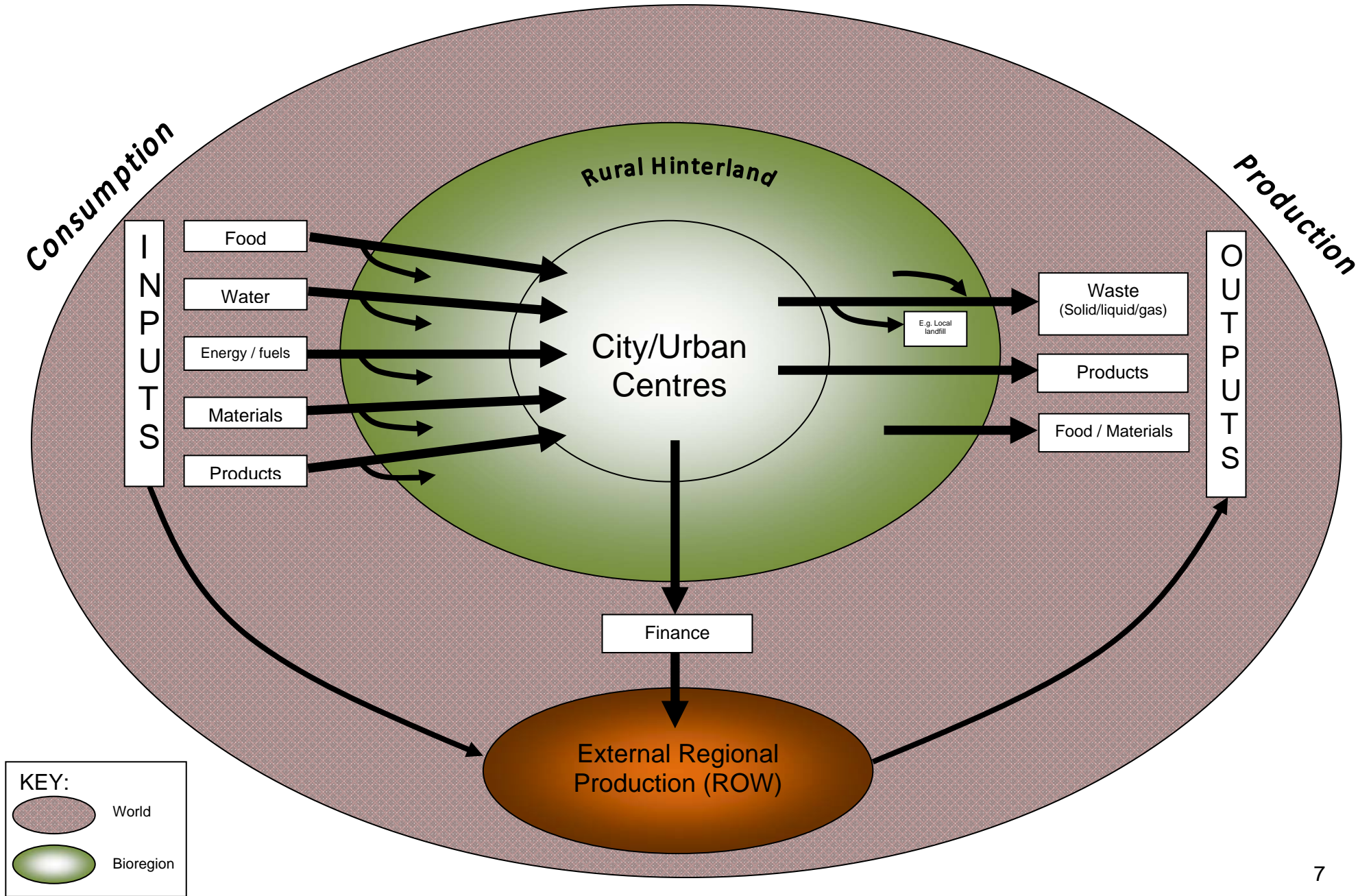
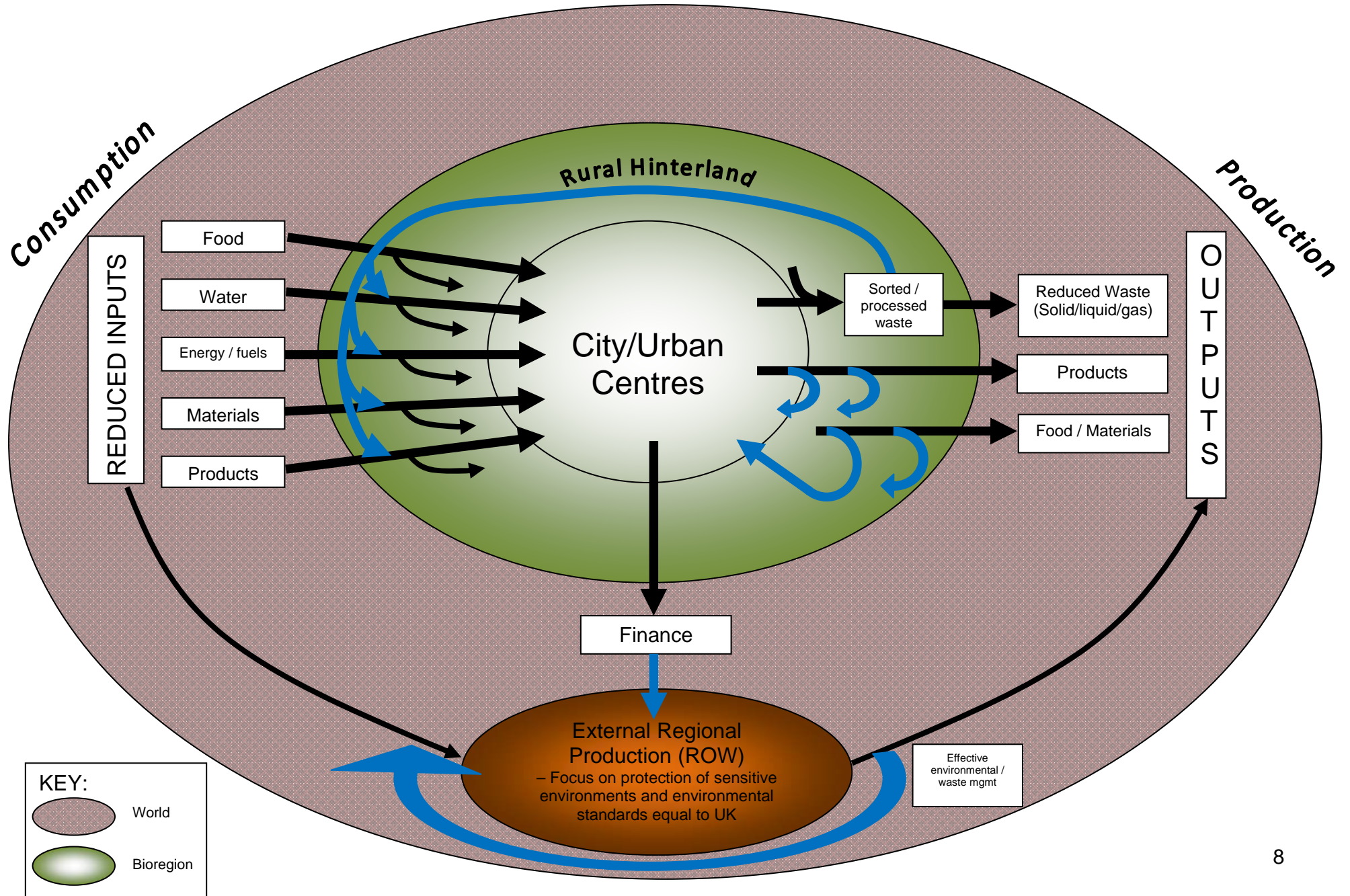


Figure 2: Linear metabolism of a city-region (adapted from Newman & Jennings, 2008, p119)



**Figure 3:** Circular, more sustainable metabolism of a city-region (adapted from Newman & Jennings, 2008, p119)

The essence of Figure 3 is that the distance between production and consumption is shortened with the advantages of saving fuel and reducing associated air pollution, with local materials, foods and products produced locally used more within the bioregion. Wastes produced within the bioregion are reused or recycled within the bioregion, simultaneously reducing the volume of inputs and the output waste stream. Financial investment and retail (through corporate or consumer responsibility, or both) gives more consideration to the environmental (and working) conditions of the production of the commodities taking place externally to the region where the demand for them is generated within the region.

By recycling and processing waste effectively and reducing pollution, Robèrt's system conditions 1 and 2 are further adhered to. By the same token, the reuse and recycling of wastes reduces the potential impact to ecosystems of overharvesting renewable materials (system condition 3) and of mining non-renewable, finite, materials (system condition 1). However, it is unlikely recycling alone would achieve such a reduction in impact to ecosystems. Rather it is argued here that responsible environmental policy by individuals, businesses and the government towards production and consumption, both internal and external to the bioregion, is necessary. This is also required in order to bring about the reality of system condition 4, that of intra-generational equity. This argument is reflected in the pioneering document on sustainable development by the World Commission on Environment and Development headed by Gro Harlem Brundtland (WCED, 1987), the core values of which are the equity of environmental quality and natural (material) resources both inter-generationally (between generations over time) and intra-generationally (within the same generation across the globe).

