PLUREL

Driving Forces and Global Trends

Module 1

PERI-URBAN LAND USE RELATIONSHIPS – STRATEGIES AND SUSTAINABILITY ASSESSMENT TOOLS FOR URBAN-RURAL LINKAGES, INTEGRATED PROJECT, CONTRACT NO. 036921

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Scenario Framework

Centre for Urban & Regional Ecology
University of Manchester

With contributions from
IIASA, CEMAGREF, CECS, ZALF

SIXTH FRAMEWORK PROGRAMME

Contents

PLUREL

Abstract

Alternative scenarios for the possible futures of peri-urban land use are an essential part of the PLUREL project.

This report provides a scenario framework, in the first case for Module 1, focusing on driving forces and the key variables for the modelling studies. The framework is based on the 'SRES' scenarios of the IPCC, adapted for the peri-urban agenda of the PLUREL project.

The scenarios are expressed through storylines, with some example visualizations. There are also a set of analytic tables which summarize the details of social, economic and environmental factors.

The scenario framework is designed to a be a working tool, to be extended and adapted for the spatial typology and policy analysis in Module 2: for the regional case studies in Module 3: the integrated modelling and impact assessment in Module 4: and the SIAT-RUR tool in Module 5.

NOTE

The sample visualizations are reproduced from the ESRC funded workshop on the UK Rural Economy & Land Use programme, by Joe Ravetz of Manchester University.

It is intended that PLUREL will develop its own scenario visualizations through each module of the project.

1. Summary

Adapted from the text by Joe Ravetz & Mark Rounsevell

PLUREL Newsletter #3, March 2008

Managing change and uncertainty

In 2007 the urban dwellers of the world became the majority of the population, for the first time in history. But there are new questions about the nature of cities, in the face of increasingly rapid and unpredictable change:

- Are traditional cities spreading further and wider into peri-urban areas?
- Are large parts of the countryside being transformed into metropolitan extensions, by global communications and economic restructuring?
- In the Europe of 2050, will peri-urban areas be wealthy and diverse, or decline and fragment?

For such questions there are no fixed or right answers. Instead, exploring future scenarios can be more useful – a way of imagining future possibilities, analysing the consequences, and constructing practical responses.

Above all, scenarios call on creativity and imagination. The predictions of science fiction writers are often more accurate than those of engineers or economists, as shown by examples such as Web 2.0, geo-stationary satellites and derivative trading.

The scenario framework

Scenarios are best organised in a framework which provides a clear logic and structure for comparing different possibilities. Module 1 of the PLUREL project has developed such a framework, based on the global scenarios of the IPCC (Intergovernmental Panel on Climate Change), known as SRES (Special Report on Emissions Scenarios). These scenarios were then adapted to the PLUREL agenda:

- Applying the global scenarios to the EU space, up to the years 2025 and 2050.
- Developing a series of possible and plausible 'shocks', i.e. rapid and important changes in particular sectors or themes.
- Focusing on the implications of each scenario for urbanisation and peri-urban land use change.

The result can be shown as a 2 x 2 framework: the vertical axis is concerned with globalised and top-down dynamics, versus localised and bottom-up dynamics. The horizontal axis focuses on public and collective values, versus private enterprise values. The results of the shocks with implications for urbanisation can be summarised:

- ***A1 – hyper-tech:*** rapid development in technology: rapid counter-urbanisation.
- ***A2 – extreme water:*** rapid climate change and water crisis: defence of the cities.
- ***B1 – peak oil:*** energy price shock: localisation of activity.
- ***B2 – fragmentation:*** localized communities with polarisation of cities.

In the scenario narratives below, the main titles show the general direction of the scenario, while the titles in brackets show a more colourful interpretation of the 'shock' variation.

A1 – 'hyper-tech' scenario: globalized and privatized

This describes a future world of rapid economic growth, global population that peaks in mid-century, and the rapid spread of more efficient technologies. For peri-urban areas in Europe, this scenario is likely to see small 'polycentric' towns and cities become even more popular. New transport technologies lead to more rapid journeys and the expansion of the commuting distances around towns and cities. This leads to peri-urbanisation and 'metropolitanisation' of rural areas on a massive scale.

A2 – 'extreme water' scenario: localized and privatized

This describes a more heterogeneous world of self reliance and preservation of local identities.. Peri-urban areas are strongly affected; affluent yet vulnerable city-regions such as London or the Dutch Randstad spend huge sums of money on defence and adaptation strategies. Population growth due to climate-induced migration puts more pressure on urban infrastructure and services.

B1 – 'peak oil' scenario: globalized government

This describes a future of environmental and social consciousness – a global approach to sustainable development, involving governments, businesses, media and households. For peri-urban areas, high energy prices have an enormous effect on location choices as transport costs limit commuting distances. Although tele-working is encouraged, most people attempt to return to larger cities and towns, and more remote rural areas decline.

B2 – 'fragmentation' scenario: localized communities

Europe sees a fragmentation of society, in terms of age, ethnicity and international distrust.. The ethnic division of cities is driven by the increased in-migration of the working-age population from outside and within the EU. Cities become more dispersed as younger migrants dominate city centres and older natives populate the outskirts and enclaves outside the cities, so that peri-urban areas become 'peri-society' areas.

Implications and next steps

The scenario 'storylines' outlined here are being used in Module 1 of the PLUREL project as the basis of 'top-down' modelling work on economic, demographic, environmental and land use changes. The scenarios are then extended with more spatial and geographical detail by Module 2, to examine the effects on different urban types. This needs more than technical calculations – for instance, does the 'peak oil' scenario mean that people will cluster in large cities, or decentralise to a wired-up countryside? So much depends on lifestyles, values, policies and cultures.

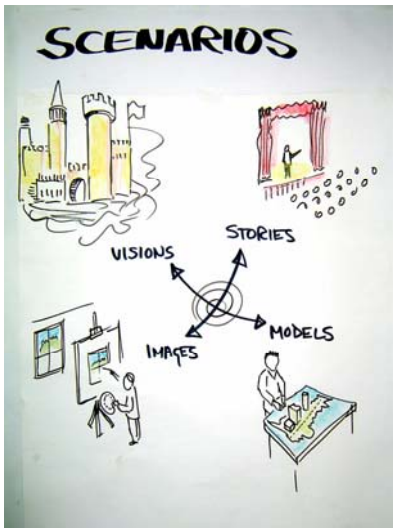
In Module 3, the 'top-down' scenarios are the starting point for the exploration of regional 'bottomup' scenarios within each of the case studies, which take on board the most topical issues and responses in each location. Modules 4 and 5 will also draw on the scenario resource, with both technical and non-technical material. So, the PLUREL scenarios provide a starting point to explore the possible futures for Europe's urban and peri-urban areas. They shine a light into four different 'cloudy crystal balls', not with the aim of forecasting the future, but in helping to understand and work with it.

2. Introduction

Towards a scenario framework

Scenarios are a technique for investigation of possible future conditions and trends, risks and opportunities. As in the graphic below, they can take different forms:

- Stories (fictional or realistic)
- Models (quantitative or qualitative)
- Images (visual or narrative)
- Visions (positive or negative)



The scenario framework, i.e. the underlying logic of developing and comparing a set of scenarios, is a cross-cutting theme for all the Modules in the PLUREL project.

It is particularly important to the 'driving forces' theme of Module 1. Therefore we have developed a scenario framework in Module 1, with the aim that this can help to link and coordinate the work of other modules.

Scenario development process

The scenario development process took several stages, between Month 3 and 15

- First, the concept of a PLUREL wide scenario 'cascade', with applications to each Module;
- Definition of the scenario framework, in a full Module 1 workshop (Vienna, July 2007);
- Application to the modelling work of each WP, in a further Module 1 workshop (Paris, February 2008);
- Consolidation and integration of comments from other Modules.

The discussion at the workshops focused on a wide range of questions:

- Scenario structure – how should the 'set' of scenarios be best organized?
- Scenario background – how should the global and economy-energy focused scenarios of the SRES, be adapted to the agenda for EU peri-urban land use?
- Scenario 'cascade' – how can the 'driving force' scenarios be adapted to the work of other Modules?

- Scenario local adaptation – in particular, how should the scenarios be adapted and customized for the case studies?
- Scenario focus – should they show gradual change or sudden transitions / shocks? Negative trends or positive opportunities?
- Scenario horizons – what are the most relevant boundaries in space and time?
- Scenarios for practical toolkits – how can they be used in the SIAT, library and resources in M5?

There are few final answers to these questions. Instead, the scenario development process involved many discussions and reflections, to reach a balanced view on the most relevant and practical way forward.

The most important point is that scenarios are not intended to be forecasts, although they may start with exploring the range of uncertainty in each component of a forecast. By asking the question 'what if', they explore a wider range of possible conditions, and possible responses.

This report is an outline which is intended for further development by other Modules in the remaining period of PLUREL.

Proposed criteria for development

The scenario framework was developed to fulfil a number of key criteria for use within the PLUREL project:

- Manageable: by limiting the number of scenarios
- Appropriate: to the urban-rural issues addressed in PLUREL
- Relevant to the concerns of end users
- Diverse by reflecting a range of plausible, alternative futures
- Applicable by partners throughout the PLUREL project and stakeholders beyond the project.

Furthermore, the framework should:

- Avoid repetition by building on existing scenario exercises
- Recognise scenario frameworks and modelling results of international importance
- Incorporate new thinking on shock or extreme event scenarios as well as dealing with trends.
- Be suitable for adaptation to other modules in the project, in particular the regional case studies which may have their own scenario agendas.

The proposed scenario framework

In a review of existing world or EU scenario frameworks, it was decided that the basic scenario outlines were best adapted from the IPCC-SRES (Special Report on Emissions Scenarios). (A summary of storylines and variables from the SRES report is shown in the Annex).

However, the SRES does not fulfil the whole of the PLUREL agenda, and so further adaptation and extension of the scenarios is necessary. Within PLUREL the adaptation of the content should reflect urbanisation processes, spatial policy, urban-regional governance, and other important drivers that act at various spatial scales.

