ECO-REGION NW

"Regional industrial ecology and resource productivity – new approaches to analysis and communication"

Title:	*Regional industrial ecology and resource productivity – new approaches to analysis and communication*
Position	Draft Chapter in: "Industrial Ecology & Spaces of innovation" Ed Randles & Miles, Ashgate 2005 (forthcoming)
Author:	Joe Ravetz
Status:	Draft 0.7
Date:	23-08-04

Abstract

Recent policy initiatives on 'resource productivity' ('RP') have highlighted the importance of eco-efficiency and dematerialization as a driver for business competitiveness, risk minimization, shareholder value and others (Performance & Innovation Unit 2001: Leadbeater 2001). This follows several agendas on industrial ecology: these focus on the inter-dependence of material flows in industrial clusters; on the 'factor four' approach which focuses on the overall

reductions in environmental impact, and on the 'eco-modernization' of industrial sectors. There is general consensus on these approaches, along with a realization that they represent different angles which may not coincide.

Research at the regional scale is throwing new light on these issues. A detailed analysis of the flow of minerals through the North West region showed how the various approaches above could be represented in different kinds of inputs to a resource flow model, where the institutional questions of responsibility and management practice were pre-dominant.

Meanwhile there is an ongoing series of resource flow / ecological footprint projects in regions around the UK. Current modeling work in the South East region is combining an economic input-output approach (production focused) with an ecological footprint assessment (demand-focussed). The design of 'scenario' inputs to such a model again highlights the importance of institutional arrangements and management practices, in assessing the scope for dematerialization at the level of regional policy and industrial sectors. This demonstrates the role of innovation in promoting industrial ecology as a component of 'regional sustainable development'.

This paper brings together previous projects and work in progress:

- Section 2 is a summary and review of the case study on minerals flows
- Section 3 develops an analytic framework for mapping 'resource productivity'
- Section 4 applies this framework to a practical scenario modeling method and project in progress.
- Section 5 draws out some key implications for regional level economic strategy and business innovation.

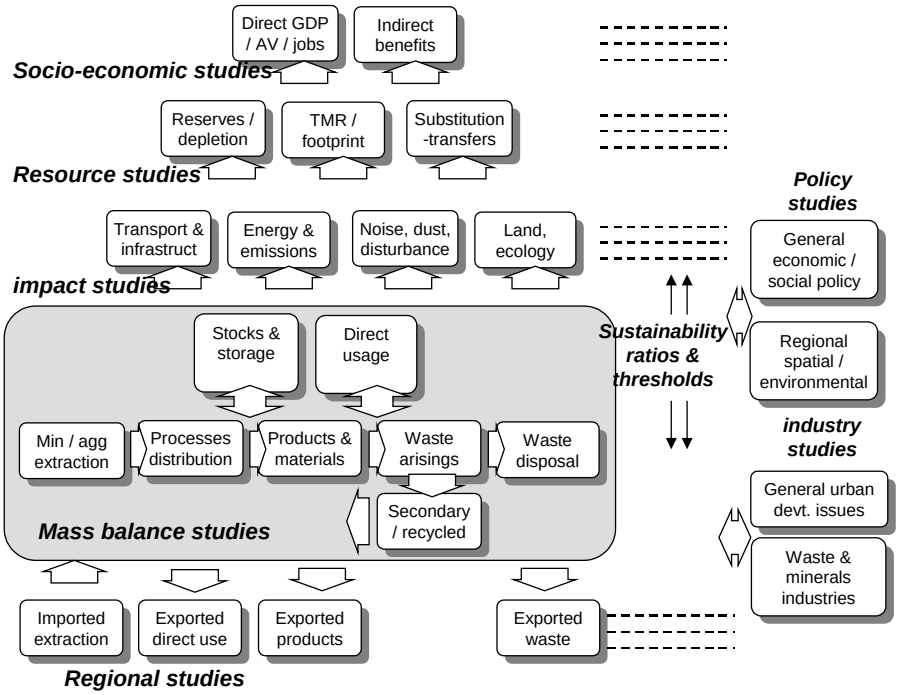
Case study: resource flow audit

This case study concerns the 'Resource Flow Audit for Sustainability', on the flow of construction minerals in the North West region of England. This was a project funded by the Landfill tax credit scheme, part of the Biffaward 'Mass Balance' portfolio, and commissioned by the National Centre for Business Sustainability. The study aimed to provide information and decision tools for a more sustainable material economy, with a 'mass-balance' approach, it aims at results and methods which are relevant to other regions, other sectors and other kinds of material flows.

Bulk minerals are one of the material foundations of a modern economy. Demand and supply is the result of the interaction of markets, urban policy, construction methods, and materials management. Consuming materials indefinitely without limit cannot be environmentally 'sustainable' as we know it; but the questions of what is sustainable, and how to move towards it, are complex and uncertain. In view of this the goals of the Resource Flow project were to:

- Analyse the question of what is 'sustainable resource use';
- Provide the data to begin to address the issue;
- Highlight the implications for business and policy.

A research mapping is shown below as a guide to the agenda of the case study.



Findings

Mass balance analysis

The tracking of material flows in a mass-balance framework is the foundation for a resource flow audit, and the basis for an informed environmental management and policymaking. It also highlights the complexity of flows, inwards, outwards and around the region, and shows that much essential data is very difficult to find in practice.

The summary of mass balance results shows the total bulk construction minerals and aggregates (1999) for the North West region (in 1000s tonnes):

Primary extraction:	21350
End-use:	26276
Imported minerals:	10,600
Total waste disposal:	10,380
Total to exempt sites:	3,758
Total recycled / secondary use:	3,370

Impacts

The environmental impacts of bulk minerals are different to those of most other resources, as their toxicity is low and geological reserves are large. The principal impacts are due to the stages in the life cycle of extraction, transport, processing, and final disposal.

- ***Extraction:*** quarrying and materials handling causes dust, noise, vibration, disruption to soil and groundwater, and impacts on amenity. On the positive side, completed and creatively

restored minerals workings can provide beneficial habitats for wildlife. The total material moved is about 4 times the rate of natural geological flows and erosion.

- ***Transport***: The energy used for haulage of construction minerals is a significant impact. Although distances are relatively short, the loadings are typically high: the tonne-miles are about 15% of the total freight in the NW, while the energy and emissions are about 10%.
- ***Process energy***: 3% of total energy use in the NW region, or 25 PJ (peta-joules) per year, is due to the production of energy-intensive building materials including cement, bricks and blocks and glass (98% of which is for export). The energy used in extraction is about one tenth of this figure.
- ***Waste disposal***: landfilling of inert waste involves dust, noise, and sterilization of land and soil. The 1996 landfill tax reduced the amount of inert waste going to landfill, but greatly increased the amount going to 'exempt' sites, with few controls and enhanced risk of contamination.
- ***Resource depletion***: the geological resources of bulk minerals are large, however there are environmental and planning constraints on new workings. Hence, the practical reserves and current depletion rate of construction minerals are dependent on future environmental policy, and whether the industry is 'demand-led' or 'supply-constrained'. The alternative of importing material from other regions or countries involves trade-offs between transport, materials handling and environmental constraints elsewhere.

'Ecological footprint': a measure of the land required to ameliorate pollution, provide renewable energy or otherwise compensate for environmental damage. The total ecological footprint for construction minerals in the NW region is estimated at 467 km^2 per year, (including glass manufacture for export). One quarter of the ecological footprint is due to transport energy and other impacts including road infrastructure. Half of the total is due to manufacture of building materials, mainly cement and glass. 15% of the total is due to accumulation of material in the urban system, estimated as coverage of land with hard standing.