In order to measure the progress of city-regions towards sustainability, various sustainability assessment methods have been devised since the 1980s. The following section will review some of these methods in relation to the systems approach to sustainable city-regions.

### **3.3. Sustainability Measurement at the City-Region Scale**

Various methods applicable to the city-region scale have been devised with the intention of measuring the broader notion of sustainability - the social and economic pillars in addition to the environmental pillar, as a cohesive whole. Graymore *et al.* (2008) give a good comparison of these methods using an evaluation criteria matrix, however due to this project's emphasis on environmental sustainability this discussion will focus on those methods that deal primarily with the environmental pillar of sustainability.

Bell and Morse (2008) claim that earlier views of sustainability centred on the maintenance of the natural resource base and environment, with the themes of carrying capacity of ecosystems and their Maximum Sustainable Yield (MSY) being the key points of reference. Indeed, what was probably the first computer model to attempt to quantify the possible effects of ignoring these two concepts came about with the work of the Club of Rome, a group of "industrialists, politicians and academics" (Dryzek, 2005, p.25) who authored the study *Limits to Growth* in 1972 (Meadows *et al.*, 1972). The study developed Malthusian theories of environmental limits, using a computer model to predict the interrelated effects of population growth, food production, natural resource usage, industrial manufacturing and pollution at a global level. The outcome of all scenario models was to predict varying degrees of economic collapse and disastrous population decline due to dwindling resource availability and environmental quality, essentially caused by human demands exceeding the carrying capacity of the earth's ecosystems. Whilst the model came under much criticism for being overly fatalistic (see Dryzek, 2005), it brought to the fore the potentially devastating human impact on ecosystems of exponential growth of economic activity and populations.

The maintenance of such 'natural capital', a term coined by ecological economics (Roberts, 2004), is arguably therefore the most fundamental aspect of sustainable development for local sustainability management. In essence, if each bioregion around the world was able to maintain or enhance its natural capital whilst sufficiently meeting human needs, then the sustainable development discourse would have achieved its ultimate goal. Two methods applicable to the

city-region scale have been devised to account for such natural capital: natural resource accounting and environmental indicators, the latter being most prominent at this scale.

Environmental indicators have a proven track record in monitoring changes in environmental quality and are used extensively by the Environment Agency in the UK. Various frameworks for mapping indicators have emerged that attempt to create cause-effect linkages to explain the reasons for poor environmental quality attributable to human activity. One of the first to be devised came from the United Nations following the 1992 Rio Earth Summit with indicators arranged in a driving forces – state – response model to attempt to capture causation and remedy (Bell & Morse, 2008, p. 29). The framework was extended and embraced by other authors to become the DPSIR framework (Driving Forces (policy / society) – Pressure – State – Impact – Response) and advocates of the logic and applicability of the framework have criticised other sustainability indicator projects for not adhering to such a consistent framework (for example, Blanc *et al.*, 2008). DPSIR is criticised however for being too inflexible and oversimplifying complex cause-effect relationships, some of which could be attributable to nature itself (see Carr *et al.*, 2007).

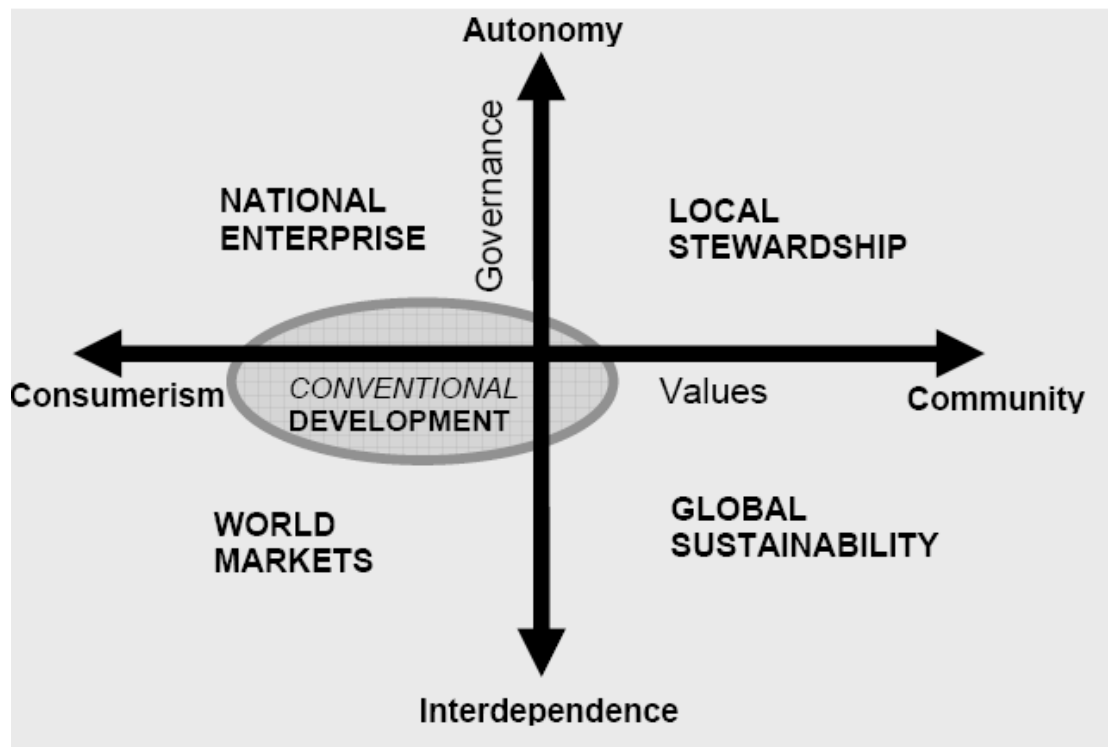
Natural resource accounting is a contribution from the field of ecological economics and is now a firm part of national economic accounts in the developed world thanks largely to the United Nations *et al.*'s (2003) System of Integrated Economic and Environmental Accounting (known as the SEEA). Presently at a national level in the UK, the only types of natural capital to be recorded are fossil fuel reserves, land cover, forestry and fish stocks (Office for National Statistics, 2006) although the United Nations *et al.* (2003) recommends a full range of natural capital to be valued, whilst admitting that there is much progress to be made in such valuation. Whilst not widely implemented at the city-region level, policy analyst Andrew Jones (2007) has called for Local Authorities to begin keeping a stock take of their environmental assets in order to bolster the green economy.

The national environmental accounts in the UK also include flows of energy, emissions, material flows, waste and water involving the UK economy and the

national / global environment (Office for National Statistics, 2006). Material flow accounting at a city-region level has many benefits for assessing sustainability since total resource use and total waste output can be assessed using both economic and physical data and linkages within the city-region and between the city-region and its external environment can be examined. It is a prominent method in examining a regional economy's metabolism with various software products emerging through funded research, designed to give information to policy makers and practitioners on a region's consumption and production within a sustainability context. Such products include the Resources and Energy Analysis Programme (REAP) by the Stockholm Environment Institute (see Paul, 2007) which mainly focuses on a region's consumption and the Regional Economy Environment Input-Output Model (REEIO) designed by Cambridge Econometrics (2003) which mainly focuses on regional production. Weidmann *et al.* (2006) give a review of the two off-the-shelf products, commenting that REEIO has the most developed scenario predicting capabilities whereas REAP is able to give information at a finer regional resolution. The latter ability is down to the data that each package uses – the REEIO approach uses national data disaggregated down to regional level, whereas the REAP approach uses a combination of national and local data to inform the material flows. Scenario visioning is introduced in the next section.

### **3.4. Future Scenarios: Visioning**

The envisioning of future sustainability scenarios has been carried out by various groups, mostly in relation to the reduction of emissions to address climate change. The UK Climate Impacts Programme (UKCIP) (2000) spawned several similar studies by using a grid-group cultural theory method pioneered by Mary Douglas (see Douglas, 2007) to envisage different possibilities. The framework is shown in Figure 4:



**Figure 4:** Four socio-economic scenarios for the UK (Source: UKCIP, 2000)

Four main themes of change were identified by the UKCIP team based on the literature on global futures. They were:

- the composition and rate of economic growth
- the rate and direction of technological change
- the nature of governance and
- social and political values

(UK Climate Impacts Programme, 2000)

The nature of governance and social and political values were thought to be largely responsible for the first two points, and can be plotted around the diagram in figure 4. The horizontal axis captures the difference in socio-economic values whilst the vertical axis shows the opposite ends of the governance spectrum.

Forum for the Future (2008) have used a similar methodology to compile their five possible scenarios for the recent Climate Futures report.

## 4. Research Questions

### 4.1. Objectives and Research Questions

Objective 1: To establish a baseline cross-sectional survey of the most recent sustainability situation in the Bristol city-region.

To achieve this objective, sustainability needs to be examined at two spatial scales, city-regional and global. The following questions will be used to address this objective, 1a and 1b relating to the city-regional (internal) spatial scale, and 1c relating to the wider global scale:

- 1a) How sustainable is the environmental management of the Greater Bristol city-region in relation to the maintenance of local natural capital resources and ecosystem health?
- 1b) To what extent is the Greater Bristol city-region self sufficient in terms of its internal usage of this natural capital (materials and energy resources) and waste assimilation?
- 1c) To what extent does the Greater Bristol city-region's consumption of materials and energy impact on the global natural resource base and the health of ecosystems globally?

