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REVIEW OF SOCIO-ECONOMIC SCENARIO FRAMEWORKS AND LAND USE SCENARIOS IN EUROPE

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Abstract

This review provides a summary of the main frameworks used to develop global or European-scale socio-economic scenarios, including the IPCC SRES. Following from this a review of the main studies delivering large-scale quantitative land use scenarios for Europe is provided, referenced against the initial frameworks. The report concludes with key issues required by a catchment-scale implementation of land use scenarios.

1.1 Introduction

A scenario is a *coherent, internally consistent, and plausible description of a possible future state*. The interaction of multiple drivers of change means that the future is inherently uncertain and likely to be without precedent. Scenarios can provide tools to consider future possibilities that in some cases may go beyond the bounds of current (or historic) trends (EEA, 2001). Scenarios do not aim to provide predictions or forecasts, but rather define the range of possibilities within the context of future uncertainty. By grouping multiple variables to ensure that the projection of future change is plausible and internally consistent, the scenario process can screen out contradictory combinations of these variables. An important distinction therefore exists with sensitivity analysis which represents an artificial adjustment of only one variable to help understand system responses (Figure 1).

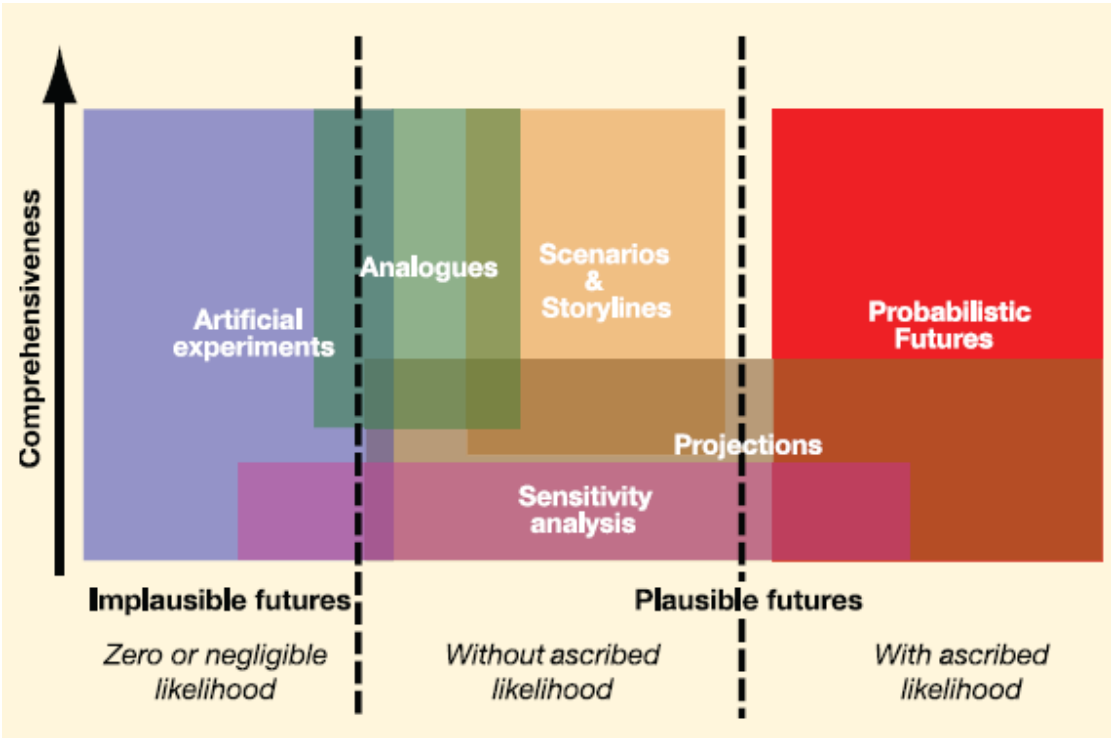

Figure 1. The role of scenarios alongside other tools to assess future change (IPCC: Carter et al., 2007)

Although people and organisations have been implicitly using scenario planning for a long time (e.g. military strategists), the earliest formal scenarios originated with work by the Shell Group and this storyline-and-simulation approach was then adopted by the Intergovernmental Panel on Climate Change (IPCC) for its Special Report on Emission Scenarios (SRES). 'Storylines' are typically used in scenario development to provide a descriptive narrative of potential changes.