'Factor Four': this theme combines the above principles with a simple formula:

- Double eco-efficiency: reduce by half the amount of floorspace and other material structures needed to provide for social and economic welfare.
- Double material intensity: reduce by half the amount of material, and/or its environmental impact, needed for each unit of structure provided

For minerals / aggregates it is generally not feasible to achieve a Factor Four reduction literally, in the urban system and economy as we know it today. However the theme is a powerful principle in promoting resource productivity and less unsustainable consumption.

Sustainable business models

On closer inspection there are different perspectives on sustainable resource use, which lead to different kinds of policy goals and business models. Below are some of the models which might aim to combine policy goals with business viability.

Reduce primary resource inputs

Resource use and waste arisings are not generally seen as part of the same problem, but all minerals quarried will at some point become a future waste. Therefore a systematic approach dealing with the full 'cradle-to-grave' flow is needed. Land use planning has an important role to play in managing demand and impacts, and solutions include:

- Shift from 'demand-led' 10-year land-banks, towards 'supply-constrained' planning, through Minerals Planning Guidance and regional policy;
- Enhanced durability and flexibility of buildings and infrastructure;
- Design of components and materials for subsequent recycling (disassembly);
- Tackle the liability issues in specification which lead to over-design and engineering (lean design);

- Landfill tax and aggregates tax need to be targeted and set at levels which ensure maximum impact.

Closing material loops

The challenge is to convert current material waste streams into resources. Closed loop processes can be promoted through a range of measures:

- Changing material specifications: targeting performance rather than content.
- Shift from low quality recycling (used as fill) towards grading and reprocessing for higher quality uses ;
- Promote multi-material recycling centres close to urban areas to minimise transport;
- Set targets for alternative materials within public procurement policy;
- Introduction of mandatory segregation in regional demolition and landfill practice.

Whole life responsibility

Generally, the concept of 'waste' needs to shift to that of 'unused resources': and the concept of 'recycling' towards a broader 'integrated resource management'.

- Promotion of Resource Management Enterprises
- 'Take back' contracts for infrastructure works;
- Public sector promotion for recycled material markets.

Regional self sufficiency and proximity

As the NW region imports much material from high quality landscapes and National Parks, it is important that the region aims to be as self sufficient as possible. However the proximity principle needs to be included in any trade-off decisions, as a strict self-sufficiency approach could increase the travel distances for many minerals.

- Limit extraction from areas of high natural beauty;
- Target future demand in line with regional resources;
- Use of proximity principle for minerals planning, with full assessment of transport impacts from haulage.

Minimise environmental impacts

The principal impact is due to energy use and climate emissions from transport and processing of bulk minerals. The largest energy uses are for the production of cement and glass for export, while transport has many other impacts:

- Increased use of rail freight and sea transport (where feasible);
- Increased use of temporary sites and stockpiles for recycled materials in urban areas to reduce transport requirements;
- Best practice energy efficiency and fuel sources for energy-intensive manufacturing.

Integrated materials management

Suppliers, producers, regulators, users and consumers of bulk minerals all need to be aware of the opportunities for increased eco-efficiency and productivity. Business information systems for 'integrated materials management' will need to match supply and demand, identify alternatives and spot business opportunities, and for this an improved knowledge base is essential:

- Collation of material flow database with consistent boundaries and definitions;

- Improve management potential through greater regional collaboration (match supply and demand more closely);
- Extend monitoring to tax-exempt sites, and major construction and demolition activities.

Indicators

Effective indicators measure, simplify and communicate. They also provide a benchmarking framework against which improvements can be measured. Although a long list of indicators were produced for the Resource Flow project, a short list of headline indicators is used to communicate the major issues of sustainable resource management. It is intended that these key indicators should be adaptable to all stages of the resource flow:

Primary mineral input/regional GDP	415 kg / £1,000
Total material moved incl. overburden & quarry waste	43.2 Mt
Primary aggregates/ construction value	4.4 t / £1,000
Secondary / recycled material	12% of total
C&D waste to landfill; (excluding landfill engineering)	20% of total
Aggregate consumption from imports	49% of total
Climate change emissions per unit material:	75kg CO_2 / tonne
Rate of annual urban increase: material buildup in system per year	15 million tonnes

Future scenarios

Minerals demand and supply is a long term business with many uncertainties. To address this, selected 'scenarios' were drawn from government studies, and analysed for their possible effects on supply and demand of minerals/aggregates:

- High economic growth, weak environmental policy: minerals / waste increase at 1.5-2.0 % per year.
- Community development, local economy, eco-efficiency: minerals demand stays level.
- Environment hazard and climate impacts: minerals demand decreases due to drop in economic growth.
- Organization development and 'management take-over' with a social democratic model. Small increases in minerals use, increase in recycling, drop in waste arising.

This last 'management' scenario is then used as the theme for a more detailed exploration of the implications of the Factor Four concept:

- Increased eco-efficiency and reduced materials intensity per unit of floor space;
- Reduced primary inputs and increased recycling and secondary use;
- Zero-waste construction and demolition practices;
- Integrated materials management systems;
- Economic and institutional systems to promote integrated materials management.

Analysis: resource productivity

The policy context to the above is that of 'resource productivity' (RP), seen as one of the principal drivers of business competitiveness and quality management (PIU 2001).
This exploration of RP draws on the case study above, for a more fundamental review of RP definition, measurement and application. This is a development of the 'Integrated Sustainable Cities Assessment Method' (ISCAM), a package of methods and tools for systems mapping and modeling (Ravetz 2000). The discussion includes:

- interaction of economic, environmental and social flows and capitals
- application of RP to different parts of the supply / demand chain
- application of RP to ecological footprint and Factor Four
- linkage between management / business models, and physical RP
- linkage between 'innovation' and regional sustainability.

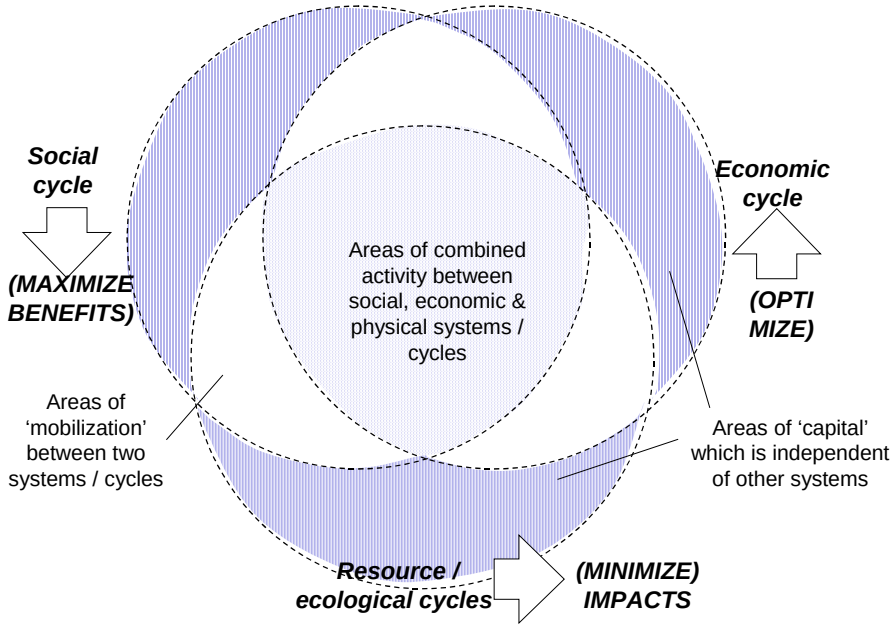
Resources, economy, society

The interaction of economic, environmental and social flows and capitals is illustrated in the diagram below. This shows several kinds of flow which can be modeled as cyclic processes:

- ***Resource flows***, from extraction, manufacture, use, disposal and return to environment
- ***Social flows***, concerning the cycle of labour, production, consumption / 'utility' / 'outputs', and social welfare 'outcomes': (deterministic modeling for this is of course more problematic).
- ***Economic flows***: the conventional 'economic' circular flow of money / capital

Resource Productivity Framework (2):

MAPPING OF SYSTEMS & CYCLES



The diagram also shows the generalized policy goal or normative direction for each of these, in the light of the concepts of 'dematerialization' (Leadbeater 2000) and 're-socialization' (Robinson & Tinker 1996):

- ***Resource flows:*** to MINIMIZE impacts, in order to maintain life support systems
- ***Social flows:*** to MAXIMIZE social welfare and social capital
- ***Economic flows:*** to OPTIMIZE, in the light of the above

Overall, this kind of integrated framework is seen mainly as a conceptual tool, not necessarily as explanatory overarching theory in itself. In particular it helps to understand the different kinds of interaction between physical, economic & social systems / processes. The visualization of 'cycles' may be conceived as running in both directions, depending on the issue at hand. For the environmental cycle, for instance, there is a fairly clear path from material extraction to use to waste and back to the biosphere. However there is also an opposite kind of causal path, whereby the demand for material consumption then 'causes' their extraction through the medium of the economic market.

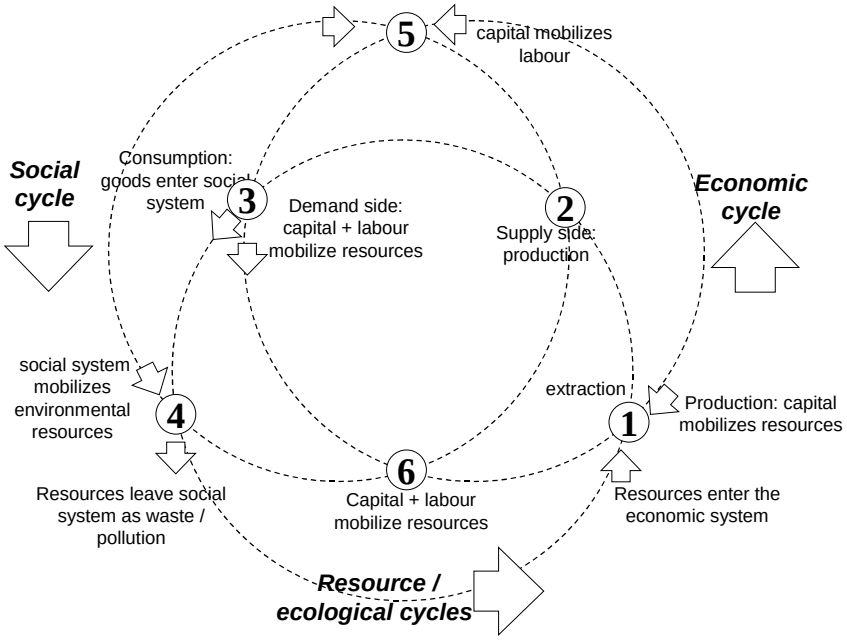
Identifying 'capital'

Where we can identify assets or resources or stored / maintained qualities, whether these are economic, environmental, or social, then this correlates with the concept of 'capital'. In economic terms this is quite familiar, subject to the many possible financial attributes of liquidity, interest, equity and so on. For environmental capital assets it may be fairly clear in economic terms (e.g. a hectare of commercial forestry), but quite volatile or fuzzy in social capital terms (e.g. a hectare of mixed community woodland). This kind of feature points to the way capital is not necessarily a straightforward quality, but something to do with potential or latent qualities for mobilization, qualities which are effective for each of the systems in relation to the others (economic, environmental or social).

Where we can identify types of 'capital' which are mobilized by combination or transformation with another type of capital, then we have a generic model of interactions. The various points 1-6 on the analytic diagram below, represent the range of possible generic interactions between flows in the economy, environment and society. This provides an overall template for more detailed modeling and analysis.

Resource Productivity Framework (4):

MAPPING OF INTERACTIONS



	PHYSICAL CYCLE		
1	**Physical resources extracted and enter economic system**	**4**	**Physical environment enables / mobilizes social activities & systems**
2	**Physical resources are processed by labour in the economic system**	**3**	**Physical community resources mobilized by economic system & capital**
3	**Physical resources are sold from economic system into social consumption**	**2**	**Physical resources transformed into independent capitalized commodities**
4	**Physical resources leave social system as waste, to return to ecological system.**	**1**	**Physical resources leave economic system as wastes, to return to ecological system**
	ECONOMIC CYCLE		
5	**Capital mobilizes social system to generate productive labour.**	**1**	**Economic production: capital mobilizes physical resources**
3	**Capital uses labour, to act on physical resources in economic production.**	**6**	**Mobilized resources are processed with added value from labour input**
6	**Physical goods & commodities, are the result of economic production**	**3**	**Economic value mobilizes social system independent of physical resources**
1	**Economic value / capital is generated, independently of physical / social effects.**	**5**	**Economic value / surplus / accumulation disengages from social system**
	SOCIAL CYCLE		
4	**Social system engages with physical environment in time & space**	**5**	**Social system mobilized as labour, by economic capital**
6	**Social system mobilized, via capital in economic production**	**2**	**Mobilized labour in economic production, to process & transform physical resources**
2	**Social system conditioned by non-material consumption / production**	**6**	**Social consumption of physical resources, after economic activity**
5	**Social experience, independent of economic consumption / production**	**4**	**Welfare gained in social system, after consumption / engagement of physical resources**

The generic interactions between economic, environmental and social cycles are shown on the diagram. The table below shows a more complete breakdown of each point in each system cycle. The flow in each direction is shown as far as this can be visualized.

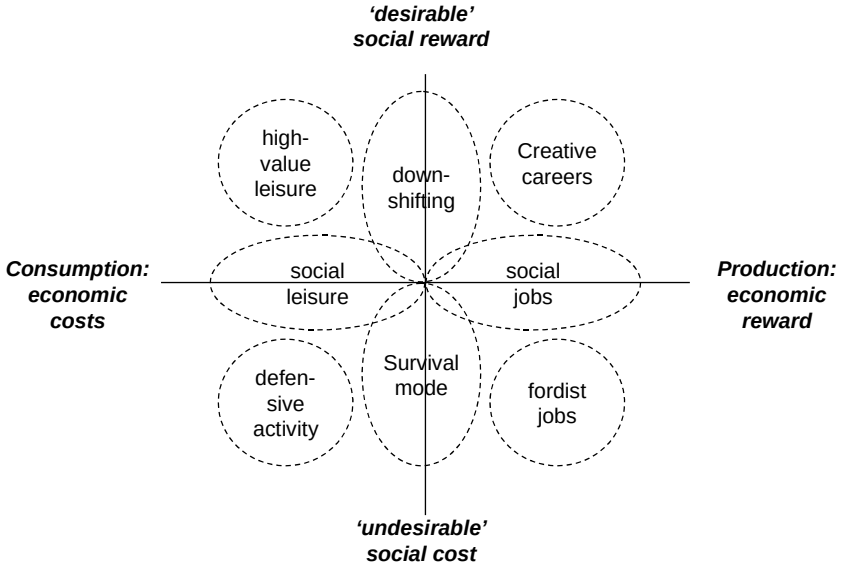
Productivity vs 'consumptivity'

One vital question is on the difference or boundary between production and consumption.
A conventional economic perspective considers production of goods or services up to the point of final demand, i.e purchase by consumers or the public sector. Consumption is then the act of purchase, or in the case of indirect services, the act of commission or physical appropriation. The diagram below shows an alternative perspective on the blurring of these boundaries.