Objective 2: To examine potential future scenarios for the Greater Bristol city-region and establish what steps are required to achieve the most sustainable outcomes.

The following questions will be used to address this objective, 2a) relating to the 'business as usual' scenario, 2b) relating to sustainable visioning and 2c) relating to the steps required to achieve those visions and bridge the gap between a) and b).

- 2a) What negative ecological impacts and inequalities could potentially occur by 2050 locally and beyond if the city-region's economic activity continues at the same rate and in the same way as in 2010?

- 2b) In what ways, socially, technically or otherwise, could the Greater Bristol city-region operate sustainably?
- 2c) What changes would need to take place in order to achieve each sustainable vision for the Greater Bristol city-region, and in what timeframe?

## **4.2. Justification for Objectives and Research Questions**

### Objective 1

Sustainability needs to be examined at two spatial scales, city-regional and global, in order to encompass the local and global requirements of sustainability and fill this knowledge gap for a holistic examination of the environmental sustainability of the Bristol city-region.

The first spatial scale (city-regional) (questions 1a and b) involves the quality and quantity of natural capital within the city-region itself: how well it is being maintained and the extent to which it is being utilised within the city-regional economy (in terms of extraction, production, retail and disposal). From this, the current extent of self-sufficiency of the city-region can be established from a bioregional perspective.

The second spatial scale (global) (question 1c) is concerned with the global impact of the city-region's overall consumption of resources and energy, in relation to resource equity across nations within the context of the total carrying capacity of the earth's ecosystems. (This is the essence of the ecological footprint methodology.) Furthermore, in relation to responsibility towards other nations and ecosystems, it is also important where possible to establish the city-region's use of 'high impact' resources that originate from, and negatively impact, ecologically sensitive regions (e.g. mahogany from virgin Amazon rain forest).

### Objective 2

The second half of the research tackles *how* the sustainability of the city-region can be progressed or in Robèrt's (2000) terminology, examines the process of *sustainable development*. To achieve this objective, the development of several potential future scenarios will be required for the region, ranging from a 'business

as usual' scenario based upon projecting trends from the baseline survey (question 2a), to a selection of 'sustainable vision' scenarios drawn up using the literature and local expertise (question 2b). Backcasting from the visions would then allow for an examination of the steps required in order to bridge the gap between current trends and sustainable targets (question 2c).

## **5. Methodology**

### ***5.1. Research Design: Strategy and Methods***

The research has been separated into four phases, two for each objective (see Section 5.2 for conceptual framework diagram). The methodological design for objective 1, the baseline assessment, is two-tiered – an indicator based method and a material flow analysis method will be used. The indicator method will be used primarily to assess environmental impacts and resource usage occurring within the city-region. However, dependent on the outcomes of the scenario visioning for objective 2, extra indicators will need to be included to measure specific trends and targets in relation to these visions. The material flow analysis will examine both resource usage within the city-region and that external to the city-region that can be attributed to activity within the city-region itself (e.g. by the consumption of imported goods and energy).

A breakdown of the phases follows, along with a conceptual diagram of the whole strategy.

#### **Phase 1.1: (Sep 2009 – Feb 2010)**

The first phase is the data collation phase, whereby various secondary sources of data on the city-region will be identified and reviewed for suitability. The first part of this (1.1,i) will involve a "stock take" of the city-region's natural capital, since maintenance of the quantity and quality of natural capital is crucial for local sustainability and resilience. Indicators such as water and soil quality as well as current land use will be used (see Part B, Appendix 1 for a discussion of indicators likely to feature and Part B, Appendix 2 for data sources identified so

far). These will be used for mapping of such indicators in phase 1.2,i), and therefore some concurrency between these two phases is likely to occur.

The second and third parts of this phase will be the collection of economic data, that pertaining to the local economy (1.1,ii) and national economy (1.1,iii). This will be used for the Material Flow Analysis in phase 1.2,ii) of the research.

#### Phase 1.2: (Feb – Jun 2010)

The data from phase 1.1,i) will be used to map indicators of environmental quality and resource usage occurring within the city-region (1.2,i). It is proposed that indicators are separated into distinct systems and geographical space where possible (e.g. water quality in River Avon) and arranged into pressure-state-impact relationships where data exists (basic e.g. discharge load from industry / contaminant concentration in river water / biodiversity of river fauna and flora).

The data from phase 1.1ii and iii will be used to examine the economic activity within the city-region in terms of the resources it uses and waste it produces, what flows are occurring within the regional economy, and what is the total energy and resource throughput used in the region's economic activity. The method for carrying out this investigation will be Material Flow Analysis (see for example, Ravetz, 2000; Browne *et al.*, 2005).

The outputs from this phase would be indicator trends for local natural capital quality and quantity, and material flows / ecological footprint to indicate the load of the city-region's activity on the global stock of natural resources and ecosystems and the efficiency of the city-regional metabolism.

#### Phase 2.1: (Jul – Oct 2010)

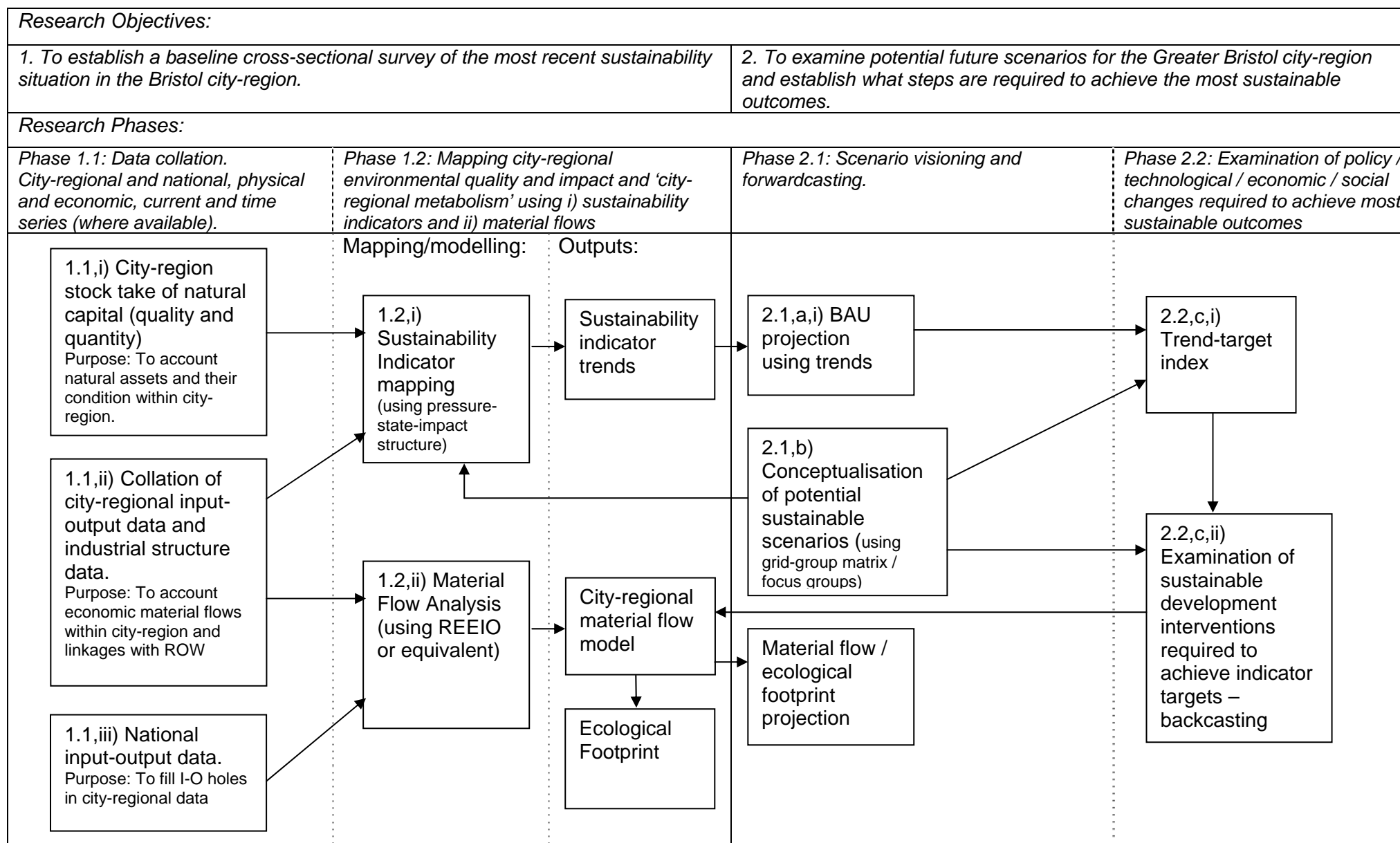
This phase will involve the projection of trends of indicators and material flows to produce a business-as-usual future scenario. It will also involve the conceptualisation of potential sustainable futures for the region using examples from the literature and focus groups with local stakeholders. Further sustainability indicators will be required at this point to capture the key credentials of each scenario and will follow the same mapping method as in 1.2,i).

Phase 2.2: (Oct 2010 – Feb 2011)

This phase tackles the issues of addressing the (negative) trends of the business as usual scenario and setting different sets of indicator targets for potential sustainable scenarios. The difference between targets and trends would then be examined using a trend-target index and the possible interventions / changes required to meet the targets discussed. Changes identified would also be fed into the city-regional material flow model in order to see the extent of change needed in material flows for a sustainable city-regional footprint to be achieved. Backcasting from the sustainable visions will then be used to identify when changes / interventions need to occur in order that the targets and business as usual trends meet and ecological footprint is reduced within an agreed time frame (such as 2050).