1.2 IPCC SRES

The IPCC SRES framework (Nakicenovic et al., 2000) used a conventional two-axis approach to describe a range of future demographic, technological and behavioural changes (Figure 2). The four SRES storylines (A1, A2, B1, and B2) represent different world futures arranged across two distinct dimensions: (i) economic versus environmental values; (ii) global versus regional governance. Each storyline provides a short narrative that explores what might happen if political, economic, technological, demographic, and social developments followed alternative global pathways (Figure 3). With regard to climate change, the SRES scenarios were translated into six main greenhouse gas emission ''marker'' scenarios: one each for the A2, B1, and B2 worlds, and three scenarios for the A1 world: A1T [conversion to non-fossil (low-carbon) fuels], A1B (balanced fuel sources) and A1FI (fossil-intensive fuel sources). The SRES storylines therefore provide both an input to climate models by future global emissions trajectories, and a diverse range of socio-economic development pathways for broader analysis. Although originally left without titles to avoid over-interpretation, further work has suggested appropriate names: for example the UKCIP/Foresight socio-economic scenarios (UKCIP, 2001; Berkhout & Hertin, 2002) suggested A1=World Markets, A2=National Enterprise, B1=Global Sustainability, B2=Local Stewardship; other interpretations are described below. This further work has also added extra detail consistent with the original narratives.

Storylines for each of these different SRES future worlds are now described with particular reference to the issues for water and land use management, followed by a critique of the IPCC approach.

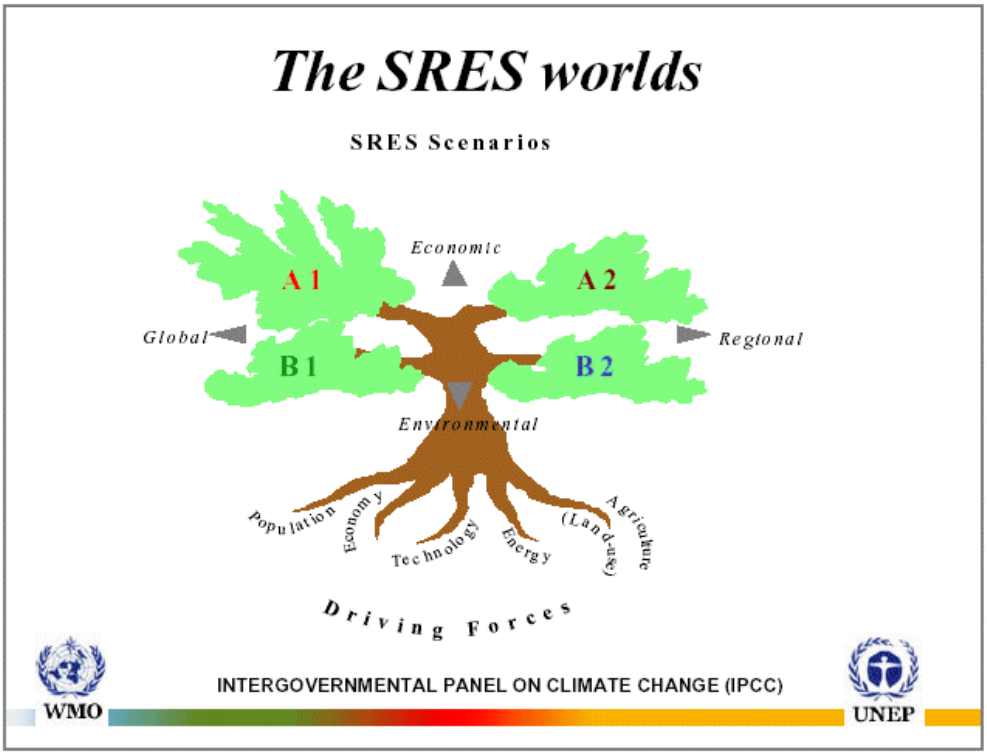

Figure 2. The twin-axis framework used for the IPCC SRES scenarios.