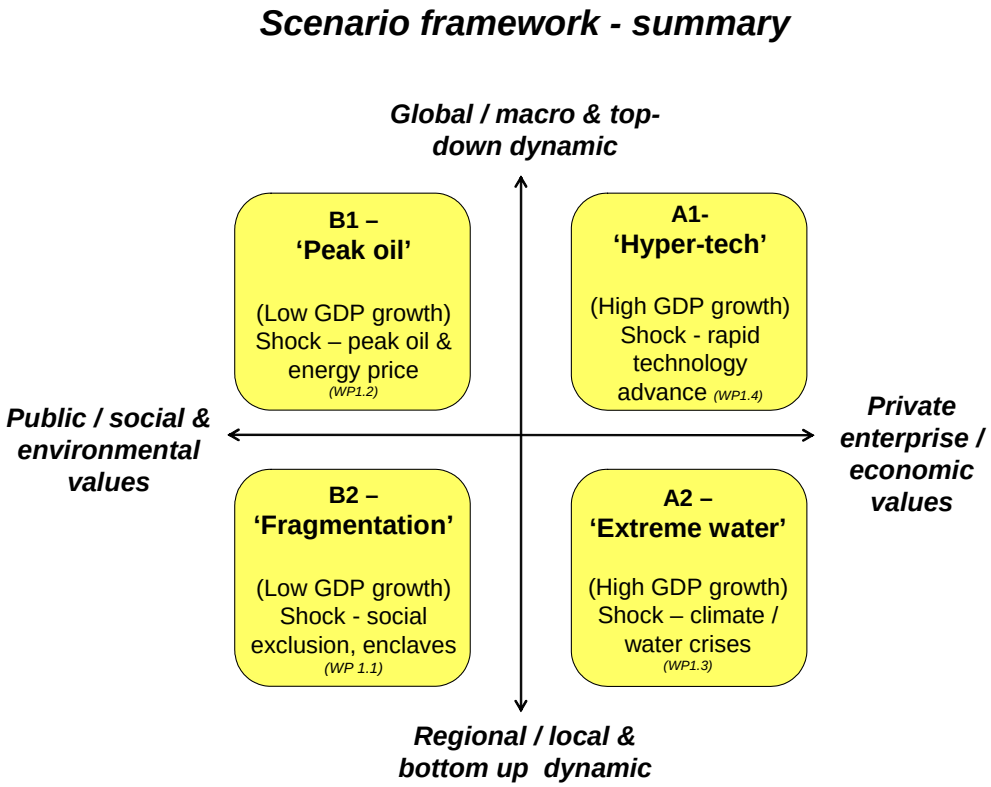
Furthermore, we proposed an extension of SRES based on the development of 'shock' scenarios. This should follow a similar method to that adopted in the ALARM project. The shocks will allow an analysis of change drivers that potentially are of great significance to urban-rural land use, and represent a novel development of regionally-interpreted SRES scenarios.

In order to limit the number of potential scenarios, we proposed to link a different shock to each of the 4 SRES storylines.. These scenarios are outlined in the figure below, and each scenario has been developed in more detail by one of the M1 work packages. The variants are as follows (showing the SRES labels and storyline titles, and the lead Work Packages for each):

- ***A1 – 'hyper-tech':*** (globalized private sector dynamic): rapid development in ICT leading to reduced commuting and transport needs, with no constraints on the location of new build (WP1.4),
- ***A2 – 'extreme water':*** (localized private sector dynamic): climate change reaches a tipping point leading to impacts including rapid sea level rise, flooding and water resource constraints (WP1.3).
- ***B1 – 'peak oil':*** (globalized public sector dynamic): an energy price shock leading to rapidly increasing energy and transport costs, and consequent changes in mobility and patterns of urban development (WP1.1),
- ***B2 – 'fragmentation':*** (localized public sector dynamic): increased localization of communities, but with social division and exclusion between natives and migrants, wealthy and poor, etc.(WP1.2),

This broad framework is summarized in Figure 1:

Figure 1. SRES scenarios and proposed 'transition / shock' variants



General summary of scenario settings:

	A1	A2	B1	B2
scenario parameters	**'Hyper-tech'**	**'Extreme water'**	**'Peak oil'**	**'Fragmentation'**
Population growth (EU 27)	Medium-High	Medium	Low	Medium
fertility	medium	medium	low	medium
mortality	low	medium	high	medium
migration (international)	medium	medium	low	medium
GDP growth (EU 27)	high: 3.4%	high: 3.2%	low 2.25%	low 2.25%
urban population growth (average)	low	high	medium	medium
peri-urban / rural population growth	high	low	very low	medium
"Shock" storyline	rapid technology advance	extreme water events	peak oil	fragmentation, social exclusion

Scenario comparisons

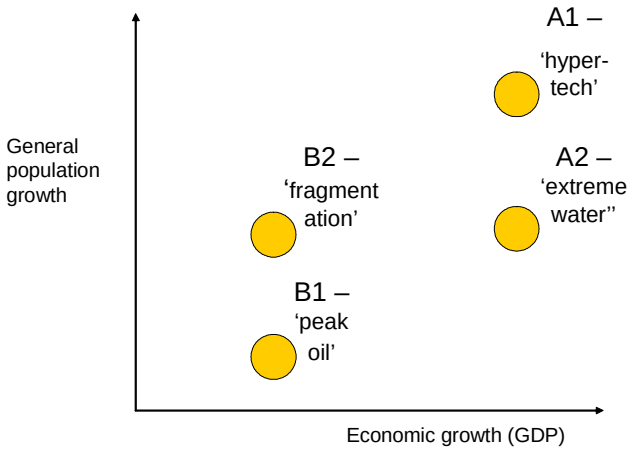
The four scenarios can also be analysed in terms of their key variables.

Figure 2 shows the economic and demographic comparisons: A1 ('hyper-tech') is high growth all round: B1 ('peak oil') is low growth all round. Scenarios B2 ('fragmentation') and A2 ('extreme water') show medium population, with low or high economic growth.

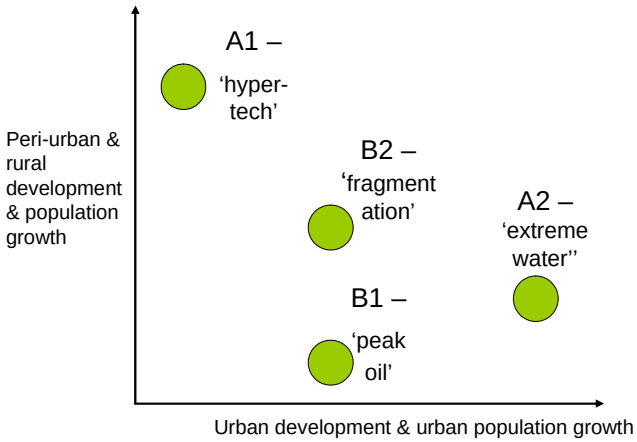
Figure 3 below shows the implications for urban and peri-urban development. Scenario A1 (hyper-tech) is highly counter-urbanized: Scenario A2 ('extreme water') is highly urbanized. B1 ('peak oil') and B2 ('fragmentation') show medium rates of urbanization, with low to medium peri-urban development.

Figure 2 & 3. scenario key variables

Scenario framework: economy & demography



Scenario framework: peri-urban development



Factors of uncertainty in peri-urban land-use

The diagrams above are based on ranges of uncertainty, in the 4 most basic variables in peri-urban land-use relationships: economy and demography; urbanization and peri-urbanization.

These need to be seen in the context of the wider factors of uncertainty in the peri-urban development, which is a complex and multi-layered system. Both quantitative and qualitative factors are explored in the scenario storylines, and the summary tables which follow. First we can outline some of the most interesting and relevant factors, both inside the technical models and in the wider contextual and qualitative factors:

Demography and social issues:

- While fertility and mortality are relatively slow changing, over several decades there emerge some very different demographic profiles.
- International and inter-regional migration are more volatile, and very dependent on policy and global economic swings, and could change rapidly.
- Urban-rural in- or out-migration is also dependent on spatial policy, the state of the cities or the countryside, and transport and communications.
- Lifestyle perceptions of city or rural quality of life, leisure and tourism, also affect the trends of peri-urbanization.

Economic and employment issues:

- Economic growth in general will affect the rate of urbanization: particularly the rate of savings and capital investment will drive the expansion of the building stock and residential land-use conversion.
- Economic structures and employment patterns also affect the trends of peri-urbanization, e.g. if home-working becomes a majority for the service industries.
- Business technology will affect not only employment but supply chain logistics, the distribution of production, services and consumption, and thereby the pressures for urbanization or peri-urbanization.

Environmental issues:

- Climate change variables are well known, but the range of uncertainty in the estimates of impacts may be increasing. These include sea-level rise and fluvial flooding; extreme weather events and hazards; soil erosion and habitat change.
- One likely climate change impact is that the urban environment may become more unpleasant and hazardous, but how much and how soon is quite uncertain.
- Water resource and flood management issues will put pressure on peri-urban development, particularly in arid climates or areas vulnerable to flooding.
- Energy demands may put pressure on peri-urban areas for production of bio-mass

Urban development issues:

- Housing investment: housing forms and patterns: housing and landuse density are all relevant to the growth and pattern of peri-urban development;
- Transport and communications are central to the peri-urban agenda: infrastructure development may promote in- or out-migration, counter-urbanization, or re-urbanization.
- Spatial planning policy may aim to manage or contain growth in larger cities, smaller cities and towns, or smaller rural settlements: or not at all.

Rural development issues:

- Agriculture and particularly the CAP reforms relating to intensive or extensive production, will be the major influence on land-use change.
- Biodiversity protection is a clear policy choice, which may put large parts of the peri-urban area out of development uses.

- Rural economic development trends are dependent on the scenario type, i.e. whether localizing or globalizing forces are dominant.

In reality each of these factors, and many more, is dependent on the others, and there are many more in the complex system of peri-urban development.

Therefore the scenarios shown here are only four sets of possibilities out of an infinite number. They aim to be internally robust and consistent, and validated wherever possible by the technical models in M1.

Implications for PLUREL research

In each of the above factors of uncertainty, there is a technical research agenda. This in principle could be quantified and modelled.

However each of the scenarios also suggests a qualitative research agenda which is different to the others.

For instance, one of the most basic technical parameters in peri-urban development is the gravity function, i.e. the field of attraction of urban areas for development, migration, investment etc.

If we look closely at each scenario it is clear that there are not only quantitative variations in the gravity function, but a qualitative difference between them, and therefore a different kind of research focus:

- ***A1 – 'hyper-tech':*** (rapid development in ICT leading to reduced commuting and transport needs): the gravity function is decentralized, globally networked, and the home / work relationship is shifted to a home / work / global relationship.
- ***A2 – 'extreme water'*****:** (climate change reaches a tipping point leading to impacts including rapid sea level rise, flooding etc): the gravity function is undermined by fragmentation of local/ regional units, disruption of activities etc, and dominated by external pressures.
- ***B1 – 'peak oil':*** (an energy price shock leading to rapidly increasing energy and transport costs, and consequent changes in mobility and patterns of urban development): the gravity function is undermined by disruption of transport on both supply and demand, behaviour change and lifestyle adaptation.
- ***B2 – 'fragmentation'*****: (**increased localization of communities, but with social division and exclusion between natives and migrants, wealthy and poor, etc): the gravity function is dominated by a socio-cultural agenda of consolidation and exclusion: i.e. distance from city is not so much the issue as distance from different cultures and ethnic groups.

These differences in research focus are to be explored through the remainder of the Plurel project.

Implications for future research

This report is a brief outline of the scenario framework which is intended to be a basis for each of the Modules in Plurel.

However, it is clear that there is much more to do on the future studies research agenda for peri-urban landuse. Below is a summary of the scope of this research agenda.

Some of this may be incorporated in later stages of the Plurel, particularly Modules 2 and 4, and any revisions to the work programme are to be discussed by the Scientific Committee.

Other broader aspects of this 'future studies' agenda may be proposed for EU research.