Write up: (Feb 2011 – Sep 2011)

## 5.2. Conceptual Model: Research Design: The Environmental Sustainability of the Bristol City Region – Current and Potential Scenarios



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## **PART B**

### **Appendix 1: Responses and Ideas in Relation to FFTF's Sustainable Bristol City Region Progress Report, May 2009**

This is a short essay clarifying some boundaries of what physical human interactions with the earth need to be measured in relation to environmental sustainability involving the Bristol city-region. It was in response to the FFTF progress report on the Bristol project, which states some of the environmental themes that will be focussed upon over the course of the project.

The following table lists the environmental sustainability initiatives given in the FFTF progress report (using the original numbering), and what physical entity they are effectively tackling. This table purposefully leaves out social objectives *per se*, as these will not be measured by this PhD:

Initiative	Actual Physical Environmental Objective
2. Built environment – regeneration and new build – low carbon	- Regeneration (to use derelict land and hence maintain region's natural capital resource) - CO <sub>2</sub> reduction (to ensure climate security) - Energy efficiency (to waste less (finite) fossil fuel resources)
3. Strong local food economy	- CO <sub>2</sub> reduction – less food miles - Food security (in some ways a political objective)
4. Sustainable mobility	- CO <sub>2</sub> reduction – less car use / congestion
5. Resource and energy usage	- CO <sub>2</sub> reduction - Resource use reduction / responsibility

Essentially at an absolute basic level, the environmental sustainability themes being focussed on for the region can be broken down into the maintenance of:

- natural resource quantity
- environmental quality

at both the regional and global spatial scales.

The two are related as so: to impoverish an environment's quality is not necessarily to reduce its overall natural resource quantity, specifically, it is to reduce its natural resource diversity and potentially weaken the ecosystem<sup>2</sup>.

Spatially, negative environmental impacts caused by the region's socio-economic activity can manifest:

- within the region (termed hereon as *local* impacts, in that they are local to the region under study), but also
- outside of the region – other regions and ROW (termed hereon as *foreign* impacts, in that they are foreign to the region).

The latter comprises those impacts on other regions / ROW caused by the supply chain of imports of products, materials and energy into the region. Essentially this is caused by foreign activity, but is attributable to the local in-region activity through the demand for imports. Additionally, waste exported / dispersed from the region to other regions/ROW is included in this category.

This leads us to two main categories of activity that result in impacts on environmental quality and natural resource quantity:

- *Resource Use* (potential and actual reduction of natural resource quantity), and
- *Waste Generation* (potential pollution and subsequent degradation of environmental quality)

Waste, in gas, liquid or solid forms, can be considered as:

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<sup>2</sup> At worst, sustained negative impacts in both cases can affect ecosystem stability, and potentially in time, could jeopardise the entire earth system. At best, sustained negative impacts could impoverish environmental quality and resources for future generations. A sustainable future would require that natural resource quantity and environmental quality are not impacted to their long-term detriment, both locally and globally.

- that created in region and disposed of in region (local source, local impact),
- that created in region and exported / dispersed (local source, foreign impact),
- that which is embodied in the region's consumption (foreign source, foreign or global impact, yet attributable to local region), e.g. waste gas pollutants (CO<sub>2</sub>) from foreign production or freight miles attributed to imported products and energy<sup>3</sup>

Waste is often viewed in terms of its *source* (where it is produced) and its *sink* (where it is disposed of). Waste can have a negative effect on environmental quality of the *sink* environments, in the form of pollution. Generally this is where the volume or type of waste is unsuitable for the sink environment to absorb it naturally without any detrimental effects to the ecosystem. Whereas individual sink environments are generally not at a wide spatial scale (e.g. local atmosphere absorbing waste gases from industry/transport, river absorbing treated sewage effluent at a point source, municipal solid waste going to landfill), the impacts of combined sink environments can be on a much wider scale (e.g. overall CO<sub>2</sub> release causing global warming, several discharges to a river impoverishing river fauna, leachate from a landfill contaminating local groundwater and causing global warming through methane release etc).

Solid waste can also have a knock on effect on natural resource quantity (resource use), i.e. if it is being viewed as waste and not being re-used / recycled, then this potentially creates more demand for virgin natural resources<sup>4</sup>. Similarly, even if landfill is well managed and does not cause pollution to watercourses (from leachate) and to the atmosphere (from methane), the space for landfill itself is limited and could be viewed itself as a natural resource short of supply. Landfill

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<sup>3</sup> Note that exports have not been stated here – this is to ensure a boundary is placed around what is being studied – essentially exports from the region would be the responsibility of other region's / ROW's consumption at the point at which they leave the region.

<sup>4</sup> Essentially, classification of waste will be crucial for accounting – if it is viewed as a resource to be used, then it should be classed as that (e.g. metal recycling – such metal should be classed as a renewable resource). The long term key is to follow nature – all waste should be viewed as a resource (this is the essence of TNS system conditions).

is effectively a two-pronged problem in this sense, bridging waste and resource use. The same could be said of burning fossil fuels inefficiently – waste of a finite resource and a cause of pollution (greenhouse gas).

Resource use has an impact on natural resource quantity and potentially, environmental quality of the source regions / countries. Natural resource quantity is mostly an issue for non-renewable resources, but could be an issue for renewable resources if these are being over-farmed or irreplaceable habitats are being lost. Environmental quality is mainly focussed on the impacts and disruption to ecosystems by extraction of non-renewable resources and by the overworking/over-farming of renewable resources (pollution is dealt with under waste however). Consumption of resources and energy by households and industry is a useful focus for attributing responsibility for resource use (ref SCP).

What follows is a more detailed break down of some of the indicators of sustainability that could be used for accounting negative environmental quality and natural resource quantity impacts attributed to the Bristol city-region's socio-economic activity. They are dealt with at two spatial scales – impacts occurring within the region (local), and impacts occurring outside of the region (foreign) but that are attributable to the region's consumption.

### Impact Within Region

The following list comprises indicators of *primary production* impact occurring within the region alone. Secondary production would be better looked at in terms of consumption; as data about specific primary resource sources for secondary industries within the region is likely to be unavailable, it would be better to look at what these businesses consume and then see if that could be procured locally using the data in this section. This production approach is the basis for the REEIO software tool.

The categories of *waste* and *resource production* can be used, but in addition, *resource supply* can also be used to account the region's natural capital stocks - their quantity and condition<sup>5</sup>.

- **Waste** (Environmental quality of *sinks* within region)
  - Gases: Pollutants from industry and transport that have local impact e.g. dioxins, organic carbon (particulates causing poor air quality, smog etc).
  - Water: River pollution within region (nitrates, phosphates, organic – EA's WQAs etc), pollution to Bristol docks, canals, lakes – all regional watercourses. Sources (state indicators) would be point source discharge consents and diffuse sources (e.g. nitrates from farm runoff).
  - Solid: Municipal waste: to local landfill and [sewage sludge overused on local fields?] [N.B. this might not be the best way of accounting waste – in fact positive indicators may be best option – recycling rates, compost production etc. Solid waste management probably best looked at holistically rather than “within” and “outside of” region], nuclear waste from Oldbury power station?.
- **Resource Production** (Natural resource quantity AND environmental quality of *sources*)
  - Non-renewable
    - Energy
      - Fossil fuel extraction within region (if any – coal?)
    - Materials
      - Minerals – metal ores, aggregates – essentially anything that comes from the earth's crust (extraction affects environmental quality, and these are finite – if they are then recycled, then this could be termed renewable – but is accounted under a different heading) (in fact, could minerals cover all non-renewable energy? All from minerals?)
  - Renewable [probably need mixture of state and impact indicators – not all farming / fishing etc has a negative impact]
    - Energy and Water
      - Plants (biofuels / wood) (can affect environmental quality e.g. biodiversity – monoculture crops (OSR- biodiesel), but equally can improve it e.g. more coppice woodland (for wood burning stoves); natural resource quantity can be affected in long term if over-farmed)
      - Other (non-living) sources (e.g. hydroelectric dams can damage biodiversity, however too much detail for this PhD – could not attribute specific energy sources to region as energy grid is far too complex (possibly could with Severn Barrage however?)) Equally, geothermal could be a positive indicator of sustainable energy source?
      - Water treatment/abstraction (both source and quantity used are important – especially in drought. Over abstraction in region affects both quality and quantity, treatment uses energy. (Consumption (overall usage) and production (abstraction / treatment) needs to be considered)
    - Resources

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<sup>5</sup> *Supply* could also refer to products produced within the region, but it might be more logical to look at production impacts in terms of its consumption.

- Plants: Food crops (agriculture), wood (forestry), garden/house plants (horticulture) – indicators of good environmental practice? Soil erosion, agricultural biodiversity etc
- Animals: Fishing (from Bristol channel) – indicators could include overfishing (livestock / fish farms probably best accounted under consumption – next section)
- [Recyclates (e.g. glass, metal etc exported from region – potentially a positive indicator)] [not sure if this fits logically]
- **Resource Supply**
  - Would estimate total natural capital stocks in all categories above, plus natural (and semi-natural) environments not used as such to supply resources. Net stocks would then be total minus production.