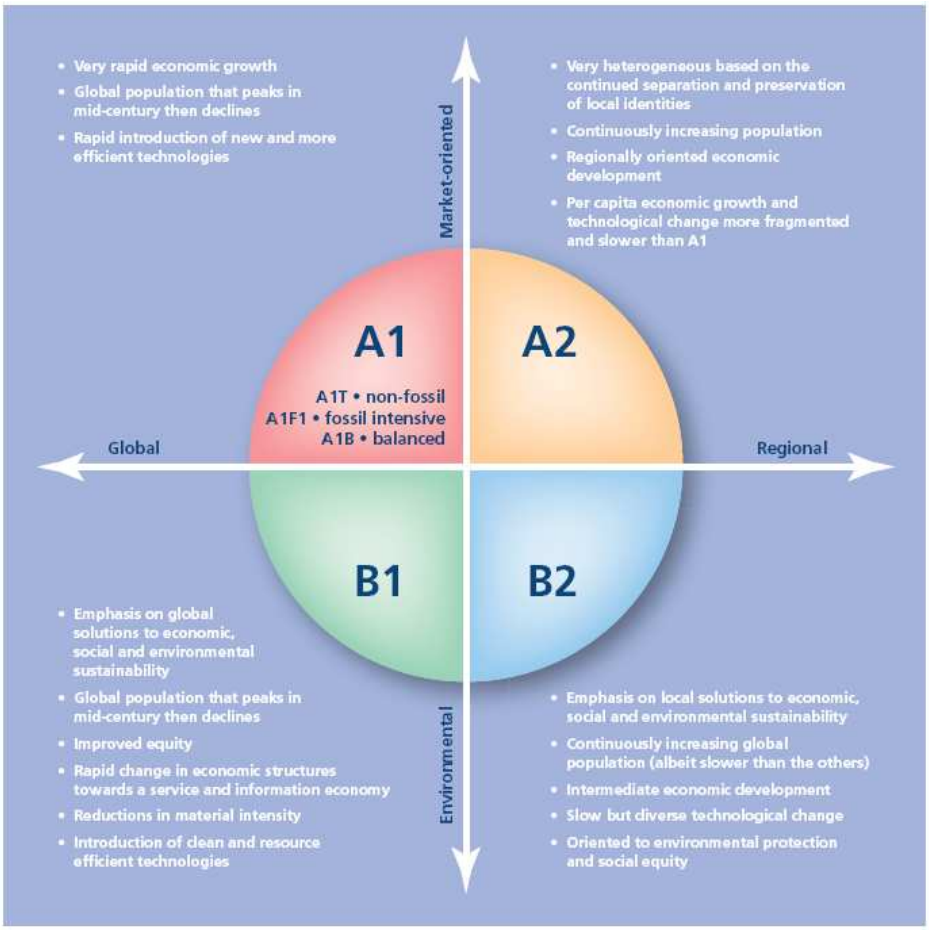

Figure 3. Key features of the SRES framework.

1.2.1 A1 World

Summary: market-oriented approach to the provision of goods and services, with increasing globalisation and large corporations.

This future world features rapid economic and technological growth due to globalisation, an increase in general wealth, and a predominance of materialist–consumerist values. Population growth is implied to be low and the economic prerogative would mean an end to subsidy-support schemes: in Europe, the Common Agricultural Policy (CAP) would be abolished. Key rights and responsibilities (e.g. flood management) would ultimately lie with the property owner (although probably managed through weak public agencies). Society would be technology-driven (e.g. hard engineering for flood defences; new reservoirs or water transfers) with lower regard for environmental impacts or demand-control measures. Agriculture and land use would be market driven, and urbanisation would increase.

1.2.2 A2 World

Summary: market-oriented approach, but with a regional or national focus and great diversity.

In this market-led world, population growth is rapid but economic growth is lower than A1 due to the heterogeneous development that results from an emphasis on self-reliance and co-operation only amongst similar cultures. In Europe this would imply common policy development (e.g. CAP+) with external trade tariffs, combined with strong national policy and identities. Again rights and responsibilities mainly reside with the property owner, but would be particularly focussed on local issues and less dominated by large corporations than with A1. Demand-control measures are a low

priority and there is a preference for hard defences and water transfers to meet immediate needs. An emphasis on food security and food sovereignty is also very likely within this scenario.