Factors of uncertainty

The above factors of uncertainty need to be explored more systematically. This has been carried out to a limited extent in the conditional probability method in WP1.1 and 1.2. However these are only discreet applications within the economic and demographic models, and the next stage would be to look more closely at synergistic and systemic effects:

- Critical causal chains of cause and effect.
- Tipping points and pinch-points.
- Emergent complexity and transformation effects.

Trend and horizon scanning analysis:

Again the above factors of uncertainty need to be linked back to a review of existing trends and patterns. Some of this is taking place within the case studies, but these are highly policy focused and locally grounded. A more comprehensive review of peri-urbanization development and its dynamics, would include:

- Horizon scanning techniques i.e. review of published sources which may validate or respond to the trend factors above.
- Trend analysis, using time series data for selected EU-wide indicators.
- Meta-trend analysis which explores the nature of the trends: i.e. whether endogenous or exogenous, qualitative or quantitative, policy-relevant or other.
- Trend projections: outlining the range of possibilities in projections for 20-30 years: particularly including not only the model variables but the off-model variables and context factors.

Backcasting and visioning:

This looks more closely at the "sustainability" question, which for the peri-urban agenda is clearly complex, as there are different layers to consider:

- Local agenda: focusing on environmental sustainability at the very local level;
- City-region agenda: focusing on the future of the peri-urban area as a working component of a dynamic city-region;
- Wider agenda: focusing on the future of peri-urban areas in the context of globalization, regionalization, and a wider sustainability agenda.

Within this there are a range of techniques; some of these will be applied in the M3 case studies, and the 'evocative events', but there is also an agenda for the national or EU level.

- Citizen visioning: uses interactive methods in focus groups or scenario workshops, to identify visions (which can be positive or negative).
- Participatory back-casting; once a vision can be formed, then the question is how to achieve it, within conditions of uncertainty and adversity;
- Policy back-casting: this follows with a closer more technical analysis of existing and potential policy opportunities, and their contribution to the vision.

3. Scenario storylines

Each of the 4 main narratives or 'storylines' below contains a range of outputs:

- A SRES label and storyline title;
- Extract from the SRES scenario summary;
- Applications to PLUREL, and the proposed 'shock' or transition agenda;
- Visualizations: these are examples from other projects, to be developed further in PLUREL;
- Narrative storyline;
- Implications for peri-urban development: and implications for PLUREL research agenda.

(A1) 'Hyper-tech' future

A globalized privatized world: with a rapid development in ICT, leading to reduced commuting and transport needs, there are few constraints on urban development and land use change.

SRES text: "The A1 storyline describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income."

Application to PLUREL:

- High GDP growth at 3.5%;
- Overall population peaks and then declines;
- High rates of international migration and social change;
- Medium / high population growth: low mortality; medium fertility; and medium mortality.
- Urbanization is at a low rate of growth: in contrast to peri-urban and rural population growth which is relatively high.

Transition / shock agenda:

In this 'hyper-tech' world, – dominated by rapid technology growth – information and communications technology (ICT), bio-tech, nano-tech, robotics, and other technologies for materials, energy, agriculture, mobility and so on – all develop more rapidly than expected. The details of these possibilities are covered in other sources (Kaku, 2006: Pew Research, 2008: Technology Review, 2008):

Implications for peri-urban land use relationships

The implications of this technological development for urbanization, counter-urbanization and urban agglomeration, include:

- Rapid rural restructuring, and rate of counter-urbanization.
- Lower rates of urbanization overall, but higher rate of urban agglomeration.
- New and more efficient forms of urban and regional transport;
- New and more distributed patterns of living / working / service provision;
- Also enabling new forms of land production and relationship to green space.
- Peri-urban activities & land-uses are market driven at a globalizing scale: large areas of land are bought by foreign investors.
- Weaker system of spatial planning leads to problems with conflicts over land uses, where generally big business takes priority over local communities.

Storyline for 'hyper-tech'

(CECS)

Global cooperation and high economic growth lead to innovation and rapid technological development. Investment in R&D is high and nations share knowledge and pool resources in a global research market place. Mobility of researchers within this marketplace is high. Other workers are also more mobile due to better, faster and cheaper means of transportation. Energy prices decline because supply is driven by new developments in renewable energy production and nuclear fission. There is a narrowing of wealth disparities worldwide and global equity is enhanced. A *virtuous circle* is created with technological development leading to greater economic growth and in turn more investment in R&D. This is the *golden age* of human cooperation and development

Consequences

Technological development leads to new ways of working. People are able to reduce commuting through tele-working and consequently there is a re-population of rural areas. Rural areas are more strongly dependent on service industries and agriculture plays a minor part in the rural economy, not least because genetic technology has resulted in unprecedented increases in crop productivity and the need, therefore, for less productive agricultural land. Most farmers are engaged in landscape gardening as they are paid to maintain the countryside for its aesthetic value for residents. Population increases because of a decline in the mortality rate arising from advances in medicine and better health care. There is also substantial immigration flows due to high levels of economic growth in Europe. However, because of a skill biased technological change, there is less need for low-unskilled labour and governments attempt to decrease the number of low skilled immigrants. Better health implies that people both exit the labour market and suffer disability at a later age. Most people now expect to retire in their mid 70s and living to over 100 years old becomes common place.

Implications for peri-urban development

Small polycentric towns and cities become increasingly popular as a place to live as a compromise between the rural idyll and the need for social services such as schools, health care and cultural activities. New transport technologies lead to more rapid journeys and the expansion of the commuting distances around towns and cities. This leads to increased peri-urbanisation and urban sprawl, with consequences for environmental impacts and the provision of urban services. As people move out of larger cities, mono-centric urban areas struggle to generate sufficient tax revenue to maintain infrastructure. Such cities lose further importance as new technologies allow business to be conducted in a decreasing number of mega-finance centres: e.g. London, Frankfurt, Paris and Edinburgh.

(A2) 'Extreme water' future

This is a more localized and privatized kind of society; climate change reaches a tipping point , leading to rapid sea level rise, flooding and water resource constraints. Peri-urban development is uneven, and more vulnerable to environmental hazards.

(SRES text):
"The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines."

Application to PLUREL:

- Population increases with a continuous pressure on urbanization
- Demographic fertility, mortality and migration are all at a medium rate of change.
- Economic growth is higher at 3.2% average.
- Urbanization proceeds with a high rate of growth: peri-urban and rural population growth is relatively low.
- Urban development and settlement patterns are maintained for the most part, with existing tensions and pressures on transport, housing etc.
- Rural economies maintain their agriculture base for the most part, with a shift back towards more localized products and markets.

Transition / shock agenda:

- 'Extreme water' - floods, storms, droughts, sea-level rise, related events.
- Accelerated climate change also has many other impacts: agricultural problems, infrastructure costs, urban environmental stress, health problems, insurance problems.
- The responses to climate impacts in this scenario are not well coordinated or funded: the result is some chaos and conflict, where those vulnerable to flooding and extreme weather events argue over the redistribution of resources
- There is an attempt at a carbon trading market, but this is also uneven and precarious.

Implications for peri-urban land-use relationships

There are further implications for urbanization, counter-urbanization and urban agglomeration.

- Peri-urban activities & land-uses are generally market driven at a local & regional scale
- There are new patterns of intensive and multi-functional land use at a local scale – specialist horticulture, animals, leisure and tourism environments,
- Cities become more hazardous and unpleasant in summer heat waves, but rural areas also suffer from environmental impacts.

- Spatial planning is more localized, and there are many experiments in new housing forms and living/working patterns.
- In response to the shock of accelerated climate change, many new possibilities emerge: floating houses and coastal harbour settlements; replanting programmes in river catchments; migratory lifestyles which take advantage of northern summers and southern winters.

Storyline for 'Extreme water'

(CURE / JC)

'Extreme Water', otherwise titled "Europe H2O", is a scenario based around the SRES A2 family, in which water crises become commonplace across Europe. Flooding, drought and sea level rise generate social, economic and environmental impacts on an unprecedented scale. A year does not go by without a major event, and in some cities and regions development activities are seriously constrained. Driving forces include climate change and associated impacts including sea level rise, increased precipitation (and hence greater flooding) in northern Europe, and lower rainfall (and therefore droughts) in southern Europe.

Continually increasing population is also a feature of this scenario, driving water crises via complex chains of cause and effect. Essentially there is an increased demand for water resources, contributing to shortages in some areas, alongside a higher demand for land, putting pressure on floodplains and coastal zones. Further, 'creeping urbanization' negatively impacts on natural water cycles. For example, surface sealing contributes to increases in urban flooding due to greater runoff volumes and also reduces groundwater recharge.

Economic growth and technological development is experienced, although in many cases uneven and fragmented. This creates regional winners and losers and introduces an equity dimension into the scenario. More prosperous areas are able to invest in adaptation strategies such as flood defenses and water efficiency technologies, whilst others remain more vulnerable and suffer from water crises more acutely. However, the dominance of the free market in political and economic thinking creates problems of its own. There is a general ignorance of the relationship between human societies and the water cycle, which exacerbates the frequency and impact of water crises.

Key features of this scenario, including possible consequences for peri-urban land use relationships, are described in greater detail below.

Sea level rise: A combination of accelerated melting of the icecaps driven by above average temperature increases in the polar regions and thermal expansion of the global oceans generates significant sea level rise of over half a metre by mid century. Coastal urban areas unable to afford enhanced protection are flooded with increasing regularity. Particular problems are experienced on Europe's Atlantic and North Sea coasts during the winter months, where the increased frequency and intensity of storms combine with higher sea levels to devastating effect. Some nations take this threat more seriously than others. The Netherlands spends billions on upgrading their coastal flood defenses whilst England is slower to act. In 2020, a repeat of the notorious North Sea floods of 1953 sees the Dutch population largely spared, although thousands perish in south east England.

Drought: Reduced precipitation due to climate change combines with population growth and increased water abstraction (particularly for tourism and agricultural industries) to create droughts that grip large parts of the Mediterranean region with increasing regularity. Associated impacts include forest fires, soil erosion and saltwater intrusion into coastal aquifers. South east and central Spain, south east Italy and south east Greece are especially badly affected. The Guadalquivir river basin in Spain experiences regular low flows. Post 2015, the residents of Seville suffer severe water shortages during most summers, leading to significant out-migration from the urban core. However, those with the ability to pay for water supplies live more comfortably in well irrigated suburban 'green enclaves'. Limited uptake of water efficiency devices, an unwillingness to impose

comprehensive water pricing, and slow technological progress in the water sector compound these problems. The number of people living in water stressed river basins therefore steadily grows. Impacts of reduced precipitation due to climate change will also lead to a higher disparity between Western and Eastern Europe. In Eastern parts of Europe, where central climate conditions with dry summers, and soil conditions that offer low water storage capacity occur at the same, likewise desertification and extreme yield reduction will take place. Agricultural land use will be abandoned in such areas. Remote areas will depopulate rapidly.