### Impact on other Regions / ROW

This is approached below from a consumption perspective. Waste, while produced in region, is not all processed / dispersed within the region and hence is viewed as *using* the sink environments of foreign regions and therefore impacting their environmental quality. In addition, waste can be viewed in terms of the *indirect* production of it imputed in products imported into the region. In other words, this waste is produced in foreign regions, and the sink environment is in foreign regions, however the responsibility for its production can be attributed to the region that is consuming the product.

Resource Use can be divided into primary resources (raw materials) either sold or used by industry within the region and secondary (products), and here focuses on the impact on the *source* environment. Instead of separating the two types, another way of approaching this is to look at all households individually, and impute all environmental impacts along the supply chain relating to the consumed products (as is the case in REAP software tool).

- **Waste** (environmental quality – *sinks* outside of region (*impact* indicators))  
Direct sources of waste production within region
  - Gases: Those produced within region that add to the global greenhouse effect e.g. CO<sub>2</sub> emissions from fossil fuel consumption<sup>6</sup> (housing / industry)

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<sup>6</sup> CO<sub>2</sub> emissions need only be attributed globally, as essentially local emissions (e.g. within region) are of little consequence to the local area – it is the overall aggregate global atmosphere that is the issue.

/ transport), methane from cattle. Also SO<sub>2</sub> that can cause acid rainfall outside of region (likely to be low however due to car catalysts from 1993 and industrial IPPC emissions legislation),

- Water: Pollution to ocean (very unlikely to still happen at high levels, so probably of little significance), river pollution (nitrates, phosphates, organic – EA's WQAs etc) to rivers that flow outside of region
- Solid: Exported municipal waste (landfill outside of region inc. fly ash disposal from region's incinerators, all exported waste), sewage sludge (exported), nuclear waste from Oldbury (goes to Sellafield?)

Indirect sources of waste production outside of region but attributable to region's consumption

- Gases: CO<sub>2</sub> emissions from freight transport (from imported products), also emissions embodied within the production of those products (can include all gaseous pollutants from industry).
  - Water: water pollution embodied in production of imported products (very difficult to quantify) (e.g. point source chemical / organic water contamination from industry, acid mine drainage from coal production etc)
  - Solid: poor solid waste management practices embodied in production of imported products (e.g. landfill, dumping in sea, open tips, nuclear waste dumping etc) (again, very difficult to quantify)
- **Primary Resource Use** (Imported raw materials affect natural resource quantity AND environmental quality of *source* environments)

Non-renewable

➤ Energy

- Fossil fuels (extraction can affect environmental quality (e.g. oil shale, open cast coal mining)<sup>7</sup>; regardless all are a finite resource)
- Nuclear (within region (Oldbury) but impact is on source environment of uranium extraction – also waste but accounted above) - running and decommissioning uses a great deal of resources (don't know specifics but else it wouldn't be so ridiculously expensive to do so; is uranium used up in the process? If it cannot be reused then is using a finite resource)

➤ Materials

- Minerals – metal ores, aggregates – essentially anything that comes from the earth's crust

Renewable [probably need mixture of state and impact indicators – not all farming / fishing etc has a negative impact]

➤ Energy and Water

- Plants (biofuels / wood) (can affect environmental quality e.g. biodiversity – monoculture crops (OSR- biodiesel), but equally can improve it e.g. more coppice woodland (for wood burning stoves); natural resource quantity can be affected in long term if over-farmed)
- Other (non-living) sources (e.g. hydroelectric dams can damage biodiversity, however too much detail for this PhD – could not attribute specific energy sources to region as energy grid is far too complex)

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<sup>7</sup> Location of resource extraction is probably important in terms of environmental impact on that country (e.g. if data exists on opencast coal extraction for those countries from which we import coal). Also in the long term, politically the location source could be important.

Equally, geothermal could be a positive indicator of sustainable energy source?

- Water use
- Resources (use values listed, but intrinsic values arguably more important)
  - Plants: Food and wood (what and where is important – food miles important but accounted for above in terms of CO<sub>2</sub> produced from fuel used. What and where is important as some sources are destroying valuable habitats (e.g. palm oil, wood from rain forest – Brazil)
  - Animals: Food, (labour (!)) (again, what and where is important – some sources over farmed e.g. fish stocks - blue fin tuna, cod. Animal welfare is a sustainability issue, but out of the scope of this PhD – if social welfare is not being focussed on. Some resource issues also tie in with welfare – e.g. ivory production is now illegal)
  - Recyclates (e.g. glass, metal used within region – potentially a positive indicator)
- Secondary Resource Use (all products having undergone some form of processing or manufacture – all primary resources and energy used is imputed along the supply chain (as in REAP methodology))
  - Essentially can use all headings for primary resource use – all *indirect* resource use, including fossil fuels used in production and transportation, all raw materials etc.

Note some environmental quality indicators are potentially positive rather than negative – perhaps these are not necessary to measure (e.g. use of geothermal power). Indicators are a mixture of *state* and *impact* type – in general terms, *state* being indicators of resources / energy used (or emission/waste generated), and *impact* referring to the environmental quality relating to the effects of that activity (this does not necessarily mean that the state and impact need to be paired – will research further).

[In terms of water pollution – what is the *state* indicator and what is the *impact*? Either *state* could be the pollution itself within the watercourse and *impact* could be the effects on flora, fauna and aesthetics, or *state* could be the flow of waste from the source and *impact* could be the actual pollution of watercourse. The latter is in fact, on reflection, *pressure* as the flow of waste and *state* as the pollution in watercourse. Whole chain ends with *impact* on flora and fauna. So whole chain is *pressure, state, impact* which is probably the best model to use].

It would be very useful for most of the above indicators if the exact country / region of source / sink could be attributed to the Bristol city-region to assess its impact on that *exact geographical area*. This is especially important for those

more sensitive geographical areas (e.g. Amazon rain forest) – these habitats are of global environmental significance.

[The question is therefore what knowledge is available of the product and process of manufacture, and the ethical issue is responsibility. Is the manufacturer responsible for the product being environmentally friendly, or the consumer for buying it with insufficient knowledge and/or conscience?]

## Appendix 2: Selection of Data Sources to Date

Sector	Source	Description / Lowest Level of Detail	Capital Type	Indicator Type (PSR)
Energy - Housing	Energy Saving Trust: HEED Database (Response data)	Records energy saving measures at individual property (postcode) level. Data from energy suppliers, government scheme agents, local authorities / other landlords, EST home energy checks and other EST programmes.	Environmental / Human / Built / (Economic)	Probably combination of State and Response
	Centre For Sustainable Energy – Fuel Poverty Indicator	Fuel poverty indicator based on household income at Lower Super Output Area level (roughly 400 households each). Data from 2003 English House Condition Survey and 2001 Census.	Human / Social / Economic	State
Atmospheric Pollution	UK National Atmospheric Emissions Inventory (NAEI) (DEFRA)	Atmospheric emissions from transport and industry. Lowest level appears to be LA. Point source data from EA (e.g. IPPC data) and LA (e.g. LAPC data). Industry fuel consumption from EU-ETS data. Where local data does not exist, aggregated from national data. Transport emissions aggregated from national DVLA licensing data.	Environmental	State
Regional Natural Resources	Generalised Land Use Database Statistics for England 2005 (Communities and Local Government; ONS)	Land use statistics, down to census ward level.	Environmental / Built	State. (Pressure could be proposed regional development?)
	Natural England – Contact Matthew Sperring	Follow up to see what data is available	Environmental	

	Green Infrastructure Tool – West of England Partnership GI Team	GIS database of green infrastructure in SW, to neighbourhood level	Environmental	State
	Countryside Information System (ADAS, DEFRA)	GIS data of rural land down to 1km square – land use, species, vegetation etc. (Possibly has been superseded by land use database – link not working 30/11/08)	Environmental	State
	British Geological Survey – Geoindex	GIS data of mineral deposits – various scales	Environmental	State (Pressure could be licensed quarries?)
Municipal Waste	Waste Data Flow	Database of UK waste arisings and recycling data down to Unitary Authority level (i.e. Bristol City Council etc.)	Environmental / Social / Economic	State / Response / Pressure
General	Intelligence West (West of England Partnership, SW Observatory etc)	Hub for various local data sources including social-economic data. To research further in more detail	All	Probably all
Input-Output Tables – Household Consumption	ONS: Family Expenditure Survey	Smallest scale is Government Office Regions. Need to research if more detailed regional data available	Economic / Social / (Environmental)	State

## **Appendix 3: Essay: Can Research in the Field of Sustainable Development be Value Free?**

### **Introduction: Values in Research**

Value freedom or 'neutrality' in social science research has been a topic of much debate within academic communities since at least the 1950s, when positivism as the dominant social science research approach fell into demise (Hammersley, 1995, p. 10). There is contention amongst academics as to whether value neutrality is possible at all, for example, May (2001, p. 54):

For those who adhere to the idea of 'value neutrality' throughout the research process, there are insurmountable problems in mounting a defence for the position.

Hammersley (1999, p.31) however suggests that value neutrality is important in avoiding:

a world in which there are groups with conflicting ideas battling against one another in the public arena, each accompanied by its own set of organic intellectuals. There is no scope for dialogue here, only struggle.