1.2.3 B1 World

Summary: sustainable approach to the provision of goods and services, with strong global institutions

Development takes a much more environmentally sustainable pathway with global-scale cooperation and regulation to achieve worldwide solutions that balance economic, social and environmental goals. Strong national and supra-national agencies and standards exist to ensure a consistent approach would be applied everywhere. Population growth is low and clean efficient technologies are introduced. The presumption in favour of environmental protection would mean a preference for 'soft' or natural flood management measures that are integrated with land use planning, water resources management and enhancement of ecosystem services. A catchment-based approach would be encouraged to integrate upstream and downstream issues. Demand-management would be a high priority.

1.2.4 B2 World

Summary: community-oriented approach to the provision of goods and services, with no global overview and dominance of local approaches.

This future world follows environmentally, economically and socially sustainable pathways but the criteria for this are tailored to meet objectives defined by local agencies with strong public participation. Although flood and water resource management are integrated with land use management, the downstream implications of actions would not necessarily be considered, and it may be difficult to manage large basins covered by several agencies. Demand control remains important but less so than in the B1 world.

1.2.5 Critique of IPCC SRES framework

Recent reviews of the SRES framework and projections have highlighted various inconsistencies (e.g. van Vuuren & O'Neill, 2006; Girod et al., 2009). Although the global-to-local decision making axis is generally accepted as a key component of future scenarios, the environment versus economy axis is suggested to be inconsistent with the principle of sustainability that underpins the B scenario worlds (i.e. environment, social *and* economic criteria). The A1 globalisation-technocratic world is generally seen as an informative exploratory scenario (interpreted by some as 'business-as-normal'). Similarly, the rationale for the A2 world is generally accepted, although this scenario can have multiple interpretations in terms of its key scale of governance and decision-making, varying from region to national or pan-national (e.g. EU level). Difficulties with the B scenario worlds stem from the decision by the IPCC to characterise the SRES as non-intervention scenarios based upon the resulting emission projections (i.e. not including mitigation measures)[1]. This can be seen to contradict the key values of the B scenarios which do clearly require intervention of some form, either via global co-ordination (B1) or based upon local or regionally defined criteria (B2).

Two other important issues can be recognised. Firstly, the SRES framework uses exploratory scenarios, rather than using a normative approach that would have identified preferred future states and then identified potential transition pathways to reach these targets. Secondly, the storylines also do not necessarily encompass the full range of possible socio-economic futures, as this was not part of their remit.[2]

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[1] This decision followed political pressure from some countries.

[2] Some current socioeconomic developments already lie outside the range of the SRES scenarios (e.g. the GDP and the growth rate of GDP in China), as also do GHG emissions rates which currently exceed the highest scenario (A1FI). This illustrates how scenario development needs to be an interactive and dynamic process that can incorporate new data.

1.3 Other Global Scenario Frameworks

The SRES storylines represent just one of the socio-economic scenario frameworks that have been used in future environmental assessments, albeit the most well-known. For example, UNEP's Global Environmental Outlooks (GEO-3 and GEO-4), described four scenarios for the future—in GEO-3 these were named as 'markets first', 'policy first', 'security first' and 'sustainability first' —which are different to the SRES storylines but have been characterised in a similar way (UNEP, 2002, 2007) (Figure 4). Whilst retaining the global/regional axis, the GEO scenarios characterise the second axis in terms of reactive versus proactive responses; hence intervention is explicitly included. The recent SCENES project (EU FP7) has adopted the GEO framework for its water scenarios.

Similarly, the second axis has been characterised in terms of low to high regulation by Westhoek et al. (2006) and this formed the basis for the development of the EURALIS scenarios (Verburg et al., 2006): see Figure 5. The Millennium Ecosystem Assessment also used 4 different scenarios with a divergence between local/regional and global-scale implementations of the ecosystem approach on one axis and the second axis contrasting proactive versus reactive approaches to key environmental issues (MEA, 2005). Some of the scenarios also have many similarities with those previously developed for the Global Scenarios Group in terms of their characterisation of continuity together with favourable or unfavourable change.