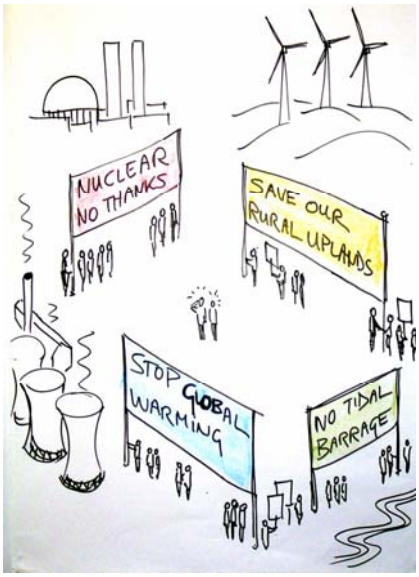
Flooding: More frequent and severe flooding is driven by a changing climate. Also, spatial planning policy frameworks are generally weak due to the strong influence of free market political ideologies. This leads to accelerated development in floodplains and limited implementation of measures to reduce vulnerability and increase resilience of new development to flooding. The numbers of people at risk of flooding increases, and the social, economic and environmental impacts of floods escalate when they do occur. Central Europe and the Black Sea region, badly hit by floods in 2002, are flooded again in 2009 and 2010. Prague is shattered and its burgeoning tourist industry suffers a devastating blow. Local scale flash flooding in urban areas is commonplace. This is caused by increasingly intense rain storms that overwhelm inadequate and outdated drainage systems. Insurance companies are reluctant to offer cover in areas at high risk of flooding, creating urban 'flood ghettos'. As population growth remains high, many people on lower incomes are nevertheless forced to look for housing in these marginalized areas.

Implications for peri-urban land use relationships:
An acceleration in the frequency and intensity of water crisis across Europe drives a range of broad changes to peri-urban land use relationships. The most significant of these include:

- Areas that experience limitations in available water supplies and regular flooding become marginalized in favor of more resilient and less vulnerable locations. Pockets of growth and decline emerge.
- Affluent yet vulnerable cities and regions, including London, Madrid and the Randstad, spend huge sums of money implementing adaptation strategies in an attempt to ensure their future growth and prosperity.
- Steady population growth, much of which stems from immigration from beyond Europe's borders, pressurizes urban infrastructure and services. This occurs particularly in areas marginalized by more frequent water crises, increasing the number of people at threat.
- Extreme summer heat and drought in the Mediterranean basin hits the tourism industry hard. Related businesses suffer leading to urban decay. At the same time, reduced water supplies for irrigation constrain the regions agricultural industry leading to widespread land abandonment. The Baltic States and Scandinavia benefit from these changes.

(B1) 'Peak oil' world

A globalized government–focused society: with an energy price shock, leading to rapidly increasing energy and transport costs, with consequent changes in mobility, trade flows and urban development.



(SRES text)
"The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

Implications for PLUREL

- Overall population peaks and then declines;
- Economic growth is lower, with GDP at 2.25% growth;
- Urbanization is at a medium rate of growth: peri-urban and rural population growth is relatively very low
- Generally, there is a technological optimism and strong policy platform, so that the pressures coming from the peak oil shock, and its economic and social effects, can be managed.
- Generally, the policy agenda is focused on globalized and networked forms of 'sustainable communities' in urban & rural situations;

Transitions / shock agenda:

This shock agenda is a quite standard item in many scenario studies. But rather than a 'what if' question, this scenario is looking increasingly probable at the time of writing (June 2008), with oil prices at $140 per barrel, an increase of nearly 10 times over 5 years.

- There is an energy crisis on a scale of the 1970s crisis, which generates an accelerated push into alternative forms of energy;
- The economic effect is to depress economic growth, and particularly material consumption and mobility;
- With a global governance perspective, there is a strong policy response on climate change, so that the whole of the carbon cycle becomes an issue at local, regional, national and world levels.

Implications for peri-urban development

There are many implications for peri-urban land use and development:

- increased public transport and demand management programmes, will tend to concentrate development and population in larger centres.
- Reduced use of private cars will rapidly affect new road development, with effects on the spatial distribution of employment and services;
- Increased costs of freight transport will change supply chains and logistics, particularly for for bulk products from agriculture, forestry and minerals;
- Farming and the food sector is also strongly affected, being heavily oil-dependent: there is a rapid conversion into more extensive, low impact and local forms of cultivation.
- Tourism and leisure are also heavily car dependent, and the changing of pattern has serious effects on many rural economies.
- Pressure for alternative energy sources, and consequent demands on land use: biomass or biofuel crops: wind, water, bio-gas or solar;
- In spite of stronger climate change policies, there would also be pressure for conventional energy developments, such as coal mining or secondary fossil fuels.

Storyline for 'Peak Oil'

(CEMAGREF / BB)

SRES reference storyline:

The B1 SRES scenario describes a future world where there is a high level of environmental and social consciousness combined with a globally coherent approach to a more sustainable development. In the B1 storyline, governments, businesses, media and households pay increased attention to the environmental and social aspects of development. Economic development in B1 is balanced, and investments are oriented to improved efficiency of resources uses ("dematerialization"), social equity and environmental protection. A particular effort is devoted to increases in resource efficiency through incentive systems, combined with advances in international institutions, which allow to rapid development of cleaner technology.

Context

High environmental and social concerns lead local, regional, national and international institutions to strengthen incentive policies for reducing environmental impacts of polluting activities. Pollutants are strongly taxed in order to orient the demand on cleaner products. The fiscal resources (from taxation, sale of tradable permits ...) are then used for RTD policies and others public expenditures, such as development of public transports. R&D incentives are used to accelerate the development and the cost efficiency of resource saving technologies. Taxation on "carbon energy" and high cost of cleaner technologies lead to a high final energy cost, reinforced by the past consumption patterns which are not balanced by increases in oil supply. So, household expenditures are progressively oriented toward low energy intensive consumptions.

Consequences

High energy price affects consumer's choices that spend more income on services than on manufactured goods through substitution effects. In short term, economic growth is also reduced by downward income effects. High transportation cost reduces trade between regions (locally and internationally) and affects the household's localization choice: They prefer living closer from economic centers; rural areas are abandoned in favor of urban and peri-urban areas with well developed public transports. Taxation receipts are used by governments and public institutions:

- to promote public transports infrastructures,
- to develop energy saving technologies,
- to invest in education, research and health system,

- to reduce social inequalities by income redistributions.

In this context of high transportation costs, economic activity will be more affected in countries with strong dependency on imports and exports, and in sprawled regions where households and producers transportation costs are higher than in concentrated areas. But, the negative sides have some positive counterparts; in a longer term horizon, the incentives for reducing the "carbon energy" allow promoting the development of locally produced 'environment friendly goods', intensive in employment; its then partially counterbalance the initial negative impacts of final energy prices rise on final consumption and employment.

Implications for peri-urban land use relationships

The high level of energy prices leads to huge effects on choices of localization for both production and consumption. Thus very local markets are promoted for goods that are environmental friendly. Indeed these latter goods allow to minimize both transportation costs and environmental impacts what is demanded by consumers whom environmental consciousness is especially high. For example organic goods are produced by farms located near from peri-urban areas and economic centers, where the population is now living. Concerns about environmental impact of international migration and transportation, implies strict regulations and low levels of migration. There is pollution, high oil prices, concern and uncertainty about the future, therefore fertility is depressed.

Indeed the household's localization is also rather different because of transportation cost: households live now closer from their offices and jobs localization. Thus population is concentrated near cities what minimizes his spending for transportation. Of course only important public transportation networks can allow this.

Therefore rural areas are rather abandoned by population in favor of urban and peri-urban areas. For the other areas located very far from centers, there is a real risk (or opportunity for nature) to get "economic deserts" which can become areas for biodiversity and protected natural environment (Forest, Natura 2000, etc.). These wide open spaces sparsely populated and protected on its fauna and flora are very favorable to the creation of new recreational areas. Besides it allows for large areas with fast growing bio-mass to capture CO2 emissions and other pollutants. Therefore there are very new economic destinations for these areas.

(B2) - 'Fragmentation' world

A localized / regionalized public sector dynamic: increased localization of communities, but with problems of social division and exclusion between social and economic groups: natives and migrants, wealthy and poor: with further effects on peri-urban development.

(SRES text)

"*The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.*

Implications for PLUREL:

- Overall population change is medium growth;
- Fertility, mortality and migration are all at medium levels;
- Economic development is low with GDP at 2.25% growth.
- Urbanization is at a medium rate of growth: peri-urban and rural population growth is also medium.
- Generally there is a focus on the dynamics of local and regional 'sustainable communities' in urban & rural situations.
- There are divergences and competition between communities and regions, accelerated by more localized forms of governance and economic activity.

Transition / shock agenda:

This scenario type is often referred to in the 'sustainability' corner, with the aspiration of living more localized and low impact lifestyles, in harmony with families and neighbours. However here is introduced a quite plausible transition (more than a shock) agenda. The effect of localized communities may be to enhance social divisions and exclusion of marginalized groups. The demographic ageing effect may be to reinforce the fragmentation of older and younger residents, of incoming or native dwellers. The effect may be not only social and cultural, but also physical, as social groups retreat into green enclaves, gated communities, behind security barriers. This also has an economic effect of depressing trade, competitiveness and innovation. On the plus side, there is a resurgence of local democracy, collective responsibility and social enterprise activity.

Implications for peri-urban development

- The already fragmented peri-urban landscape becomes further segmented into particular social groups, ethnic or religious groups.

- In such isolation, fundamentalism increases and so does the distrust between each group. Although much of the land area is public, and used for local food production, there are complex rules on access and land use.
- There are 'green enclaves' of apparently high quality communities and settlements, but exisiting only behind security gates and fences.
- Due to the general slow-down, some more remote rural areas become depopulated and in some cases almost empty, as the demographic structure filters out younger people.

Storyline for 'fragmentation'

(IIASA / VS)

In this scenario Europe experiences growing social friction due to increasingly fragmented societies in terms of age, ethnicity and lack of international cooperation. The voter-strong elderly population implies a greater level of intergenerational transfers. However, the working-age population is increasingly disinclined to transfer resources to the elderly; they argue that they will need to save for their own retirement while parts of their pay-as-you-go pension schemes are simultaneously phased out, providing fewer benefits for them. Moreover, the elderly are seen to be healthier than ever, but unwilling to accept the jobs offered to them, causing intergenerational conflicts to increase in magnitude.

Relatively large migrant populations with different sets of values, cultures and religious beliefs have limited social contact with native populations. This leads to increased social fragmentation, mutual distrust and limited willingness to support individuals outside of one's own group. Political voting shifts, due to a decreased willingness to pay for other residents in one's own country, result in a shrinking welfare state. The situation is worsened by increasing problems of tax evasion. Cities are particularly challenged as they are characterized by older native populations and younger migrant populations – which reduce the ability for joint political action.