The quote from Hammersley is a criticism of the post-enlightenment view, in which the values of the enlightenment – the search for truth integrated with other values thought to improve humanity, such as freedom, equality and social welfare (1999, p. 20) – are rejected as it is claimed what is true or good cannot be judged objectively or absolutely (1999, p. 28). Hammersley (1999, p.17) claims that advocates of value neutrality would use the concept as an ideal guide, whilst acknowledging that in reality practical judgement may not entirely eliminate bias.

If the value neutrality position is taken, a view of claims as either factual "positive" statements or normative "what ought to be" value statements (May, 2001, p. 47) could be a useful delineation. However Nagel's (1961, in May, 2001) depiction of value judgements as being "characterising", that is, estimating the degree to which something is present, or "appraising", that is, claiming something is better

or worse according to a moral code, is also a useful separation. Characterising judgements could be considered factual or positive within the scientific community, even though they could be estimated using one person's judgement. Equally not all normative statements are appraising, in that the judgement could be simply aesthetic (for example the extent to which a person exhibits beauty) without claiming whether this is good or bad.

This essay will explore these concepts in relation to debates and research in the field of sustainable development.

### **Sustainable Development: Background and Main Themes**

The sustainable development discourse, as pioneered and politicised by the World Commission on Environment and Development headed by Gro Harlem Brundtland (WCED, 1987), is broadly based upon the following core values: the equity of environmental quality and natural (material) resources both inter-generationally (between generations) and intra-generationally (within the same generation). To put it another way, its focus is to ensure that through time, the human race responsibly stewards the natural environment in a way that current and future generations, globally, can access natural resources and a healthy environment from which they can meet their own needs.

The enduring quote from the Brundtland report (as it has become known) that refers to inter-generational equity is widely stated in the environmental literature (for example, Connelly & Smith, 2003, p.5; Bell & Morse, 2003, p.2, United Nations *et al.*, 2003, p.2; Dryzek, 2005, p.145; Roberts, 2007, p.3):

Humanity has the ability to make development sustainable to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs.

(WCED, 1987, p.8)

Perhaps not so commonly quoted is the intra-generational equity theme from the Brundtland report, that of ensuring that all people across the globe within the same generation should be able to 'meet their own needs':

The Commission believes that widespread poverty is no longer inevitable. Poverty is not only an evil in itself, but sustainable development requires meeting the basic needs of all and extending to all the opportunity to fulfil their aspirations for a better life. A world in which poverty is endemic will always be prone to ecological and other catastrophes.

(WCED, 1987, p.8)

Such statements about what “ought to be” would generally be described by May (2001) as “normative” statements or Nagel (1961) as “appraising”. Whilst issues such as poverty, pollution and finiteness of natural resources could be viewed as factual (although with a large element of characterisation – the extent to which these phenomena are present), the way these issues are tackled, be it with research, policy change or direct action, will clearly involve claims and policies that are undoubtedly normative / appraising.

Appraising values in the vein of Brundtland’s are by no means new within the sphere of human civilisation. Both themes above could be characterised by a traditional value of human compassion for one another, as taught by Jesus Christ during his ministry around 30 AD: the command to “Love your neighbour as yourself” (Matthew 22:39). In fact, a more specific early reference to intra-generational equity could be taken from 1 John 3:

If anyone has material possessions and sees his brother in need but has no pity on him, how can the love of God be in him? Dear children, let us not love with words or tongue but with actions and in truth.

(1 John 3:17-18)

Trower (2007) describes the values of the enlightenment, of the quest for truth, progress and spiritual fulfilment, to have been borne out of western Judeo-Christian values, although the search for the answers through scientific enquiry could be said to have departed from traditionally held Christian beliefs. It could be argued that the values behind sustainable development – concern for fellow humans in the future and across the globe presently – is routed within the

enlightenment view of progress to improve conditions for humanity whilst searching for the truth of how this can be achieved.

In this sentiment, Brundtland calls at a national level for poorer countries to experience “a new era of economic growth”, and “an assurance that those poor get their fair share of the resources required to sustain that growth” (WCED, 1987, p.8), whilst at the same time “those who are more affluent adopt life-styles within the planet's ecological means - in their use of energy, for example” (1987, p.9). As well as addressing the global gap between rich and poor via sustainable (reduced) consumption in developed nations whilst the Third World simultaneously undergoes vital economic growth to meet basic human needs, Brundtland is also hinting in the latter statement of the need to manage the earth's resources within the global ecological ‘carrying capacity’ (e.g. see Rees, 1996).

### **Environmental Limits to Growth**

This theme of ‘environmental limits’ to human development is another not originating within the sustainable development discourse; Selman (1996) and Dryzek (2005) refer to the historical concept of ‘maximum sustainable yield’ in relation to, for example, fishery catches, forest felling and game hunting (Dryzek, 2005), and Roberts (2004) describes Thomas Malthus’ (1797) theories of the effects of population rise on optimal agricultural yields. More recently the issue came to prominence in the early 1970s through the work of the Club of Rome, a group of “industrialists, politicians and academics” (Dryzek, 2005, p.25) who authored the study *Limits to Growth* in 1972 (Meadows *et al.*, 1972). The study developed Malthus’ theories of environmental limits, using a computer model to predict the interrelated effects of population growth, food production, natural resource usage, industrial manufacturing and pollution. The outcome of all scenario models was to predict varying degrees of economic collapse and disastrous population decline due to dwindling resource availability and environmental quality, essentially caused by human demands exceeding the carrying capacity of the earth's ecosystems.

The *Limits to Growth* study and the rather fatalistic discourse that emerged from it has been named the ‘survivalist’ movement by Dryzek (2005), in part due to its

“apocalyptic horizon of environmentalism” (2005, p.30) and for its call for strict population and environmental control via more powerful national governments. The polar opposite ‘status quo’ viewpoint, whereby no global environmental limits are recognised and a combination of technology advancement and human ingenuity in a free market are thought able to solve all environmental problems and resource scarcity, is termed ‘Promethean’ or ‘cornucopian’ (Dryzek, 2005; Roberts, 2004). The latter viewpoint is also that commonly taken by the neo-classical economic discipline (Daly & Cobb, 1994).

It could be argued that these two opposite viewpoints have come about through differences in the characterising judgement of the extent to which environmental limits are present. To survivalists, the limits are very near. To cornucopians, the limits are at least a long way off. It could even show the difference between two philosophical perspectives – survivalists conscribing to the positivist or realist viewpoint, whereas cornucopians have taken a constructivist point of view and claimed the idea of limits has been socially constructed.

The Brundtland sustainable development concept aims for a position between the two viewpoints, whereby limits are recognised but not “absolute” as they are in effect:

imposed by the present state of technology and social organization on environmental resources and by the ability of the biosphere to absorb the effects of human activities.

(WCED, 1987, p.8)

It could be expected that the biospheric limit on pollution absorption would be fairly constant, or may in fact contract with further or prolonged environmental degradation, whilst technological advancement and social organisation could potentially expand the environmental limits of finite natural and energy resources by using those resources more efficiently. This is clarified later in the report:

The accumulation of knowledge and the development of technology can enhance the carrying capacity of the resource base. But ultimate limits there are and sustainability requires that long before these are reached,

the world must ensure equitable access to the constrained resource and reorient technological efforts to relieve the pressure.

(WCED, 1987, p.45)

Hence the Brundtland concept of sustainable development does indeed recognise environmental limits and therefore a possible realist perspective, but does not subscribe to the survivalist viewpoint of sudden economic collapse, rather it is predicted that the limits “will manifest themselves in the form of rising costs and diminishing returns” (1987, p.45) and that a technocentric approach (Roberts, 2004) will enable the expansion of environmental limits through technological and social efficiency. In fact a key concept in the Brundtland report is that of decoupling economic development (growth) from environmental impact: “technology and social organization can be both managed and improved to make way for a new era of economic growth” (WCED, 1987, p.8).

Claims for environmental limits are rooted in what is taken by many to be factual, natural-science values. However, the variations in the extent the limits are present support May (2001) in his claim that characterising judgements will always be a part of the natural and social sciences.

Whether economic growth itself is sustainable is a further ongoing debate. Daly and Cobb in *For the Common Good* (1994) draw conclusions about how economic growth should be measured. They argue that if economic growth were to be measured using an indicator of sustainable economic welfare (such as Hicksian Income), rather than Gross National Product (GNP)<sup>8</sup> that mainly measures the economic throughput of commodities through the economy, then there would be an argument for sustaining economic growth. This could be construed as what Brundtland was referring to as a “new era of economic growth”. However, if nations continue to focus solely on increasing GNP, then Daly and Cobb suggest that economic growth will eventually become unsustainable, as “any physical subsystem of a finite and non-growing earth must itself also eventually become non-growing” (Daly & Cobb, 1994, p.72). Instead they recommend that national macro-economies should operate within an

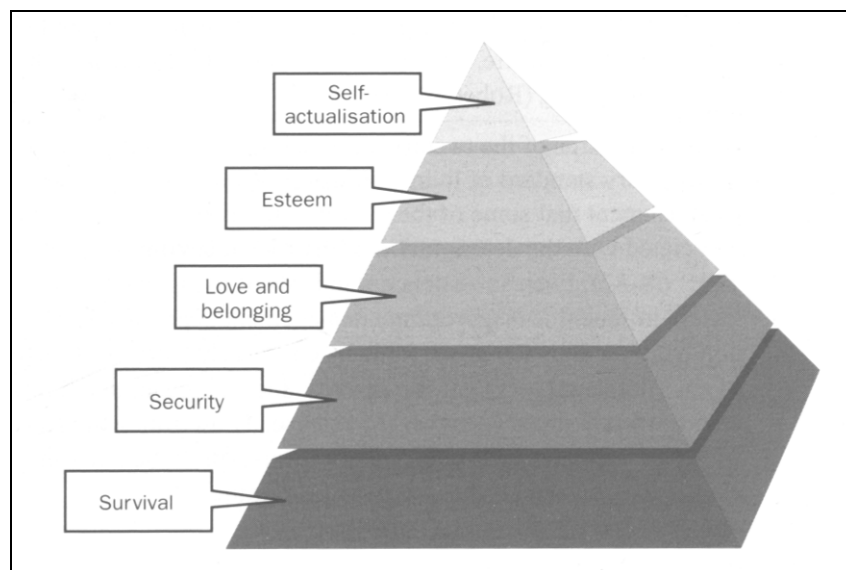
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<sup>8</sup> (Gross Domestic Product (GDP) in UK)

optimum scale relative to the carrying capacity of the nation's ecosystem – in effect that economies should be, or will become anyway, “stationary-state” (1994, p.375) and that “development” in sustainable development should “refer to the qualitative change of a physically non-growing economic system in dynamic equilibrium with the environment” (1994, p.71).