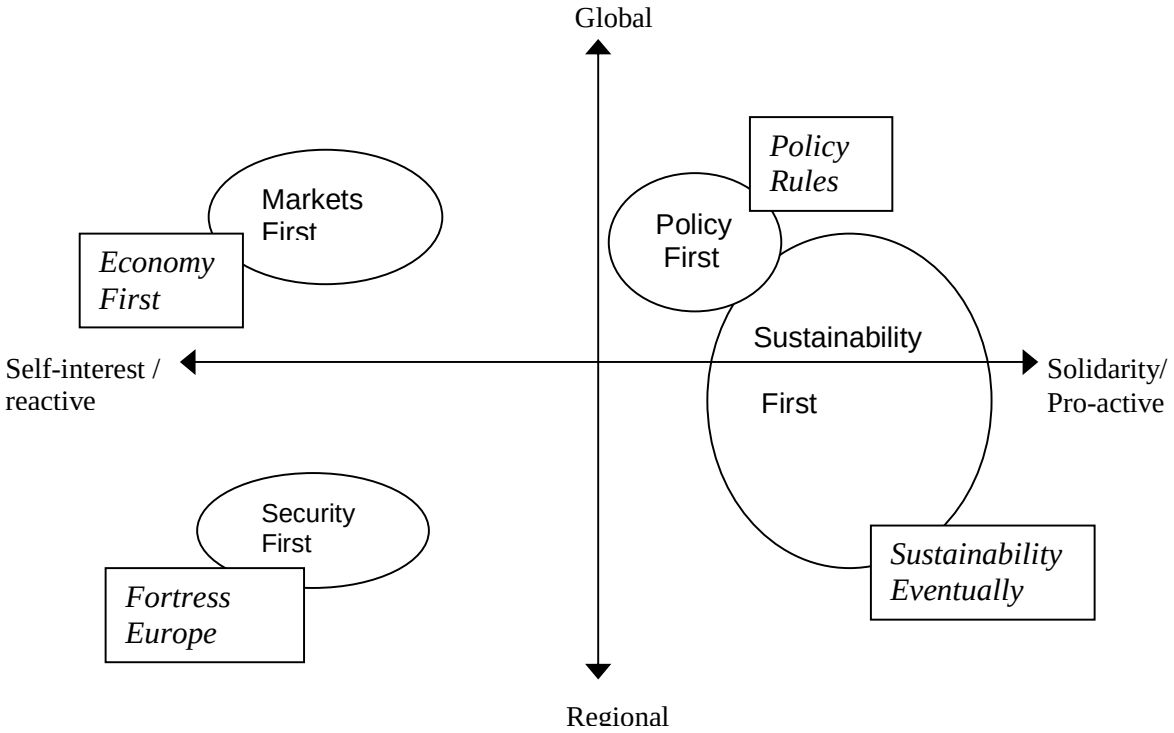


Figure 4. The GEO scenarios including revised descriptions developed for the SCENES project (Economy First, Policy Rules, Fortress Europe and Sustainability Eventually).