Cohesion is becoming more of a challenge on the international scale across the European Union. Large structural adjustment programs, which were meant to decrease inequality within the EU, lose support. Member states increasingly prefer to focus on solving their own issues.
The effect of less centralized governing increases the difficulties in sharing the burden of international mitigative efforts to reduce environmental challenges, including costly policies to reduce climate change and for more sustainable resource extraction. For example, mutual distrust implies that fewer are willing to share the burden of reducing greenhouse gas emission reductions. This leads to less effective international joint efforts to mitigate climate change. Other joint challenges faced by the EU become less feasible, as member states meet the demands to share reliable data on sensitive issues, such as resource use and pollution levels, with increased suspicion. Overall, trust between states is low, leading to common agreements not being reached – or not being followed.

Cities are more dispersed as younger migrant populations dominate city centers and older natives populate outskirts and green enclaves outside the cities. The ethnic division of cities is driven by the increased in-migration of the working-age population from outside and within the EU. The elderly in ethnically diverse cities are more likely to migrate to rural areas and form relatively closed communities. A change in migration patterns is expected in the future when the working-age migrant population grows older, and the current elderly population becomes more vulnerable and seeks family support from their in-town offspring. High growth in the social sector demand for the care of the elderly is being paid by the working-age population, diminishing their ability to care for their dependants. This in turn increases demand for childcare from the early ages onward. Self-reliance and preservation of local identities is the rule of conduct. Rural centers concentrate on sustainable farming and adequate social support for their population structure. Specialized care is sought in towns.

Economic growth differentials are large among areas and different states alike. The population growing up is more likely to engage in livelihoods and social environments close to their origins. Economic development levels do not converge.

4. Summary tables

Role of the summary tables

These summary tables are the main method of comparing between scenarios, and ensuring consistency within the scenario.

The first table shows core factors from SRES and the PLUREL agenda, together with the transition / shock agendas, as developed in the Vienna workshop. From this, the top 5-6 factors need to be selected, for presentation in the 'radar' diagrams which will sum up the scenarios.
The following tables are a first outline, which may be improved through the rest of the Plurel. They show:

- Core variables in each theme, which are likely to be quantified, and if possible modeled.
- *Other variables which are more likely to be **qualitative** or less easy to quantify (in italics)*

More detailed work in each WP would aim to summarize:

- The application of each scenario to the model variables and model structure in each WP (note this can be a software model or conceptual model)
- Model inputs and outputs
- Exogenous variables..... (background context)
- Endogenous variables.... (Policy & actor responses)
- The more qualitative & fuzzy variables, which can be linked to stakeholder analysis.

Beyond that is the applications which are envisaged through the rest of the project:

- Application to the peri-urban 'typologies' in M2
- Application to the case studies typologies in M3.
- Application to the integrated framework & impact assessment in M4
- Application to the SIAT-RUR simulations in M5.

Summary of scenario variables

	A1	A2	B1	B2
MAIN TITLE	**'hyper-tech' world**	**'extreme water' world**	**'peak oil' world**	**'fragmentation' world**
SRES family	faster growth, converging	faster growth, diverging	energy / env. sustainability, converging	local solutions, diverging
CORE VARIABLES	globalizing, privatized	localized, privatized	globalized, governmental	localized, governmental
EU population growth – 70 percentile of CPF	Med-High70	Medium 50	Low 30	Medium 50
fertility	medium	medium	low	medium
mortality	low	medium	high	medium
migration (international)	medium	medium	low	medium
GDP growth (EU 27)	high: 3.4%	high: 3.2%	low 2.25%	low 2.25%
TRANSITIONS / SHOCKS				
	'hyper-tech world' - rapid technology growth – ICT, bio / nano-tech, global-mobility.	'extreme water' - floods, storms, droughts, sea-level rise, related events.	'peak oil world' - , energy crisis, landuse effects, & strong climate policy response	'fragmentation' - demographic ageing & migration leading to social exclusion, & recession
SPATIAL VARIABLES				
urban population growth (average)	low	high	medium	medium
peri-urban / rural population growth	high	low	very low	medium
rural – urban migration	rural society	urban	urban	peri-urban
general urbanization trend	counter-urbanization	sub-urbanization	compact city urbanization	peri-urbanization
QUALITATIVE VARIABLES				
(From workshop notes)	Fast Development changes Unity in EU Low urbanization & weak planning	High urbanization Disintegrated & multi-functional growth	Sustainable EU Cleaner affluence Technological optimism	Regional competition Green enclaves Diverging solutions Empty regions

Summary table – economic variables

SRES family.	A1 – type	A2 - type	B1 - type	B2 - type
	'hyper-tech' world	'extreme water' world	'peak oil' world	'fragmentation' world
ECONOMIC DRIVERS (generally refers to EU member state weighted average).	**globalizing / privatizing**	**localizing / privatizing**	**globalizing / collectivizing**	**localizing / collectivizing**
Population growth	Medium-High	Low	Medium	Medium
Oil price	medium	Medium	high	lower
economic world growth	High	Low	low	Medium
R&D expenditure	High	low	medium	Medium
ECONOMIC VARIABLES				
Economic growth	High	Medium	High	Medium
Income per capita convergence	High	Medium	High	Medium
Employment	High-medium	Medium	High	Low
Agriculture production	Medium	Medium	Low	High
Industrial production	High-Medium	Medium	Medium	Medium
Services production	High	Medium	High	Medium
Trade growth	High-medium	Medium	Medium	Low
External balance	High	High	High	Low
LAND-ECONOMY VARIABLES				
Agricultural Land-Use growth	Medium	Medium	Low	High
Forestry Land-Use growth	Medium	Medium	High	Low
Urban Land-Use growth	High	Medium	Medium	Low
Nature conservation land-use	Low	Medium	High	High

Summary table – social / demographic variables

SRES family.	A1 – type 'hyper-tech' world	A2 - type 'extreme water' world	B1 - type 'peak oil' world	B2 - type 'fragmentation' world
	globalizing / privatizing	**localizing / privatizing**	**globalizing / collectivizing**	**localizing / collectivizing**
SOCIAL VARIABLES **(generally refers to EU member state weighted average)**.				
net population growth (relative to BAU trend)	Medium-High	Low	Medium	Medium
fertility rates	Medium	medium	low	medium
mortality rates	low	medium	high	medium
in / net migration into EU	medium	medium	low	medium
demographic age structure (model output)	*older*	*younger*	*medium*	*older*
rural – urban migration	rural society	urban	urban	peri-urban
general urbanization trend	counter-urbanization	sub-urbanization	compact city urbanization	peri-urbanization
OTHER VARIABLES *(note these are for further discussion)*				
household formation				
public & community services				
social exclusion / inclusion	medium	medium	lower	high
ethnic & cultural patterns				
wealth & occupational structure				
well being & quality of life???				
gender & employment???				

Summary table – environmental variables

SRES family.	A1 – type	A2 - type	B1 - type	B2 - type
note: growth refers generally to period 2020-2050	'hyper-tech' world	'extreme water' world	'peak oil' world	'fragmentation' world
	globalizing / privatizing	localizing / privatizing	globalizing / collectivizing	localizing / collectivizing
climate change: CO2 eq emissions (summary of SRES variables)	0.9%	1.4%	0.5%	0.7%
climate change: temperature rise, drought, extreme events	high	high	medium	medium low
environmental driving force: energy prices	low	high	medium	high
environmental infrastructure; peri-urban land % for water, waste, energy	medium	high	medium	high
environmental functions: organic / stewardship agricultural area%	medium	low	high	high
environmental quality: air, water, soil, biodiversity	medium	low	medium	high
environmental spatial policy: protected / ecological land area %:	low	medium	high	high
OTHER VARIABLES				
environmental 'resilience' of eco-systems to pressures	*medium*	*low*	*high*	*medium*
environmental values on the supply side: business environmental management	*medium*	*low*	*high*	*medium*
environmental values on the demand side: low-impact lifestyles & consumption choices	*medium*	*low*	*medium*	*high*

Summary table – technology & infrastructure variables

SRES family.	A1 – type	A2 - type	B1 - type	B2 - type
note: growth refers generally to period 2020-2050	'hyper-tech' world	'extreme water' world	'peak oil' world	'fragmentation' world
	globalizing / privatizing	localizing / privatizing	globalizing / collectivizing	localizing / collectivizing
commuting distance	high	medium	low	medium-high
teleworking levels	medium	medium	high	medium
transport network density	high	medium	high	low
General urbanization trend	counter-urbanization	sub-urbanization	compact city urbanization	peri-urbanization
urban population density / land intensity	low	medium	high	low
built environment / floorspace intensity	medium	high	medium	low
building energy / carbon intensity	low	high	low	low
transport growth (km / cap)	medium-low	high	low	low-medium
transport energy / carbon intensity)	medium	medium	low	low
Mobility (transport intensit ((goods+ individuals)/ GDP)	high	high	medium	low
urban infrastructure investment	medium	high	high	low
agriculture energy / carbon intensity	medium	high	low	low
agriculture land intensity (N-surplus kg/ha)	medium	high	low	low
Resource use productivity (GDP/ non-renewable resource consumption)?	low	medium-high	low	low
Innovation drivers[1] (educational level)	high	medium	high	medium
Knowledge creation[1] (R&D expenditures)	high	high	high	low
Innovation & entreprenneurship[1] (SME)	medium	high	medium	high
Application[1] (sales, employment innovation markets)	high	medium	high	low
Intellectual property[1] (patents trademarks)	high	medium	medium	low

[1] European Innovation Scoreboard 2005: European Trend Chart on Innovation
http://trendchart.cordis.europa.eu/scoreboards/scoreboard2005/pdf/EIS%202005%20Methodology%20Report.pdf

Summary table – spatial development & policy

Note: this is only an outline of possible issues at this stage. The aim is that this will be developed by Module 2.

SRES family.	A1 – type 'hyper-tech' world	A2 - type 'extreme water' world	B1 - type 'peak oil' world	B2 - type 'fragmentation' world
SPATIAL MODEL FACTORS (M2/ M4)				
Accessibility -affected by innovation in the transport network and ICT (teleworking) leading to reduced commuting times	Very high Due to high rates of technological innovation	Medium Due to local, but fragmented investment	Low Due to high fuel costs and environmental concerns	Medium to Low Due to environmental concerns and social fragmentation
Location preference – for urban services or for rural green spaces	Services and some green space	Services	Green space and some services	Green space
Planning policy – the aim of reducing urban sprawl and restricting urban development in flood risk and environmental protection zones	No intervention Market led	Low intervention Economically-orientated	Moderate intervention Environmental concerns	High intervention Environmental concerns
OTHER SPATIAL VARIABLES (M2/ M4)				
urban / rural land price & economic intensity				
spatial policy priority – regulatory / fiscal				
urbanization / rural function gradient				
urbanization / rural multi-functional pattern factors				
transport / communications network accessibility factor				
transport network distance / mobility factor				

4. Scenario cascade

(this section is an update of the initial framework report of Feb 2007, CURE)

Scope & purpose of the cascade

Each part of the PLUREL project will be producing 'futures' information in some way or other. As it is a large and complex project, there is a clear need to organize such a large body of information in a practical 'scenario framework'. This should help to organize a large number of possible variables into a common structure, which also helps to organize the modeling and data analysis.
The proposed scenario framework is in the form of a 'cascade' with 4 levels, from general to specific. These match approximately to Modules 1-4.