Mapping resource productivity

Resource Productivity Framework (8):

BOUNDARIES: PRODUCTION VS CONSUMPTION



Changing balance of quantity of material reward and quality experience in work and leisure in post-industrial societies.
Source: adapted from Handy 1995: Rifkin 1994

A more evolved perspective on RP would look at the interaction of each part of the cycles of economic, environmental and social systems, and the mobilization or impact which is effected at each point. For example, referring to the case study:

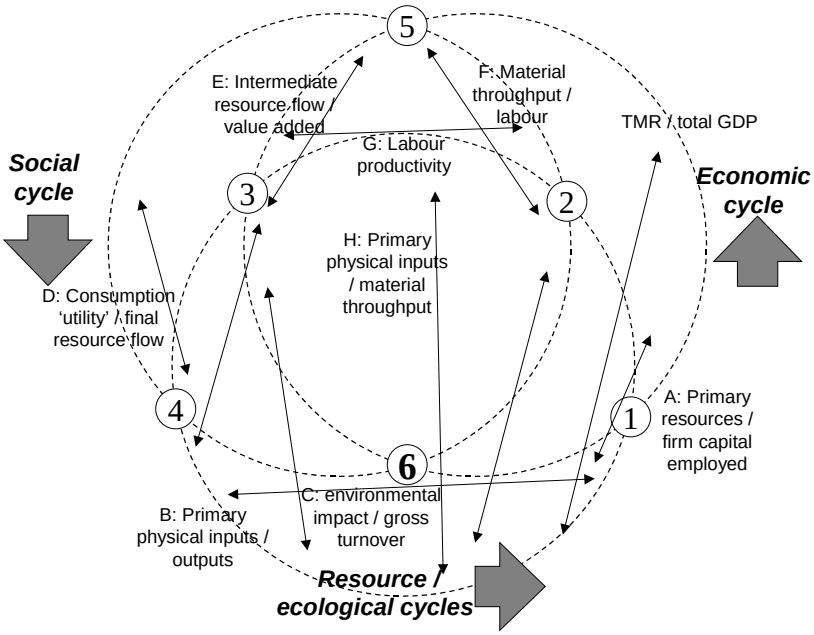
- Capital mobilizes plant to extract minerals to provide construction concrete, which serves the demand for social housing.
- Employment is generated in local quarries which supply minerals markets while creating disturbance in a National Park area.

The interaction of the social system here is often left out of the RP calculation, as it is generally complex and volatile. For instance it is easier to assume that the 'value' of construction minerals is equal to their retail / wholesale market value. This is plausible up until the point at which the social system and its embedded 'capital' / 'value' is predominant: i.e. the 'value' of the undisturbed landscape: or the 'value' of the finished social housing to the community and neighbourhood.

The framework above can be used as a basis for mapping different types of RP, in terms of ratios between the various economic, environmental and social cycles:

Resource Productivity Framework (6):

MAPPING RESOURCE PRODUCTIVITY



The mapping shown here is not exhaustive but serves to demonstrate the various dimensions of a full RP assessment.

- A: Primary resources / firm capital employed
- B: Primary physical inputs / outputs
- C: environmental impact / gross turnover
- D: Consumption 'utility' / final resource flow
- E: Intermediate resource flow / value added
- F: Material throughput / labour
- G: Labour productivity: net output / employee
- H: Primary physical inputs / material throughput
- Total material requirement / total GDP

Naturally the selection of performance indicators for such a complex situation is an issue in itself. In the Resource Flow Audit case study there was extended debate over several steering group meetings on the appropriate indicators.

In summary so far: this analysis so far has deliberately been removed and focused on one particular kind of resource flow. In the next section we outline a scenario modeling framework currently under development. In the final section we explore the implications for regional strategy and management: and to business strategy and innovation.

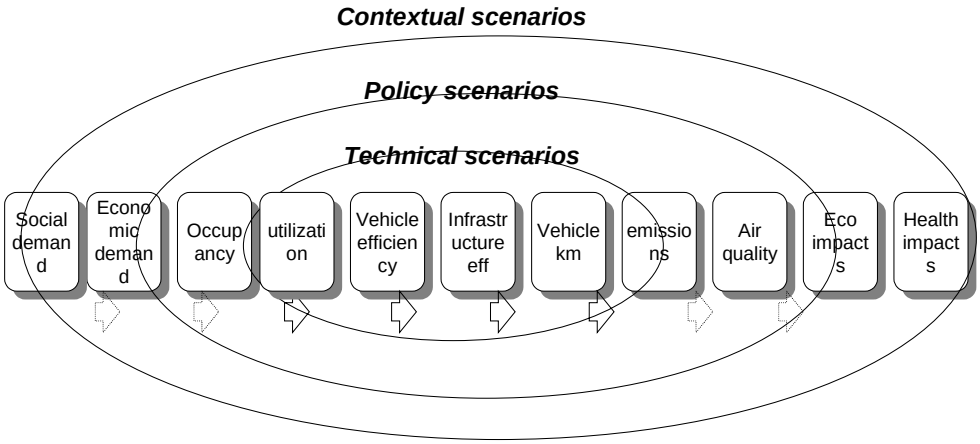
Scenario modeling

Scenario framework

This section is an outline of the development of 'scenarios' – i.e. composite descriptions of alternative future conditions and trajectories. Some of the main types of scenarios are shown in the diagram below, with an example from the transport sector:

- Technical scenarios: variations on specific and quantified issues: e.g. proportion of waste recycled.
- Policy scenarios: wider possibilities for policy actions: e.g. large increases in disposal taxation:
- Contextual scenarios: general possibilities for society and the economy.

SCENARIO FRAMEWORK



This diagram is arranged around an expanded version of the DPSIR (driving forces, pressures, state, impacts, responses) framework (European Environment Agency 1996: Ravetz 2000). A very simple breakdown of the likely interactions of these factors are charted in the table below, in terms of technology, policy, economics and lifestyles.

	Underlying forces	Driving forces	Pressure	Infrastructure	Technology	State	Impacts	Outcomes	Response	
Technology innovation				•	•					
Policy: regulation / planning			•	•		•				
Policy: fiscal / management		•					•			
Market change	•						•			
Lifestyles & values	•							•		

Scenario framework:

Analysis of recent developments in scenario methods shows several different types. Each of these is relevant to regional analysis and its modelling approach:

- ***Policy / issue scenarios***: structured around topical and conflicting sectors and themes. In the SE such themes might include transport, housing and environmental protection.
- ***Contextual scenarios***: these illustrate possible alternative trajectories for general socio-economic conditions, at the UK / EU / world levels.
- ***Footprint scenarios***: these provide 'envelopes' for the footprint as a measure of aggregated environmental impact, in particular referring to the 'Factor 4' targets.
- ***Resource scenarios***: these are focused on the materials management aspect of resource flows, in terms of technology, regulation, markets and consumption choices.