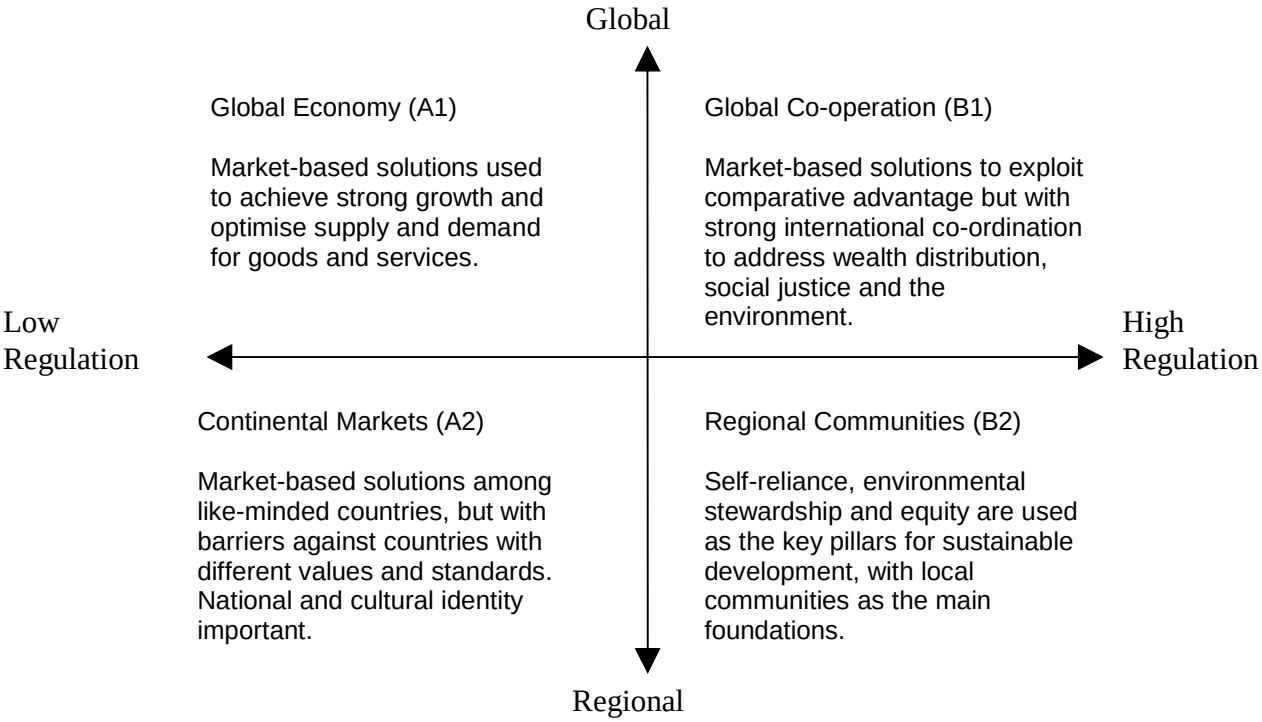


Figure 5. Scenarios characterisation developed by Westhoek et al (2006) for EURALIS

A cross comparison between each of the scenario frameworks and worlds is shown in Table 1 suggesting that there are broadly 4 basic scenario archetypes, although with considerable variation of interpretation within some of these.

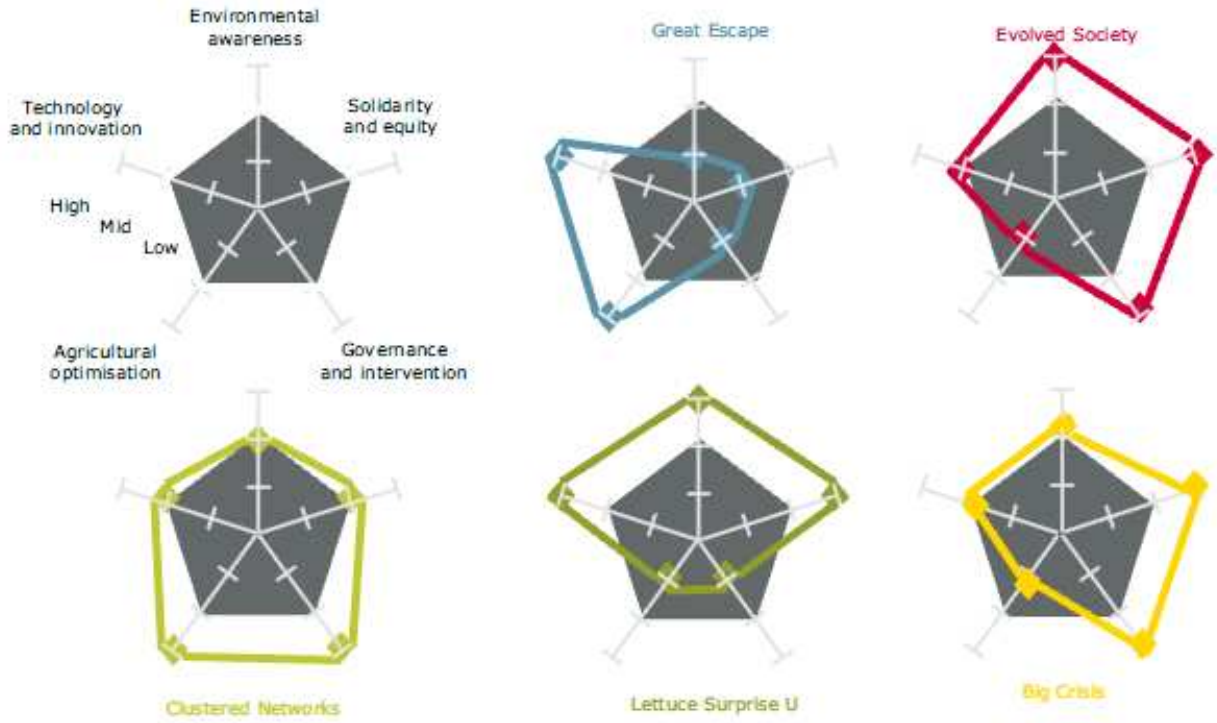
CLASSIFICATION	IPCC	GSG	GEO	MA
Global Market	**A1 (A1B)**	**Market Forces (conventional)**	**Markets First**	**Global Orchestration**
Continental Barriers - Fortress	**A2**	**Barbarisation - Fortress World**	**Security First**	**Order from strength**
Continental Barriers - Collapse		**Barbarisation - Breakdown**		
Global Sustainability - Policy	**B1**	**Policy Reform (conventional)**	**Policy First**	**(elements of Global Orchestration)**
Global Sustainability - Technology	**(elements of B1)**	**Great Transitions – New Sustainability**	**Sustainability First (global elements)**	**Techno Garden**
Regional Sustainability	**B2**	**Great Transitions – eco-communalism**	**Sustainability First (local elements)**	**Adapting Mosaic**