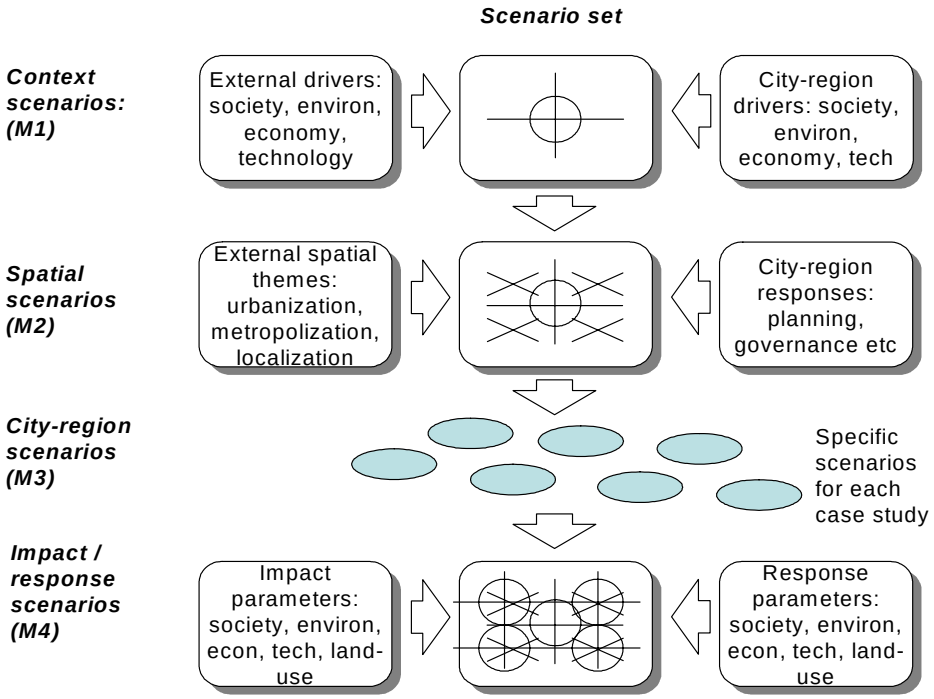
This concept has been drawn from other sources: EEA, Environment Agency UK etc.
It has now been fitted to the particular needs and structure of PLUREL.
Note that these 'scenarios' are not predictions or accurate models of future states. They are 'what-if' investigations, as a kind of tool to be used in the research process. They can help to test possibilities, relationships, sensitivities, responses etc.

Outline of scenario framework

In summary, the framework includes a scenario set which is relevant to each of the Modules 1-4:

- ***Context scenarios:*** ('driving forces'), mainly in Module 1. These are focused on global / external conditions and driving forces, together with social, economic, environmental and technological influences on peri-urban land use.
- ***Spatial scenarios***: ('pressures') mainly in Module 2. These are focused on alternative possibilities in spatial development, urbanization, regional development etc.
- ***City-regional scenarios***: ('state'), mainly in Module 3. This introduces the case study perspective and its typology, and for each city-region 'type' there will be a range of alternative futures which is particularly relevant and significant in that location.
- ***Impact & response scenarios***: ('impact'), mainly in Module 4. This focuses on the impact assessment tools, and the range of possibilities in impact / responses functions, such as environmental valuation, social vulnerability etc.

Scenario framework



Context scenarios (M1)

These involve both 'external' and 'internal' drivers of change acting on landuse in the urban region. The scope of these drivers are likely to include many contextual issues beyond the scope of the technical tasks in the WPs in Module 1:

- Economy: growth, trade, investment, restructuring, incomes, employment etc.
- Social: demographics, restructuring, cultures, behaviour, household, media, lifestyles, etc
- Environmental: climate change, policy, urban infrastructure, land-based sectors.
- Technological: infrastructure, manufacturing, science / innovation

The development of this scheme is shown in Sections 1 and 2 of this report.

Spatial scenarios (M2)

The above framework can then be applied to the spatial growth and policy agenda of Module 2. This is generally a theme which is much less studied, and reference should be made to the scenario structure in parallel projects: MOland, Molusc, MOSUS, Sensor, Prelude etc.

- Urban growth - basic issues of household size, dwelling size, urban gravity fields etc.
- Urban spatial patterning – growth, perforation, agglomeration, counter-urbanization, re-urbanization etc.
- Urban 'metropolization' – socio-economic patterns of agglomeration, poly-centric development, rural restructuring, behavioural change.

- Urban development governance – spatial planning, urban regeneration, local –regional government, public services, public infrastructure etc.

City-region type scenarios (M3)

This introduces the case study perspective, and looks at the application of the context / spatial scenarios in each city-region type, as represented by the case studies.
In practical terms, for each city-region 'type' there will be a range of alternative scenarios which is particularly relevant and significant in that location.
These scenarios would take in the general development trajectories in each location, but with a focus on land-use relationships:

- Land-use patterns – spatial connectivity, contiguity etc
- Land-use cover –functions, services, values

Impact & response scenarios: (M4)

This aims towards the impact assessment / systems analysis tools in Module 4. It focuses on the range of possibilities in agent behaviour: and in impact / responses functions, such as environmental valuation, social vulnerability etc.

- For instance, a cost-benefit approach to policy impact should use a range of shadow values, rather than a single value, and this range can then be combined with other ranges.
- Likewise, the social impact may depend on responses to vulnerability, or adaptive capacity, and a range of possibilities can also be combined into an impact / response 'scenario'.
- Agent based modelling (ABM) clearly needs to follow a scenario framework, in order to set the priorities of agent relationships (e.g. profit motives over social motives etc).

SIAT scenarios: (M5)

We anticipate that the SIAT can be organized around this kind of scenario framework, although it is too soon to define the contents. We might aim to design a SIAT which could provide feedback on scenarios on each of the 4 levels, and then enable the user to input her/his specific questions or experiences:

- Context scenarios
- Spatial scenarios
- City-region scenarios
- Impact / response scenarios
- Specific 'what-if' questions

This design challenge can be visited again when the main scenario framework is in place.

Scenario cascade method

The result of this scenario 'cascade' should be a flexible framework, which is 'loose coupled', to enable constructive exploration, modeling and analysis of a wide range of issues.
However: if we take 4 'context' scenarios, multiply by 4 'spatial' scenarios, with 7 'city-region' scenarios, and 4 'impact' scenarios, then there would be over 100 different combinations, which is not very practical.

A more useful approach is the cascade principle, which focuses on what is most significant and relevant at each level. So within one context scenario, and one spatial development scenario, there might be one or two city-region scenarios which are most interesting in each of the case studies: the impacts of this can then be tested with a range of impact / response functions. These most 'significant and relevant' scenarios can then be explored and modelled in greater detail.

5. Annex

Scenario types & applications

Working Definition

(NG)

Scenarios, while much-used in many contexts, can mean different things to different people. A dictionary definition for 'scenario' is 'a postulated sequence of events.' It is our opinion that the definition proposed by Royal Dutch / Shell, which reflects the dictionary definition, should be used as the PLUREL working concept.

> *"A scenario is a story that describes a possible future. It identifies some significant events, the main actors and their motivations, and it conveys how the world functions. Building and using scenarios can help people explore what the future might look like and the likely challenges of living in it.*
>
> *Decision makers can use scenarios to think about the uncertain aspects of the future that most worry them—or to discover the aspects about which they should be concerned—and to explore the ways in which these might unfold. Because there is no single answer to such enquiries, scenario builders create sets of scenarios. These scenarios all address the same important questions and all include those aspects of the future that are likely to persist (that is, the predetermined elements), but each one describes a different way in which the uncertain aspects of the future could play out.*
>
> *Scenarios are based on intuition, but crafted as analytical structures. They are written as stories that make potential futures seem vivid and compelling. They do not provide a consensus view of the future, nor are they predictions: they may describe a context and how it may change, but they do not describe the implications of the scenarios for potential users nor dictate how they must respond.*
>
> *The use of images can help to make scenarios more comprehensible. Some aspects of scenarios may be described with numbers for use in the quantitative analysis of policies and strategy, but the richness of scenarios as a strategic tool stems partly from the fact that they can include more intangible aspects of the future.*
>
> *Scenarios are intended to form a basis for strategic conversation—they are a method for considering potential implications of and possible responses to different events. They provide their users with a common language and concepts for thinking and talking about current events, and a shared basis for exploring future uncertainties and making more successful decisions.*

Application to PLUREL

The Shell 'text-book' definition is a useful reference point, particularly for high-level long term scenarios. More recent experience, such as the UK Foresight programme, focuses on more on the application of scenarios to strategy, evaluation and learning of organizations and networks.

Experience from the European Environment Agency shows the 'storyline – simulation' combined approach.
A project such as PLUREL is concerned with future studies in many ways, and it is important to develop scenarios in the best possible way. So these are some questions:

- How to generate scenarios which are relevant and significant to all parts of the project?
- How to develop a 'scenario framework' which helps to link the work of one module to another module?
- How to make this useful, both for quantitative modeling, and for qualitative mapping / storylines?
- Do we need to define 'high-level' scenarios with fixed links to detailed scenarios?

The next section contains a concept for a scenario framework which responds to these questions.

Background to scenario methods

NOTE: This section reviews the general background of scenario development and application (based on the CURE report to the UK Environment Agency, 2003): and the Strategic Futures Team: *'A Futurists Toolbox'* London, Strategy Unit, (formerly Performance & Innovation Unit) (www.strategy.gov.uk)

The term 'scenarios' is now widely used to cover a range of future-based assessment methods and tools. Scenario methods, as developed and used to underpin strategic intelligence, are based on both a formal technical foundation, and a large body of experience over the last 30 years.[1]

Until 1970, futures work and planning were based mainly on traditional extrapolative methods, i.e. extrapolating from past trends into the future. But with the onset of significant social changes and the growing speed of change, futures methods have had to adapt, and new techniques were developed. Scenario methods became one of these techniques. They were first used by the RAND Corporation, and later by Royal Dutch Shell and other multinational companies. Scenario methods and processes are now one of the most frequently used futures methods. Scenarios can be defined as:

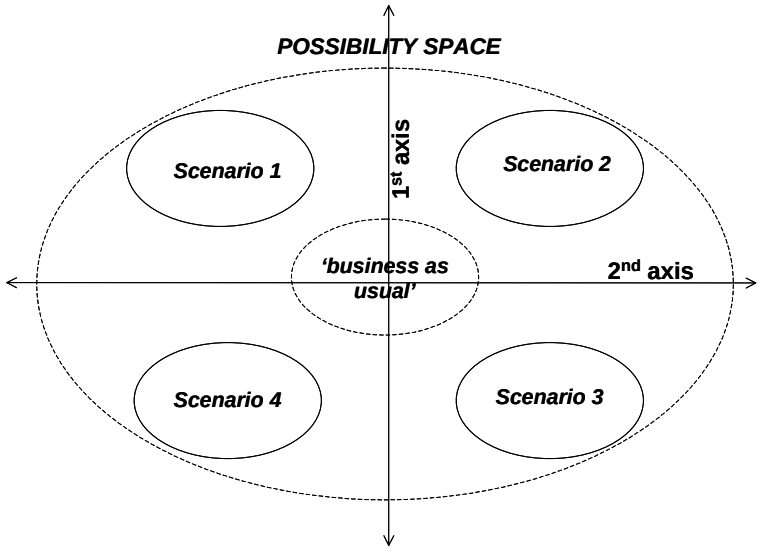
- "internal coherent descriptions of alternative images of the future",
- "holistic, integrated images of how the future may evolve",
- Or most simply, "histories of the future".