Footprint scenarios
When the linked database system is complete, this will enable a range of scenario types to be analysed for aggregated reductions in footprint. For these a time horizon of 50 years is probably appropriate (2000 – 2050):

- Business as usual: generally 2-2.5% compound = 250% growth in 50 years
- Stabilization: 0% growth (Factor 1)
- Green scenario: 50% reduction (Factor 2)
- Deep green scenario: 75% reduction (Factor 4).

Each of these involves a combination of various factors as below. This forms a kind of hierarchy, where the top may be generally perceived as the easiest or lowest level of 'risk' in terms of the institutional patterns of decision makers.

- Technology change
- Spatial development and infrastructure
- Regulation & management
- Policy & taxation
- Economic market change
- Economic sectoral change
- Lifestyle & cultural change

Resource management scenarios:
These scenarios draw from the resource / footprint framework above, and then explore in more depth some practical questions: what would be the specific objectives and targets: how these could be achieved: who would be responsible: and what might be the trade-offs or impacts:

- Smart technology: doing more with less: reducing primary inputs
- Closing loops through local / regional economy: linking of production to consumption
- Smart regulation: targeting of policy: whole life responsibility: reduced waste arisings
- Smart fiscal measures: charges and incentives
- Smart markets: whole life responsibility: integrated supply chains
- Smart consumption: leasing, networking, service concepts
- Integrated materials management: frameworks

Scenario trends and 'givens'

A recent international review of global scenarios identified key driving forces with a very high probability of continuing in the short and medium future (Rotmans et al 1998). For a regional resource scenario framework, such trends might be taken as external 'givens':

- ***Social factors***: the ageing of the population as life expectancy increases, birth rate reduces, healthcare improves and environmental protection improves,
- ***Economic factors***: the globalization and liberalization of business organizations, supply chains, factor markets, financial flows, production and consumption
- ***Technology factors***: the breakneck rate of innovation in ICT and bio-technology, and the implications for economies, organizations, technologies, cultures

- ***Environment factors:*** the onset of serious anthropogenic climate change, causing ecological stress and disruption to economies and societies.

What is interesting is that these 'givens' appear to be quite certain at first sight, but on closer inspection they open the door to many more layers of uncertainty. While the fact of climate change, for instance, is now widely accepted, the actual results are still very uncertain, and even more so are the impacts of climate change on a regional economy, society or environment. The projection of such trends into the future raises the question of surprises or 'side-swipes' – unexpected events coming from outside the frame. Some common surprises which surface in many scenario exercises include:

- ***social factors***: new forms of diseases and vulnerability reduce life expectancy
- ***economic factors***: global capitalism falters due to currency speculation
- ***technology factors***: global ICT systems are overtaken by viruses and saboteurs
- ***environment factors***: a flip in ocean currents reverses the effect of climate change

The purpose of generating scenarios, using social processes or technical models, is not just to imagine future conditions, but also concerns exploring and bringing to the surface the dynamics of present day trends. The emerging techniques of interactive scenario workshops deliberately look beyond normal policy horizons, as a means of taking such trends and shifts to their logical conclusion, and exploring different angles on the dynamics of change:

- ***visible changes and trends***: their conflicts and tensions, which can be projected for the shorter term.
- ***underlying dynamics:***, which may be projected in waves or cycles for the medium term.
- ***transitions and transformations:***, where social and economic structures change irreversibly in the longer term. One example would be the growth of IT and the structural changes which come from it.
- ***Surprises and discontinuities***: unexpected 'side-swipes', for example the September 11th attack
- ***results, outcomes and impacts*** of such future possibilities: for instance the impact on the environment of social change, or vice versa.
- ***the implication of such possibilities*** for present day decisions and activities.

Many participative scenario workshop sessions show a strong tension between aspiration and reality – between 'what we want' and 'what we get'. This forms the essential matrix on which scenarios for 'sustainability' may be constructed.

Scenario applications

The above 'normative' theme highlights the application of scenarios as information systems in their own right, on a spectrum between different kinds of systems:

- Direct control of 'engineering' type systems:
- practical operation of management systems
- competition for agendas in political systems
- expression of much deeper fears / hopes in cultural systems.

Within this spectrum a range of possible user applications can be charted out***:***

- ***Long term practical***: strategy and planning issues, for the public sector and larger organizations
- ***Short term practical***: investment and management issues, for larger & smaller businesses
- ***Long term rhetorical***: values debates and awareness raising, in the NGO and public sector
- ***Short term rhetorical***: values, priorities and topical issues, for consumers and the public.

Model framework

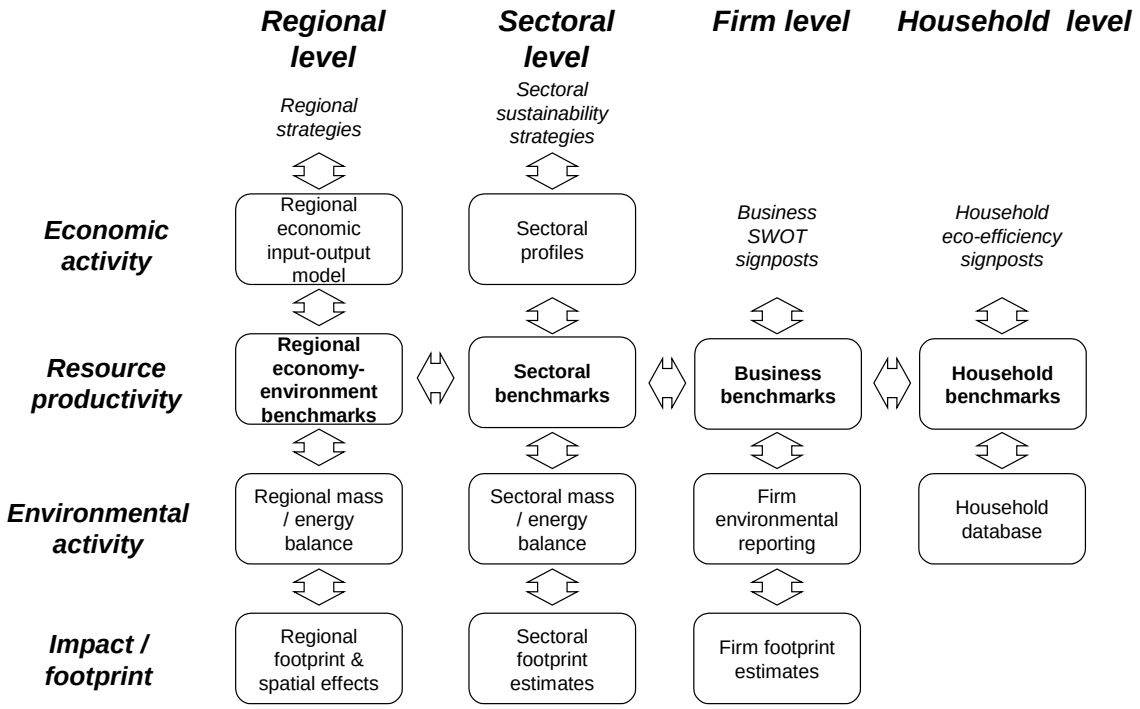
The large databases involved in resource flow analysis, together with the need to actualize the scenario frameworks for different types of users, suggest the use of integrated models. However these are then subject to many constraints, as at the end of this section.