Table 1. A summary of the main scenario archetypes and cross-referencing of frameworks. GSG Global Scenario Group; MA Millenium Ecosystem Assessment.

A rather different approach was followed by the recent PRELUDE scenarios (EEA, 2007; Volkery et al., 2008) which used a multi-axes approach for the socio-economic drivers of land use. The drivers were assigned different priorities in each scenario and then used to define five distinct scenario groups (Figure 6). Despite the difference in origins, some similarities with the other scenario frameworks can

be identified: for example 'Great Escape' as an interpretation of an A2-type world, 'Evolved Society' as an interpretation of B1-type world.

Finally, it is also worth noting that beyond these conventional frameworks a range of other scenarios have been developed during various European projects. These projects have explored similar issues but typically with a specific remit or focus. For example, the EU Standing Committee on Agricultural Research (SCAR) Foresight panel produced a set of scenarios contrasting an ecosystem-based approach with the threats that a poorly-adapted ('business as normal') world would face in terms of food, energy and environmental security (SCAR, 2007). Another project, Scenar2020, explored alternatives to the 'business as normal' scenario through either a regionalisation or liberalisation agenda with regard to world trade (Nowicki et al., 2007).



Aggregate driving forces to describe scenarios

Driving Force	Description
Environmental awareness	= ((2 x renewable energy) + (2 x environmental awareness) + climate change))/5
Solidarity and equity	= ((4 x social equity) + quality of life + (2 x human behaviour) + health concern)/8
Governance and intervention	= ((3 x policy intervention + subsidiarity)/4
Agricultural optimisation	= ((4 x agricultural intensity) + self-sufficiency + international trade)/6
Technology and innovation	= Technological growth

Note: Of the original 20 driving forces the ones addressing economy and population were not used in this aggregation. They are: population growth, ageing society, settlement density, internal migration, immigration, daily mobility, economic growth.

Figure 6. Radar diagram of key drivers used for the PRELUDE scenarios (EEA, 2007)

2. SCENARIOS OF LAND USE CHANGE FOR EUROPE

A series of large-scale projects in Europe have used the aforementioned scenario frameworks and modelled the implications for future land use change (LUC), with particular emphasis on agricultural futures. The two main studies have been the ATEAM project (with a future time horizon of 2080) and the EURALIS project (with a time horizon of 2030). These projects have acted as forerunners for other studies, such as the ACCELERATES project which used the ATEAM scenarios to further explore the LUC implications. ATEAM and ACCELERATES used the SRES framework whilst EURALIS used the modified framework of Westhoek et al. (2006) that makes intervention more explicit, although they remain broadly compatible. Further developments have included the ALARM (biodiversity) scenarios (Spangenberg, 2007) which have used similar methods to ATEAM/ACCELERATES, and the SENSOR project (Schößser et al., 2010) which developed policy 'scenarios' and used the same land use model (CLUE) that was used in EURALIS. The PRELUDE scenarios (EEA, 2009) have also been characterised in terms of LUC, using the ATEAM models for the analysis but are here described separately as the socio-economic scenario framework is rather different.