There are two key elements of the scenario method. Firstly, they are not predictions of the future. The aim is not to foresee the future, but to show how different interpretations of the driving forces of change can lead to different possible futures. Secondly, scenarios are aimed to make better decisions in the present about issues that have long-term consequences for the future.

A variety of different scenarios are usually prepared in order to emphasise the possibility of different alternative futures. By setting up several axes of change (e.g. high/low economic growth), and scenario variations for each of these combinations, a "possibility space" is created. It is somewhere within this "possibility space" that the future is likely to unfold, as in Fig.1 below.

[1] General guidance and source material, as listed in the Appendix, would include: Ringland 2002: Strategy Unit 2001: May 1996: EEA 2001: Goodwin 1998: Schoemaker 1990: Local Government Association 2000.

Scenarios and the future 'possibility space'



Scenario benefits and drawbacks

Scenario methods can provide a wide range of benefits:

- Strategy evaluation or checklist against general planning. Is there something we might have forgotten?
- Way of sparking debate – internal or external to the organisation. It is important to clarify the purposes and assumptions behind the scenarios.
- A tool to create a general consensus. This may be useful when an organization wants to start an internal discussion which could lead to a reformulation of strategy.
- A 'backcasting' tool which starts with a preferred future and outlines scenarios from the future back to the present. Combining the two, it is possible to choose an optimal scenario in terms of its desirability and probability. On the basis of such a "focus scenario", a more detailed strategy can be drawn up.
- The explorative scenario method is the most commonly used method. It is typically used as an "early warning" tool aimed at pinpointing *if* and *when* specific policies or overall strategies need to be changed.

On the other hand, scenario methods may have some disadvantages:

- It can be difficult to translate the outcome of a scenario process into concrete decisions.
- The method is based, for the most part, on qualitative information which, by its very nature, is imprecise.
- The method draws up a "possibility space" giving the decision-maker a choice of futures. Decision-makers who are used to a solid piece of advice or direction will not always appreciate this.

Context: scenarios in public policy

In the corporate sector scenarios are an essential tool of the trade. Routine business decisions are based on 'what-if' calculations of probability and risk, while long range corporate strategies can be based on a wider future 'possibility space'. For both of these the objectives generally converge towards a single point, i.e. benefits or risks to the bottom line.

However in the public and civil sectors, corporate objective are often complex, multi-layered and subject to public and political influence. This makes it more challenging but more essential to use scenarios as a tool for corporate management.

Most organizations or research programmes have some kind of futures activity, in forecasting, strategic planning, risk management, policy evaluation, impact assessment and so on. However this is often quite adhoc and not formalized or coordinated.

Scenario types & applications

Each of the above themes and functions covers very different kinds of systems, each with its own drivers of change. For instance, the future prospects and driving forces on water quality issues, might be quite different to those for water resources issues. From the review of the Agency's functions, different types of scenarios begin to emerge:

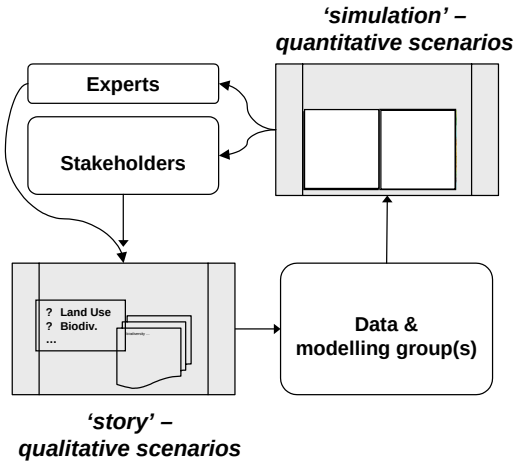
- General socio-economic trend based: as in UK Foresight 'Environmental Futures' and the UKCIP 'socio-economic' scenarios
- Engineering-based: as in water resources strategy, where a quantitative model is built on a socio-economic scenario structure.
- Policy / regulatory based: where the 'endogenous' factors as in land use / land quality
- Systems based: relating to more complex problems, where quantitative modelling cannot provide the whole of the solution: e.g. as in energy / emissions scenarios.

Some of the above can be explained also from the perspective of defining the type of change in the system under consideration.

- Quantitative and predictable change (based on relatively well-known trends and driving forces, for deterministic forecasts): e.g. population projections:
- Quantitative & volatile change (based on relatively volatile and complex trends and driving forces): e.g. information technology. These are risk-based (stochastic) forecasts based on estimates of variability and quantifiable uncertainty.
- Qualitative & volatile change (less straightforward to measure or even identify): e.g. consumer culture, media and lifestyles. These are risk-based projections where uncertainties are less easy to quantify.
- Cross-linkages and other more complex effects: e.g. climate change impact on tourism: transport policy impact on land quality. These are risk-based scenarios where uncertainties are difficult to quantify due to inherent complexity.

Combined 'story and simulation' approach

(source: EEA 2000).



These issues are captured in the combined approach of 'story and simulation' ('SAS'), promoted by the EEA. This illustrates how technical 'simulations' can be developed from data and modelling systems, reviewed by experts and stakeholders, then compared to 'stories' or narratives, and then refined in an ongoing cycle.

Scenario horizons

Time horizons: there is much variation in the definition of the effective 'horizon'. Generalizing from various scenario / future studies techniques, this might be taken for most sectors as starting at 5 years:

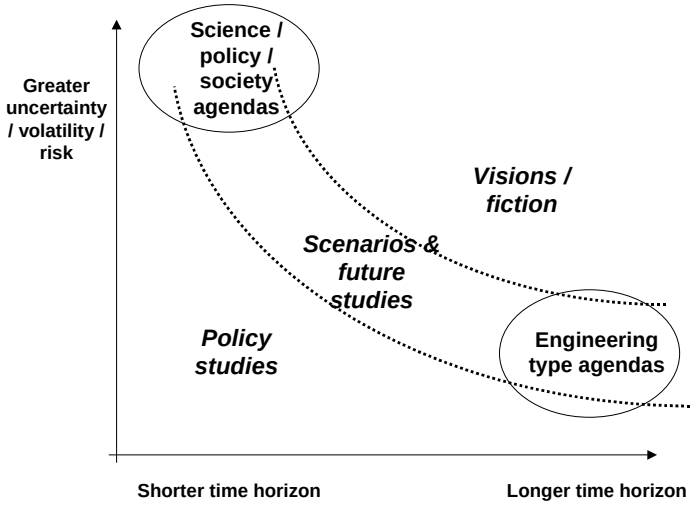
- ***Short term***: 3-5 years: the visible & practical horizon in most policy-based issues: e.g. CAP reform, chemicals policy
- ***Medium term***: 15-25 years: strategy horizon for larger infrastructure, landuse planning, population projections etc.
- ***Long term***: 20-80 years: trend projection / extrapolation based: flood defence & climate change.

Analysis of scenario scope

For a combined view on the application of scenarios to different kinds of problems, the time horizons can be combined with the organizational horizons above:

- ***Shorter term problems*** on the science – industry interface: these are often characterized by complex physical effects, split responsibilities, ethical & cultural questions, and urgency of decisions: e.g. chemicals, hazardous processes, genomics.
- ***Mixed timescale*** issues which have more complex sets of parameters: e.g. land quality, forestry & agricultural policy.
- ***Longer term problems,*** mainly on the engineering – environment interface: water resources & demand: flood & coastal defence: climate impacts:
- ***Very long term problems*** with indepth science base and risk framework: climate change, radioactive waste.
- ***Cross-cutting issues*** and methods: technology assessment: integrated appraisal: risk assessment.

Scenario horizons



The relationship of time horizon to the uncertainty and volatility of the agenda is shown in Fig.4, which illustrates a spectrum from policy (relatively defined), to scenarios (relatively uncertain), to science fiction (completely speculative).

Scenario types

Scenarios for each of these types of problems can be developed for different purposes, which can be arranged in a '4-P' structure:

- ***'Probable'*** scenarios: an extension of forecasting with an identified range of probability for a series of outcomes. These require (often extensive) data sets, including time series, and /or sound theoretical or systems understanding.
- ***'Possible'*** scenarios: widening the scope to include external influences, unforeseen surprises, feedback effects and so on. Possible scenarios can include a probabilistic description of certain outcomes, but these outcomes remain contingent on the unknown or unknowable probability associated with that scenario. (Many scientific and engineering scenarios, such as climate change and flood risk scenarios, are now extending in this direction).
- ***'Preferable'*** scenarios: identifying desired future conditions and objectives, and the criteria by which these are judged preferable, so that ways and means towards them can be found. Also titled 'inward-bound' or 'normative' scenarios, these are generally used in the 'back-casting' approach which works from the preferable scenario back to present day actions.
- '***Projected***' or '*Business-as-usual*' scenarios ('BAU'). These may be based on probabilistic or possible scenarios: BAU scenarios are often required as a reference point for determining whether a decision or policy option may perform better under one or other future scenarios. They may also be taken as a 'policy-off' or 'counter-factual' scenario for the purposes of policy evaluation.

Scenario structures

Another way to provide a formal structure for scenario drivers, inputs and outcomes, is shown in the modelling diagram below, taken from the REWARD project (Section 3.1). This is based loosely on

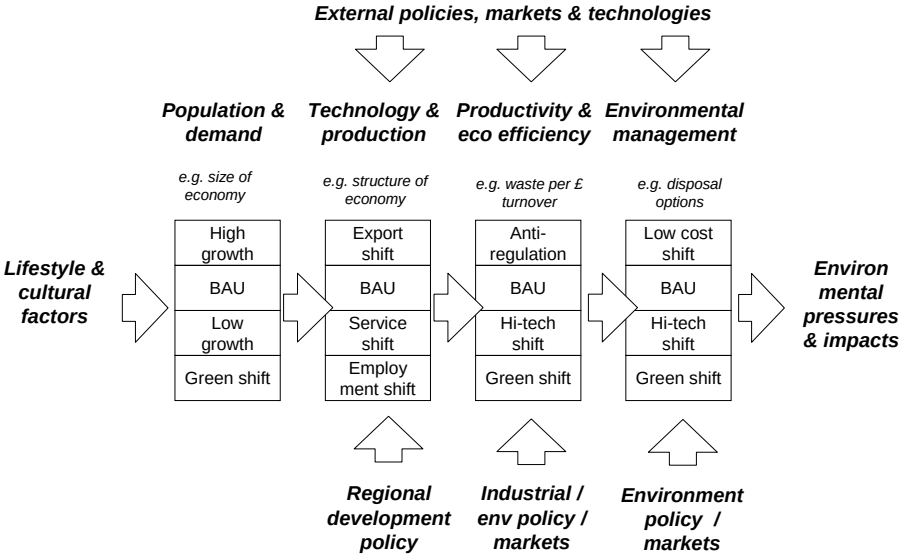
the DPSIR ('driving forces, pressure, state, impact and response') framework of the EEA. It shows the steps of the model operation broken down into four components:

- ***Population and demand***: factors which affect the overall size of the economy, labour force and consumption: regional migration, demographic factors, and household incomes / savings.
- ***Technology & production***: factors which affect the share between economic sectors, and the transactions between each of the sectors: e.g. the size of the waste management sector, and its use of transport services.
- ***Productivity and eco-efficiency***: the resource intensity or the amount of waste / emissions produced for each unit of activity in each sector: e.g. the waste from construction activity.
- ***Environmental management***: for some topics, there is further choices to be made: e.g. waste disposal / recycling methods.