Such an integrated model is under development as a working framework, currently in the South East region, and shortly commencing in the North West. This 'linked database model' links several kinds of information system / model / database:

- Economic input-output matrices with resource coefficients
- Component ecological footprint database and coefficients:
- Mass balance / resource-flow database:
- Integrated scenario accounting model: based on the 'Integrated Sustainable Cities Assessment Method'.

When fitted together with a benchmarking and reporting framework for firms, sectors and households, the overall framework appears as follows:

TECHNICAL FRAMEWORK



'Resource productivity' model

The 'Regional & Welsh Appraisal of Resource Productivity & Development' (REWARD) project is currently building a computer model for the economy and environment, for 6 English regions and Wales. This model is titled the **'Regional Economy-Environment Input-Output' model (REEIO).** The REEIO is a new and powerful computer tool for regional strategy and policy appraisal. The finished package, due to be completed in 2004, will contain for each of the partner regions:

- A detailed model of the regional economy in input-output format: this allows tracking of direct and indirect effects to the regional economy of policies, programmes, or changes to an industry or sector.
- A set of environmental pressures which are directly caused by economic activity: including energy, air emissions, transport demand, water demand and solid waste.

The package comes in the form of user-friendly windows-based software. This allows for further more detailed components, such as energy or waste, to be linked to the main model. One of the spin-off benefits is a powerful database of economic and environmental indicators, trends and projections, for each region. This project is funded by a partnership of the Environment Agency, 6 Regional Development Agencies[1] (RDAs) and the National Assembly of Wales.

The REEIO is based on a detailed 'input-output' model of each regional economy:

- This is arranged in 49 sectors, each of which makes transactions with each other sector. The economic data and trends are consistent with regional / UK forecasts.
- There are 6 types of employment and 25 types of occupation.
- Economic and labour market results are generated with assumptions for macro-economic growth and population change. Economic 'supply-side' strategies are not modelled directly, but can be represented as providing growth opportunities within the relevant sectors.

The REEIO then makes links with key environmental and resource pressures:

- Transport sector: demand is related to households and economic activity: supply is by occupancy, modal split, and vehicle efficiency.
- Energy sector: final demand is related to households, transport, industrial and commercial activity: energy supply is by 13 economic sectors, 6 fuels, with special treatment of power generation.
- Air emissions: including greenhouse gases, SO_x, $N0_x$, VOCs, PM.
- Waste sector: arisings include household, industrial / commercial, sewage, power station ash /slag, incineration ash and other: waste disposal includes landfill (active / inactive), incineration, recycling / re-use.
- Water sector: final demand is related to households and economic activity: also with a regional supply / demand balance.
- Land-use change: based on housing demand and industrial / commercial development rates.

Model components: mass balance & activity model:

The balance sheet and activity spreadsheets are designed as the main linking device between the economic input-output model and the resource / footprint databases.

They are based on the existing system of the 'Integrated Sustainable Cities Assessment Method' (ISCAM) (Ravetz 2000). This was developed to provide the simplest possible model for accounting and scenario building, requiring a minimum of data, and with nothing hidden in a black box – 'what you see is what you get'. The entire input and output can be shown as a spreadsheet report, on a par with the financial accounts of any large organization. This kind of accounting framework is not an end in itself, but a tool and reference point, and can contain several components:

- 'core accounts' with current baselines, BAU trends, and SD projections. (The 'core account' sheets are shown at the end of each chapter in Part D)
- 'core indicators' containing the most critical factors, with a 'trend-to-target index' calculated for each (The 'core indicator' summary table is at the end of this chapter)
- visual output in the form of charts and graphs is very useful, and can be linked interactively to the core accounts, so that changes can be seen in 'real time'. A sample sheet for the transport sector is attached.

[1] North East Regional Association, South West of England Development Agency, South East Economic Development Agency, East Midlands Development Agency, East of England Development Agency, Greater London Authority and the National Assembly of Wales.

The core accounts tables are organized into 8 or more worksheets, linked together through easily quantified and aggregated factors such as energy, carbon, or land. (Further research is exploring the possibility of economic value-based linkages, and environmental toxicity-based linkages). Each sheet contains a similar pattern of columns:

- 1995 or current values, with 1970 or historic values where possible
- business as usual (BAU) scenario: shares, values and totals
- sustainable development (SD) scenario: shares, values and totals
- 'trend to target' index for selected indicators, as in the next section

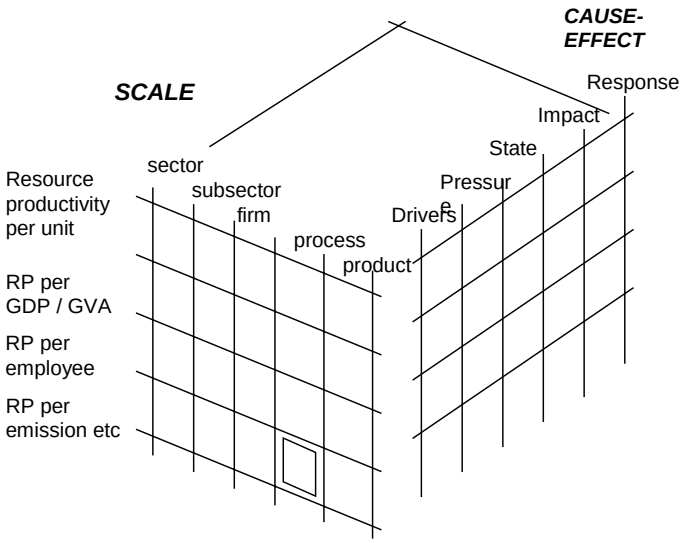
The most fundamental 'key driver' is the GDP growth rate and sectoral share. The scenarios shown assume a compound growth rate of 2% per annum, or an increase of 60% over 25 years. Key drivers such as 'commercial floorspace/GDP' and 'freight tonne-km/GDP' have in the past remained fairly constant, and this is reflected in the BAU scenario. In the SD 'sustainable development' scenario these drivers are shown with substantial reductions, assuming the same rate of GDP growth.