### Human Needs vs. Wants

This suggestion that material wealth does not in fact equal human welfare is another debate within the sustainable development discourse – what constitutes human needs and how can they be met? Roberts (2007) describes a study by Max-Neef *et al.* (1991) where the authors examined the relationship between a hierarchical structure of human needs (such as that pioneered by Abraham Maslow (1970)) (see Figure 1) and the satisfiers of those needs.



**Figure 5:** Maslow's Hierarchy of Needs (Source: Roberts, 2004)

The relationship between low level needs and satisfiers was considered to be fairly specific, for example, the needs for survival, such as hunger, thirst and warmth, require the satisfiers food, water and clothing/shelter respectively – essentially material needs. However, higher level needs according to Max-Neef *et al.*, such as esteem and self-actualisation, can be met in various different ways and the satisfiers tend to be far more culturally determined. The authors suggest that these satisfiers can be loosely categorised by those that meet the need, and those that appear to do so but ultimately leave the need unmet (termed pseudo-

satisfiers). Max-Neef *et al.* conclude that the over-consumption of material goods is a manifestation of such pseudo-satisfiers being encouraged in society to meet higher needs, but that ultimately they negatively affect people's quality of life and have a negative affect on long-term sustainability due to the overuse of natural resources.

The origins for why the culture of the western world tends to encourage overt materialism is also open to debate, however Cobb and Daly (1994) point the finger at economic theory as it emerged from the industrial revolution. They reference Joseph Schumpeter (1975) who comments that:

“This system of ideas, developed in the eighteenth century, recognises no other regulatory principle than that of individual egoism”

(Schumpeter, 1975, cited in Daly & Cobb, 1994, p.4)

Daly & Cobb call for a different economic focus, whereby an individual is viewed as “person-in-community” rather than as an individual solely out for personal gain (1994, p.7), and hence the focus of society becomes the improvement of community relations rather than individualistic increasing consumption of goods and services. They recommend a change in economic theory from what Aristotle termed “chrematistics”, the short-term maximisation of income from property or wealth, to “oikonomia”, the “management of the household so as to increase its use value to all members... over the long run” (1994, p.138).

### **Ecological Economics**

The background of Herman Daly, co-author of *For the Common Good* (1994), is in ecological economics. This particular economic discipline extends neo-classical economics to encompass the accounting of natural resources, and is therefore particularly relevant to sustainable development. The United Nations *et al.*, in their introduction to the *Integrated Environmental and Economic Accounting* (2003), state that whilst economists often disagree on the meaning of sustainable development, they are usually in agreement that the concept is “closely related to the long standing economic concept of income” (2003, p.4) as defined by the economist John Hicks:

income is the maximum amount an individual can consume during a period and remain as well off at the end of the period as at the beginning.

(Hicks, 1946, cited in United Nations *et al.*, 2003)

This concept of sustainable income has motivated what has become the 'capital approach' to sustainable development. As Daly & Cobb (1994) state, to operate the concept is to "keep capital intact" (1994, p.72), in other words, to maintain the capital (wealth) that generates the income. Formerly in economics, produced (man-made) capital assets were considered the foundation of wealth and natural capital was largely ignored as a "limitless" "free gift of nature" (United Nations *et al.*, 2003, p.4; also Daly & Cobb, 1994; Roberts, 2004). However, in response to growing awareness of environmental concerns, economists have acknowledged that a nation's natural capital is essential to its income (United Nations *et al.*, 2003, p.4).

Daly and Cobb (1994) therefore give an updated definition of capital as: "a stock that yields a flow of goods or services" of which there are two categories, "natural capital" which is the "non-produced means of producing a flow of natural resources" and "humanly created capital", which is taken to mean man-made assets that provide the "means of production" (1994, p.72). The capital approach and definitions of capital have also been extended beyond that of environment and economy to include social capital. The three themes of 'environment', 'economy' and 'society' within the sustainable development discourse have together become known as the 'Three Pillar Approach' (United Nations *et al.*, 2003; Roberts, 2004). The NGO Forum for the Future's (2007) *Five Capitals Model* broadens the approach for application to business, using the themes "natural capital" (natural sources, sinks and processes), "human capital" (individual health, education, skills etc), "social capital" ("value added" productive human relationships, partnerships etc), "manufactured capital" (buildings, infrastructure, technologies as means of production) and "financial capital" (assets in a form of currency that can be "owned or traded"). However, it could be argued, as does Taylor (2003), that the original Brundtland concept of sustainable development was mainly concerned with environment-society and environment-economy relations rather than sustainable social capital *per se*, and

a more restricted definition based mainly upon the maintenance and distribution of natural capital is preferable to make the sustainable development concept more practical.

As to why natural capital had been ignored for so long by economists, Daly and Cobb (1994) suggest that the reason is due to neo-classical economic theory asserting “that humanly created capital is a near-perfect substitute for natural resources” (1994, p.72). They argue that if this theory were applied to Hicksian income, in order to ensure a total stock of capital (wealth) be maintained for generating income, the consumption of natural capital would need to be “offset” by an equivalent increase of humanly created capital (1994, p.72). This scenario can be defined as “weak sustainability” as it allows for the exhaustion and degradation of natural resources (United Nations *et al.*, 2003, p.6) and generously assumes that in the long term, man-made capital is able to replace earth system functions historically controlled by ecosystems. In contrast, “strong sustainability” insists that natural and man-made capital are in fact complementary and rarely substitutable (Daly & Cobb, 1994; Daly, 1995), and the maintenance of both forms of capital is the only way of ensuring long-term income for nations (United Nations *et al.*, 2003).

Debates about the optimum scale of human economic activity have been wide and varied. Daly and Cobb (1994) for instance concur with Schumacher’s *Small is Beautiful* (1973) proposal that economic activity should be locally orientated operating within environmental limits, yet unified globally through communication networks and shared ethics viewed towards caring for the entire globe. This view has also evolved into “bioregionalism”, whereby the indigenous populations and resources of an area are the focus of the area’s economic activity (for example, see Sale, 1985; Carr, 2004).

Some years later, as a response to Schumacher’s (1973) book, Wilfred Beckerman wrote *Small is Stupid* (1995), which criticised the precautionary principle of living within environmental limits as foolish since it is argued such limits can never be determined accurately and market forces would eventually counteract resource scarcity through substitutability. He goes as far as to suggest that “sustainable development” is in fact a meaningless term. He considers strong

sustainable development, if taken to mean preserving the environment exactly as it is, as being "morally indefensible" (1995, p.2) as it rules out humans adequately meeting their material needs, whilst weak sustainable development, if just taken to mean the maximisation of "society's welfare" (1995, p.2), renders the term redundant. In defence of the term and the concept, Herman Daly (1995) in response to a journal article of a similar nature by Beckerman, distinguishes "absurdly strong sustainability" (1995, p.49) from strong sustainability and criticises Beckerman for not grasping the main concept of strong sustainability – that of the complementarity of man-made and natural capital.

### **The Systems Approach**

Natural capital however is only part of a wider earth system. Deeply rooted in the natural sciences, Homberg *et al.* (1996) describe the earth systems of energy and matter that enable life on earth as they relate to the earth sciences and the science of physics.

The earth is considered as separated into different "spheres" depending on attributes and function, namely (from the inside out) the *lithosphere* (the core, mantle and crust), the *pedosphere* (soil), *hydrosphere* (water), *biosphere* (all life forms), and *atmosphere*. All life forms and earth support systems have to exist across the earth's surface area of  $5.1 \times 10^8 \text{ km}^2$ , within a vertical dimension of 50km. Homberg *et al.* describe the *ecosphere* as being those parts of the earth that *directly* maintain their "structure and flow using the energy flow from the sun". They class all spheres bar the lithosphere in this category, as whilst the lithosphere does undergo changes of structure and flow in relation to rock creation (e.g. from sedimentation) and weathering (e.g. from erosion), these are mainly effected by other spheres (and hence are an *indirect* effect of the sun's energy). This is also a useful separation as it draws a line between non-renewable resources from the lithosphere and renewable resources from the ecosphere, inasmuch as mineral formation is hugely slower than primary production of plants.