For each of these components there will be a range of available settings. In the REWARD model there is the facility to input numbers with very high precision: other models might simplify things for the user by providing sliders with 'low-medium-high' settings. If the narrative method is used then these structure is just a guide to more discursive exploration. Whichever method is used, a general template of settings may be useful:

Scenario – modelling linkages

- ***High growth***: high population / economic growth, material consumption, low



environmental protection etc.

- ***BAU ('business as usual')*** – projections which extrapolate from existing trends as far as possible.
- ***Low growth***: low population / economic growth, material consumption etc.
- ***Green option***: assumes more rapid shift towards more sustainable economies, technologies, lifestyles & environmental management.

Creating scenarios

There is a large literature on scenario methods and processes.
The key point here is the difference between 'top-down' and 'bottom-up' methodologies:

- Top-down approach: starting from the perspectives of experts and decision makers, in a process which focuses on the more analytic or technical side of the scenarios.
- Bottom up approach: working with the concerns and visions of stakeholders, employees, clients or citizens, in a process which generates scenarios from lay knowledge.

Combining these approaches with the probable / preferable or outward / inward bound division above, we can chart out various combinations.

Summary of scenario creation processes

	TOP DOWN	*MIXED APPROACH*	*BOTTOM UP*
"Outward Bound" (Exploratory) Approaches	1. Analysts define "what-if" scenarios	2. Analysts heavily structure group discussion or survey instruments to focus on a few predefined exploratory scenarios	3. Experts involved in free-form exploratory scenario workshop, or provide survey responses (e.g. conventional forecast Delphi), grouped by statistical methods to yield scenarios.
Mixed Approaches	4. Analysts define scenarios based on different theories/ perspectives	5. Analysts define normative profiles, these are elaborated by experts	6. Experts grouped according to worldviews and expectations by statistical methods or discussion, and then elaborate scenarios as distinct groups.
"Inner-Directed" (Normative) Aaches	7. Analysts define normative end-state scenarios	8. Analysts define normative scenarios, experts comment on them, identify key issues.	9. Experts involved in free-form normative scenario workshop, or provide survey responses (e.g. goals Delphi): grouped by statistical methods to yield scenarios.

Source: Ian Miles, 'Scenarios and Foresight– towards a constructive integration': working paper available on http://www.altfutures.com and http://les1.man.ac.uk/cric

Applying scenarios to policy development

Traditional scenario applications were often focused on a one-off product, i.e. a set of scenarios as reference points for strategy. A more evolved view on scenario methods sees their application as a continuous operation, embedded into policy making processes at various levels throughout the organization.

- ***Early forecasting processes:*** The general aim here is to inform the early stages of strategic policy, to stimulate and challenge, provide common frameworks, encompass a wide range of issues.
- ***Later forecasting processes:*** Further down the line, more focused and structured scenarios may help to integrate and check coherence, policy integration, and facilitate internal communication of results from component studies.

- ***Strategy processes:*** This is a more specific function aimed at testing the robustness of policies / strategies under different assumptions, impacts in different contexts, to identify contingencies and policy gaps, relevant resources, etc. This has much in common with established methods of policy appraisal, risk assessment and others.
- ***Organisation & management processes:*** in the organization at large, the use of scenarios can help to promote more effective exchange of views and visions, and enable operational activity to be coordinated and placed in context. They can help to identify internal resources and scope for managing contingencies, thus engendering creativity and innovation (thinking "out of box").
- ***External communication:*** scenarios here can help to develop and communicate synthesised, illustrated views of issues and prospects for wider audience.

Overall, the application of scenario methods is simply one way to build capacity for 'strategic intelligence' – an essential component in any organization large or small.

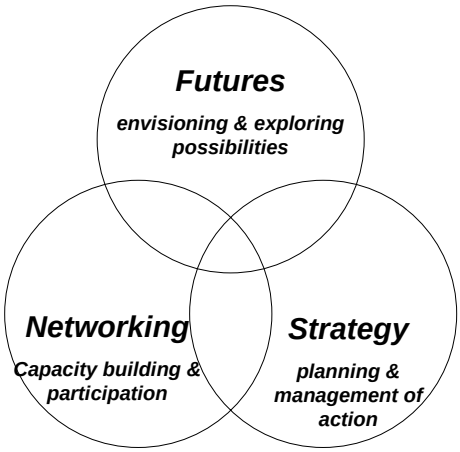
Applications to Foresight

At one end of the spectrum of applications, scenario work can be focused on specific 'stories and simulations' directed to particular questions. At the other end, scenario work can be applied in a wider context of strategic intelligence, involving a wide range of stakeholders at the corporate or regional level – this is now developed as the cluster of methods and tools known in various forms as Foresight.

Foresight is a systematic, participatory, future-intelligence and medium-to-long-term vision-building process, aimed at present-day decisions and mobilising joint actions. Generally, Foresight arises from a convergence of trends underlying recent developments in the fields of 'policy analysis', 'strategic planning' and 'future studies'. It brings together key agents of change and various sources of knowledge in order to develop strategic visions and anticipatory intelligence. Foresight contains five essential elements ***- anticipation, participation, networking, vision and action.*** It operates best at a sectoral level, regional level or corporate level, where proximity or a shared agenda provide a focus for mutual communications.

The difference between Foresight and other future studies activities relates to the participative dimension of Foresight, which is well adapted to the regional level. On the other hand, Foresight demands orientations to policymaking that may be unfamiliar to regional actors used to working within compartmentalised divisions. Foresight seeks to break down such barriers; however Foresight is only worthwhile when there is a possibility to act on the results that it will generate.

Scenarios in the Foresight approach



SRES material

Storyline summaries

Extract from the Emission Scenarios of the IPCC Special Report on Emission Scenarios (SRES)*

A1. The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technologies).

(NOTE: The SRES A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system: fossil intensive (A1FI), non fossil energy sources (A1T), or a balance across all sources (A1B). For PLUREL we assume the balanced version A1B).

A2. The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than other storylines.

B1. The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter, as in the A1 storyline, but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2. The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population, at a rate lower than A2, intermediate levels of economic development, and less rapid and more diverse technological change than in the B1 and A1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels.

SRES key variable summary tables

Scenario group	1990	A1FI	A1B	A1T	A2	B1	B2
		fossil	balanced	non-fossil			
Population (billion)	**5.3**						
2020		7.6	7.4	7.6	8.2	7.6	7.6
2050		8.7	8.7	8.7	11.3	8.7	9.3
2100		7.1	7.1	7	15.1	7	10.4
	1990-2020	**1.2%**	**1.1%**	**1.2%**	**1.5%**	**1.2%**	**1.2%**
annual growth	2020-2050	**0.5%**	**0.5%**	**0.5%**	**1.1%**	**0.5%**	**0.7%**
	2050-2100	**-0.4%**	**-0.4%**	**-0.4%**	**0.6%**	**-0.4%**	**0.2%**
World GDP (1012 1990US$/yr)	**21**						
2020		53	56	57	41	53	51
2050		164	181	187	82	136	110
2100		525	529	550	243	328	235
	1990-2020	**3.1%**	**3.3%**	**3.4%**	**2.3%**	**3.1%**	**3.0%**
annual growth	2020-2050	**3.8%**	**4.0%**	**4.0%**	**2.3%**	**3.2%**	**2.6%**
	2050-2100	**2.4%**	**2.2%**	**2.2%**	**2.2%**	**1.8%**	**1.5%**
Per capita income ratio:							
Annex 1 / nonAnnex 1	**16.1**						
2020		7.5	6.4	6.2	9.4	8.4	7.7
2050		2.8	2.8	2.8	6.6	3.6	4
2100		1.5	1.6	1.6	4.2	1.8	3
	1990-2020	**-2.5%**	**-3.0%**	**-3.1%**	**-1.8%**	**-2.1%**	**-2.4%**
annual growth	2020-2050	**-3.2%**	**-2.7%**	**-2.6%**	**-1.2%**	**-2.8%**	**-2.2%**
	2050-2100	**-1.2%**	**-1.1%**	**-1.1%**	**-0.9%**	**-1.4%**	**-0.6%**
Final energy intens (106J/US$)a	**16.7**						
2020		9.4	9.4	8.7	12.1	8.8	8.5
2050		6.3	5.5	4.8	9.5	4.5	6
2100		3	3.3	2.3	5.9	1.4	4
	1990-2020	**-1.9%**	**-1.9%**	**-2.2%**	**-1.1%**	**-2.1%**	**-2.2%**
annual growth	2020-2050	**-1.3%**	**-1.8%**	**-2.0%**	**-0.8%**	**-2.2%**	**-1.2%**
	2050-2100	**-1.5%**	**-1.0%**	**-1.5%**	**-0.9%**	**-2.3%**	**-0.8%**
Carbon dioxide, fossil fuels (GtC/yr)	**6**						
2020		11.2	12.1	10	11	10	9
2050		23.1	16	12.3	16.5	11.7	11.2
2100		30.3	13.1	4.3	28.9	5.2	13.8
	1990-2020	**2.1%**	**2.4%**	**1.7%**	**2.0%**	**1.7%**	**1.4%**

annual growth	2020-2050	**2.4%**	**0.9%**	**0.7%**	**1.4%**	**0.5%**	**0.7%**
	2050-2100	**0.5%**	**-0.4%**	**-2.1%**	**1.1%**	**-1.6%**	**0.4%**
Carbon dioxide, land use (GtC/yr)	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**
2020		1.5	0.5	0.3	1.2	0.6	0
2050		0.8	0.4	0	0.9	-0.4	-0.2
2100		-2.1	0.4	0	0.2	-1	-0.5
	1990-2020	*1.0%*	*-2.6%*	*-4.2%*	*0.3%*	*-2.0%*	*-100.0%*
annual growth	2020-2050	*-2.1%*	*-0.7%*	*-100.0%*	*-1.0%*		
	2050-2100		*0.0%*		*-3.0%*	*1.8%*	*1.8%*

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