Model components: benchmarking

The concept of benchmarks is to set out a framework for the interaction of economic activity with environmental impact / resource consumption. This would contain, as per the 'cube' visualization below:

- Environmental factors in waste, materials, transport, energy, water, minerals, toxicity burden if known etc
- Economic / social factors: GDP / turnover, GVA, employees, capital investment, other EHS / corporate responsibility
- average / best practice for similar firms / products
- average / worst / best practice for the sector and sub-sector
- comparison with regional pressure points, limits, goals and targets

ECO-REGION: BENCHMARK FRAMEWORK

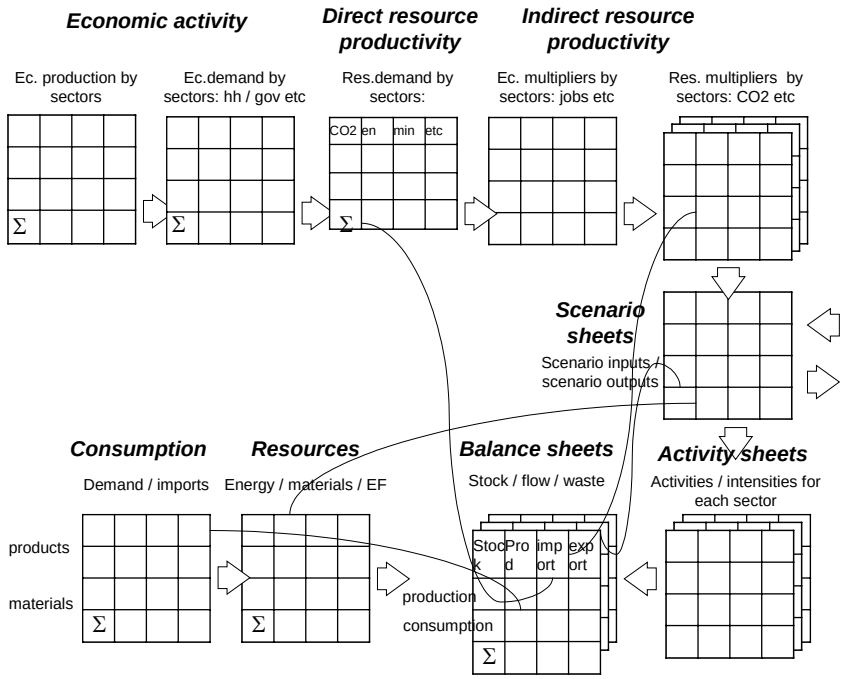


Integrated linked database model

The framework for the integrated database model is set out as a series of steps:

- Step 1: imputation of direct / indirect material inputs to *household* demand sector. This uses input-output matrices to 'impute' the flows of resources, both direct and indirect to final demand sectors.
- Step 2: imputation of direct / indirect material inputs to *government* sector: the final demand items above are attributed for the government sector.
- Step 3: develop mass / energy balances from consumption data. This includes for key themes such as energy, carbon, minerals / aggregates, water and land, a standard balance sheet format showing: stocks, production, consumption, waste, imports and exports.
- Step 4: normalize resource flow coefficient by mass / energy balances. In the same way that the economic input-output coefficients are scalable by the size of the economy, so are the resource coefficients then fitted to regional balance figures. Clearly boundary issues are crucial in the definition of what is production and consumption.
- Step 5: identify key activity intensities and sub-model disaggregations. The 'activity model' is designed as the meeting point between each component, and the point at which scenario inputs and outputs are collected.

ECO-REGION: MODELLING FRAMEWORK



Model operation

- The linked database model' is constructed as an accounting model, i.e. it does not aim to find 'equilibrium' between factors such as prices and demand.
- The model is constructed around a set of 'change factors': e.g. the rate of energy efficiency improvement in industry; or the rate of change in passenger travel per GDP per capita. These are set in default position to reflect the 'business as usual' trends and projections, as far as these can be identified. Therefore if the model is 'run' with all these default settings, it should produce a detailed description of future conditions for the next 20 years, and outline profiles at decade intervals for 50 years.
- The scenario inputs then alter these change factors to reflect the range of possible / plausible / desirable scenarios as in the previous section.

- Trend-based scenarios: this simply takes the current trends and their alternatives and projects forwards. The effect is generally to describe possible futures which are progressively more extreme.
- Back-casting scenarios: an alternative approach is to identify future goals and targets and then work backwards. Linear programming is a technique which may be developed to do this with more mathematical rigor if the demand is there.
- Off model issues: as with all models, close examination shows that there are more issues outside the model than inside it. The relatively simple model and standard software proposed here allows for any number of 'off-model' components to be developed: e.g. analysis of waste arising by social groups: detailed housing stock / condition models etc.
- Economic model: there is potentially a need for an input of economic expertise for the fine-tuning of this model, particularly for the input-output matrices components. CURE has had preliminary discussions with Cambridge Econometrics, the developers of the Environment Agency 'WRERP' regional modeling system, who are kindly supplying prototype data for use in this project. A portion of the CURE budget has been reserved for specialist advice from Cambridge Econometrics.

Modeling issues

- At this point the 'linked database model' is envisaged mainly as a development tool, i.e. suitable for researchers or policy analysts.
- The model will be constructed in MS Excel / Access 2000, which allows a limited range of 'macros' i.e. shortcuts and navigation aids to be built in.
- This also enables limited interaction and display of results over the internet, however this is restricted to users running MS Office 2000 applications.
- The most viable and useful form of internet access within the current project is likely to be where a range of scenarios are generated and reported by the research team. This will generate graphic materials which can then be displayed on the Taking Stock website, in combination with narratives, images, quotes and other materials.
- User outputs: this will be generated as a series of 'reports' in MS Access, i.e. pre-formatted screens with a combination of text and chart material.
- Scenario management: a range of scenarios in the above typology will be generated and stored in a 'library'. The visible outputs from this could then be mounted on the project website for general access.
- Data access: work is in progress to explore the possibilities of accessing the baseline data as a valuable resource in its own right.

Implications

Regional strategy and resource productivity

At the regional level there is often a strong correspondence and 'fit' between physical functions, social identity, economic units and political territories. Because of this the regional level brings opportunities to improve on the current state of fragmentation of policy objectives, and move towards the goals of sustainable development. In general the regional level offers an opportunity to make new linkages for the SD agenda, between the local and the national scale, where economic and urban policy is often in a greater state of flux. All these add up to huge opportunities for regional strategy, with a much wider scope than the conventional focus on economic production:

- Production: including goods, services, public services, environmental capital

- Consumption: the culture and psychology of consumers, clients, citizens, institutions
- Structural change: the issues of distribution, equity, logistics, supply chains and so on, as in the example below on e-commerce.
- Quality of life / added value: social or environmental capitals and resources.

Each of these represents an agenda for potential innovation and learning opportunities. The policy issue is then how such opportunities could be taken, at what kind of risk, and whether the structures are in place to realize them? This is a huge research agenda which would take a book to explore (Ravetz 2000), but some implications for regional development might be:

- A regional 'environment strategy' would aim to improve eco-efficiency in material metabolism, attaining factor four and beyond: waste itself will be a resource in a closed loop cycle of production and consumption:
- pollution 'bubbles' to set environmental standards for risk thresholds and exported substances
- regional materials management to promote integrated chain management, re-use, re-design for zero-emission and zero-waste in industry, retail and household sectors

- A regional 'energy-climate agency' would aim to de-carbonize the regional energy metabolism, through a partnership mediating demand and supply:
- energy services firms and partnership energy agency to accelerate efficiency in all sectors, with a CHP programme for urban & industrial areas
- regional renewable programme linking land-owners and utilities to public purchasing policies.

Each of these depends on economic development and financial investment: this is a case for the regional investment funds now setting up to be targeted on green finance at every level of the regional system. Such funds could be run by a partnership of commercial banks and venture capital, public bodies and TECs, with direct links to the RDA and government offices. Their main objective would be in bridging market barriers to increase the viability of investment in SD ventures:

- clean technology 'growth pole' with technology transfer network, linking R&D, HEIs and industrial bodies
- market development programme, linking green investment and public purchasing policies to venture capital and supply chains
- preferential finance for environmentally accredited businesses and projects, as piloted by the Coop and NatWest banks
- infrastructure development: long term equity or underwriting to environmentally-led schemes such as CHP and public transport
- partnership agencies: preferential capital, equity investment and underwriting to the regional energy agency, transport agency and similar consortium bodies
- employment development programme: tackling unemployment and local business development, supporting the New Deal with energy efficiency and similar programmes.