The ecosphere depends on ordered energy (high exergy: low entropy) from the sun, which the earth receives as short-wave electromagnetic radiation and reflects it back into space as dissipated long-wave radiation (low exergy: high entropy)

(1996:4). Homberg *et al.* use a simile of the radiation connecting the earth to a battery – the positive terminal being the “hot sun” and the negative being the “cold interstellar space”.

Aside from the natural earth systems, Homberg *et al.* (1996) also describe the *sociosphere* (human society) that exists within the biosphere. They separate the sociosphere into a material supporting part, the *technosphere* (buildings machines, tools etc) and an immaterial part, the *human sphere* (emotions, aspirations, thoughts, ideas, traditions, institutions (and could be argued, relationships)), which controls the technosphere. Within the technosphere, energy and materials are extracted from the ecosphere and lithosphere to produce services (and products) to the human sphere, usually through the conversion of those materials and energy (1996:5). Whilst these materials may be disposed of after a period of time, all that is consumed is the “exergy or structure”; as with the first law of thermodynamics, “energy and materials are degraded but do not disappear” (1996:5).

In separating the social world from the natural world, and the material human realm from the immaterial, Homberg *et al.* are attempting, and it could be argued achieving, the separation of fact from value in human existence. With regard to values, they claim that relations within the sociosphere rely on value issues, however relations between the sociosphere and ecosphere are issues of physical and operational efficiency (1996:6). The criticism here could be that whilst the sociosphere / ecosphere relationship is viewed in factual terms, efficiency itself could be considered a technocentric value.

However, it could be said this value is closely related to sustainable development itself – that of improving the relationship between human beings and nature to ensure the futurity of both, whilst enabling the creation of some material wealth to compliment their natural environment.

In addition to the human exchange of matter and energy with nature, Homberg *et al.* also discuss the other effect human activity has on nature – that of “manipulation”. They categorise this activity into “displacement” of the ecosphere, whereby the infrastructure of the technosphere deters or disturbs ecosystems or

geophysical cycles, “reshaping” of ecosphere structures such as damming rivers or ploughing, and “guiding” of ecosphere processes and flows such as agrochemicals in agriculture and genetic engineering. Broadly, the authors are referring to human activity other than resource extraction, use and waste production that can potentially negatively affect the ecosphere in terms of its biodiversity and natural service provision.

By formulating this systems depiction of sustainability issues rooted in natural laws, Homberg *et al.* provide a framework in which to measure and monitor sustainable development. Vitaly, this is where their theory departs from positivistic, essentially “value-free” language, to normative “what ought to be” statements.

The 1996 paper set out four “socio-ecological principles for a sustainable society” that later became part of The Natural Step toolkit utilised within business to ensure the business progresses towards a sustainable future in the environmental sense of the term (for a detailed description of the toolkit, see Robèrt (2000)). The four principles (or “system conditions” as they became known) are as follows:

1. Substances extracted from the lithosphere must not systematically accumulate in the ecosphere.
2. Society-produced substances must not systematically accumulate in the ecosphere.
3. The physical conditions for production and diversity within the ecosphere must not systematically be deteriorated.
4. The use of resources must be efficient and just with respect to meeting human needs.

(Homberg, Robèrt et al., 1996)

Principle 1 is concerned with the human “exchange” of non-renewable materials with nature. Arguably it could be clearer in that it is not immediately obvious that it is referring specifically to the source and sink of materials, and not also the accumulation of materials from the lithosphere into the technosphere (i.e. material goods). Despite this possible ambiguity, it addresses directly the waste

hierarchy of “reduce, reuse, recycle” that is considered good practice in the waste management field (see for example, Department for Environment, Food and Rural Affairs (2008)). It also addresses the issue of gaseous pollutants from industry being released to the atmosphere, such as carbon dioxide, sulphur oxide and heavy metals.

Principle 2 is concerned with substances produced by society (using those extracted in 1 and from within the ecosphere) that are released back to nature as pollution. These substances are synthetic or radioactive in nature. Interestingly, the persistent synthetic examples given by Homberg *et al.* are those that have since been banned in production globally through legislation – CFCs, DDT and PCBs.

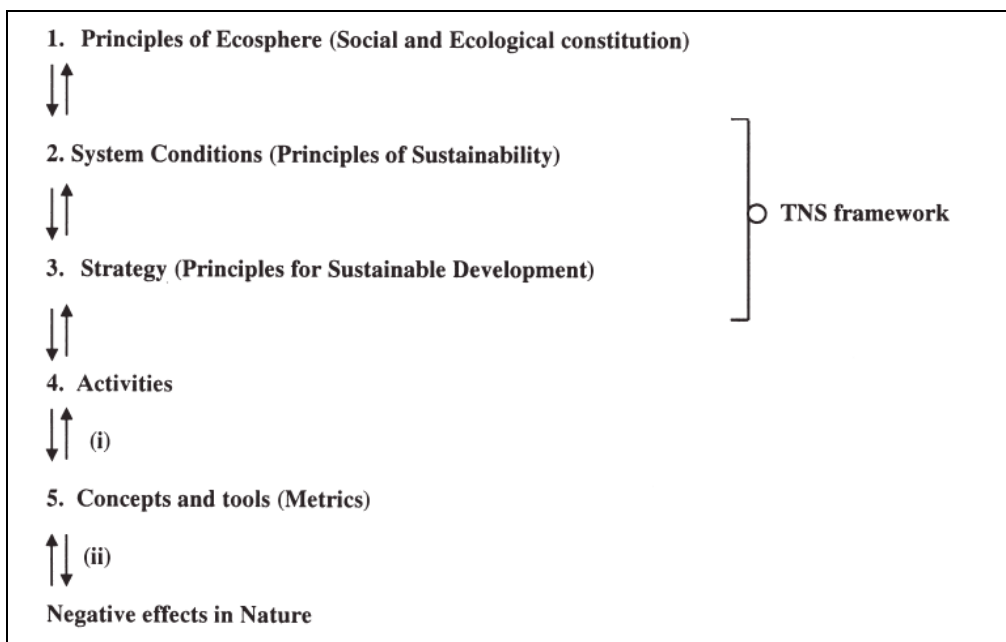
Principle 3 is concerned with “manipulation” of the ecosphere and the use of renewable resources. To elaborate, it is claimed that “society must neither take more resources from the ecosphere than are regenerated nor reduce natural productivity or diversity by manipulating natural systems” (1996:10). The latter claim is a particularly ‘strong’ sustainability viewpoint. Homberg *et al.* draw attention to the strong possibility that reliance on the productive capacity of the ecosphere to supply renewable materials and energy will be of greater importance when fossil fuel and uranium use is reduced, through the application of Principles 1 and 2, or it could be argued, when resource stocks run low.

Homberg *et al.* sum up the first three principles as being limited by nature itself, in terms of assimilation capacity (for waste) and for resource flows, although later in the report they acknowledge that limits for resource flows could be expanded, for example by cultivation of the deserts (1996:10-11).

Principle 4 relates to the coordination of environmental management within the human sphere, and plays to the intra-generational equity theme of alleviating poverty as declared in the Brundtland report.

In conclusion, Homberg *et al.* describe the four principles as a stationary state within a (dynamic) societal metabolism, and that actions through time should be part of a strategy to fulfil the principles. Robèrt (2000) takes this concept further

and argues for a semantic difference between principles of *sustainability* and principles of *sustainable development*. The principles for sustainability are the four system conditions (described above) that determine a “favourable outcome” in the systems (2000:248), whilst the principles for sustainable development relate to the process, or strategy, to achieve the principles for sustainability. Robèrt describes these two stages (The Natural Step (TNS)) in relation to an overall framework for approaching sustainable development (Fig 1).



**Figure 6:** Robèrt’s (2000) framework for sustainable development

Robèrt (2000:249) describes levels 1-5 as being a hierarchy. If the principles of sustainability (2) are ignored, the negative impacts in nature can be measured by the metrics (5) in (ii). In terms of strategy, what is most relevant to measure (5), (i) are human activities (4) causing the negative impacts. The strategy for action (3) to inform these activities can then be drawn up based upon the principles of sustainability (2), which themselves are based upon the principles of the ecosphere (1). In this sense the metrics, that are measuring sustainability, are assessing both the *impact* on nature as well as the *pressure* caused by activities, and whether these pressures are in line with the normative system conditions.

## **Conclusions**

It is probably fairly safe to say that research in the field of sustainable development cannot be value free for the reason that all debates on its definitions require characterising judgements that claim the extent to which environmental impact, resource depletion and limits to growth are present, and any definition as to how sustainable development can be achieved will by its very nature require an appraising normative judgement of value. Separating these types of judgement up however could be very useful in the objective observation of how sustainable a practice is, for example, in the measurement of flows of finite resources and energy set against estimated values of the total of these resources available on the earth. If these observations were to avoid appraising judgements wherever possible, comparisons of different countries, regions, towns and lifestyles could be made based on the amount of resources used and pollution / impact created. How to go about reducing the impact of the activities of these spatial entities, if that was indeed a value that humankind wished to pursue, could then be taken on by the people in the localities in which the activity is taking place giving more flexibility to solutions. As hinted at by Local Agenda 21 that was borne out of the Rio Conference in 1992, the answer could be in global factual measurement wherever possible, and local normative policy making.

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