The point for the regional industrial ecology agenda, is to highlight the many types of innovation which would be needed to implement such a programme:

- Innovation in institutions to handle such networks and partnerships
- Innovation in financial models, trading schemes and markets
- Innovation in consumer and public services on the demand / consumption side
- Innovation in social enterprise and citizen responsibility to enhance social capital
- as well as the conventional focus on technological innovation:

Structural change and resource productivity

This takes the issue of e-commerce as one dimension of structural change, i.e. change which includes markets, technologies, institutions etc (Forum for the Future 2000). It is raised here because there are both contrasts and linkages between the flow of heavy construction minerals, and the dematerialized flow of digital information.

The case study showed that an effective resource management enterprise for sustainable resource use could depend on enhanced use of ICT:

- Tracking of minerals demand in space, time, ownership,
- Matching demand with supply of new, re-used, recycled minerals in various grades
- Interactive markets / shadow markets which enable trading between public, private, third and consumer sectors
- Lean design specifications to minimize demand
- Comprehensive assessments of impacts, costs and benefits to different social groups

To understand the implications of this a step back is needed. Much analysis of structural change through ICT / e-commerce tends to assume that markets, production processes, societies and so on will remain the same except for the e-commerce impact on speed and scale of activity. In contrast we would suggest that e-commerce is already instrumental in shaping much more fundamental and qualitative change, even while it is now available to a minority of people --

- qualitative change in economic & market structures: i.e. instant / virtual markets, virtual distributed corporations, virtual stakeholder networks, consumer agglomeration markets, reverse auctions, consumer-consumer markets (C2C).
- qualitative change in institutional structures, i.e. relations between governments and markets, transparency & accountability of corporations
- qualitative change in cultural norms: i.e. global media and styles:
- qualitative change in industrial and technological processes: i.e. justintime production, outsourcing, multi-agent contracting
- consequent qualitative changes in retail and distribution are impossible to predict, but interesting to imagine.

To explore such possibilities and their impacts on spatial structures, we can review some fundamentals. Information, communication and transport have historically been two sides of the same phenomenon - centred on the 'connectivity' of human organizations, economies and societies.

- specialization of function: i.e. possible increased effectiveness:
- diversity of function: i.e. possible increased robustness and resilience:
- internal structures and information flows: i.e. possible increased internal cohesion
- external responses and feedbacks: i.e. possible increased external inter-dependence

Such connectivity, and the innovation which promotes, it can occur in many different ways as with the qualitative change axes above:

- political connectivity: larger political projects e.g. EU, WTO
- institutional connectivity: larger & more complex organizations e.g. TNCs
- cultural connectivity: common norms & languages
- social connectivity: community & kinship networks e.g. ethnic mixing
- technological connectivity: sophistication / standardization in processes & products
- industrial connectivity: extended supply chains, accelerated diffusion
- environmental connectivity: functions / identities of places as part of larger wholes
- economic connectivity: larger / more specialized markets & investment channels

For most active players in ICT the economic axis is the main focus, but linkages with other axes are equally relevant for a wider view. What is particularly interesting is that connectivity on one axis often seems to imply the opposite – disconnectivity – on another. Does this imply a zero-sum outcome, i.e. that an evolutionary end-goal of total connectivity in all dimensions is not possible? Some examples show such effects:

- Political connectivity of single institutions – democratic disconnectivity of citizens from pluralist society & civil liberties
- Economic connectivity of single global market – environmental disconnectivity from local impacts

It is very interesting to contrast this ICT-based connectivity with the current view of the 'learning region' (Morgan 1996): or the 'richness of cities' with creative open diversity, and large capacity for learning and resilience (Christie and Levett 1999).

Economic Connectivity & business strategy

Clearly e-commerce has the potential for rapid restructuring of markets, production and trading interactions at every level from global to local. This can be seen with the theme of intermediation – in other words the agencies and actions involved at each step in a supply chain or distribution chain.

- Dis-intermediation is the process of removing intermediaries, suppliers, brokers, distributors and other middle men, who are rendered obsolete by the faster and cheaper access of e-commerce.
- Re-intermediation is the process of establishing new agencies which act as brokers of information and capital in markets which would otherwise be non functioning. The 'dot-coms' are prime examples of pure re-intermediaries without any other more tangible functions.

The next step looks at different dimensions of advanced industrial economic sectors, each of which may be affected in different ways by the e-commerce potential for dis- or re-intermediation:

- Material resources: global restructuring with territorial base
- Logistic or material production economy: global re-structuring of production & supply chains, subject to cheap transport
- Capital flow economy: wholly virtual and mobile, subject to currency & tax issues
- Local service economy: local and territorial structure and delivery
- Creative production economy: global re-structuring with strong centralist hierarchy
- Cultural consumption economy: global re-structuring with strong centralist alongside de-centralist and territorial base
- Social economy: strong local decentralist base with shared norms & trust, but also potential for global networks

Implications

Each of these dimensions above is a primary driver in different ways, for the prospects and the distribution in economic activity.

Likewise they point the way towards new business models which may aim to implement the ideal of the integrated 'resource management enterprise'. Such business models may be oriented around a simple 'resource productivity' agenda, i.e. doing more with less': or a wider frame which includes social, economic and environmental interactions at each stage in the supply chain.

The public and civic sector support needed to enable such business models may be helped by the use of benchmarks and performance indicators, and the modeling system and resource framework which underlies it. The current modeling project outlined in this paper is one such system aiming in that direction.

In summary, the dynamics of business strategy are not necessarily aligned with the policy goals of sustainability. One involves a convergent focus on business objectives, whereas the other involves a wide range of collective goals and aspirations. However there are many situations where the overlap is significant, and these are the primary targets of the regional –level strategy above.

References

Christie I & Levett R, 1999: 'Towards the Ecopolis: sustainable development and urban governance; Report no
12 of the Richness of Cities project' Leicester, ECOS Distribution

Leadbeater C, 1998: 'Welcome to the knowledge economy' In: Hargreaves A & Christie I, (Eds), Politics of the Future: the third way and beyond' London, Demos
Morgan, K, 1997: 'The Learning Region: Institutions, Innovation and Regional Renewal' In: Regional Studies Vol 31/5:491-504
Ravetz J, 2000: 'City-Region 2020: integrated planning for a sustainable environment' (with a foreword by the UK Secretary of State for the Environment), London, Earthscan, in association with the TCPA
Ravetz, J, 1998: 'Integrated Assessment Models: from global to local': Impact Assessment & Project Appraisal, **16/2**:147-154
Ravetz, J, 2000: 'Integrated Assessment for Sustainability Appraisal in Cities & Regions': Environmental Impact Assessment Review, **20**(2000):31-64
Ravetz J (2003) Integrated planning for a sustainable environment – the City-Region 2020 project: Croners' Environment Journal, special issue on planning, Vol 10:12-13
Ravetz J, 2002: 'Local Sustainable Development Indicators: a Review and Evaluation': Web-based Report from DG Environment / Sustainable Towns & Cities Campaign
Ravetz, J, 1999d: 'Economy, Environment & the Sustainable City: Notes from Greater Manchester': In: Roberts P & Gouldson A (Eds): 'Integrating Environment and Economy: Local and Regional Strategies': London, Routledge