The methodology for development of large-scale spatially-explicit LUC scenarios has typically followed a two-phase nested modelling approach, with a demand-based assessment of commodity prices for a larger aggregate area followed by a downscaling and allocation process to infer sub-regional patterns (Carter et al., 2007). Scenario assumptions based upon macro-drivers and policy priorities identify demand for goods which are then compared to their potential supply based upon biophysical land suitability criteria to define land values. Land use is allocated on the assumption that profitability is optimised therefore LUC is primarily determined through a sequence of steps dictated by macro-economic modelling of supply and demand.

2.1 ATEAM and EURALIS

A common feature of these two projects is that for most scenarios they indicate unallocated or 'surplus' land; this occurs due to increased agricultural yields and improved productivity (from continued technological development). By implication, this surplus land is inferred to be at risk of 'abandonment' because no use has been allocated, although this conclusion is based upon existing (i.e. conventional) uses, and these studies have had an emphasis on agricultural land use. 'Abandonment' is inferred to be most likely in marginal agricultural areas as future farming activity becomes concentrated in the more productive regions (e.g. Rounsevell et al., 2006; Verburg et al., 2006). Climate change is also suggested to potentially further exacerbate the difficulties faced by some marginal areas. As a consequence of the projected reduced area of agricultural land in Europe, it is also implied by these projects that other land uses, such as forestry, could expand in area. Summary changes for the EURALIS scenarios are presented in Table 2 and a description of land use changes from the ATEAM scenarios in Table 3.

	A1	A2	B1	B2
Urbanization	2.37	1.38	1.33	0.41
Land abandonment	6.35	2.49	6.28	5.21
New nature	2.11	0.55	4.58	3.18

Table 2. Land use changes in Europe (+ % change) from the EURALIS scenarios. 'Land abandonment' does not include an offset from new farmland and 'new nature' does not include nature areas lost to other land uses (Verburg et al., 2006)

Comparing project findings, the contraction of agriculture is most apparent in the A1 scenario world (or equivalent) due to the loss of subsidy support that is now provided through the CAP. Results are less consistent for the other scenarios, with EURALIS identifying the least land abandonment in A2 due to a 'Fortress Europe' storyline and the imposition of trade barriers. By contrast, ATEAM identifies a likelihood of significant land abandonment in the A2 scenario, almost to the same level as A1. This may also be a consequence of the different time horizons of these two studies as ATEAM extends to the 2080s (rather than the 2030s with EURALIS) and hence much larger changes tend to be projected (up to 50% abandonment in the A1 scenario, depending on climate scenario). ATEAM has the least land abandonment in the B2 scenario.

Spatial patterns of LUC are variable between scenarios and between scenario studies. In ATEAM, Finland was the only country where agriculture responded to climate change by increasing in area, in this case at the expense of forests; elsewhere the national trend was projected to be for declining total areas of agriculture (Audsley et al., 2006). 'Hotspots' of surplus or abandoned land tended to be modelled in existing marginal areas where productivity levels are currently lower, notably areas at the fringes of agricultural zones, for example those fringing the uplands (e.g. in Ireland, Scotland, Greece, Sweden, central France, Appenines of Italy etc.) and in arid areas particularly in central Spain.

% Land use change	B1	B2	A1FI	A2
Cropland - food	-7.0	-6.4	-10.7	-10.4
Grassland	-1.1	-6.7	-8.7	-10.0
Forest	3.5	5.6	0.8	0.7
Urban	0.05	0.06	0.09	0.08
Bioenergy	3.4	7.4	8.7	8.7
Protected	6.1	6.1	6.1	6.1
Surplus	1.1	0.0	9.8	10.9

Table 3. Land use change including 'surplus' in the ATEAM scenarios (HadCM3 climate model) (Schröter et al., 2005)

2.2 PRELUDE

The 5 scenarios in the PRELUDE study also projected a range of LUC patterns into the future based upon the key scenario assumptions (Figure 7). Cropland declines in most of the scenarios and the forested area either remains constant or expands, which represents a similar summary headline to ATEAM and EURALIS (although this may not be entirely unexpected as the ATEAM model was used). Surplus or abandoned land is also a feature of at least 3 of the scenarios where it covers more than 10% of Europe. A summary of the key features of these scenarios is shown in Table 4.

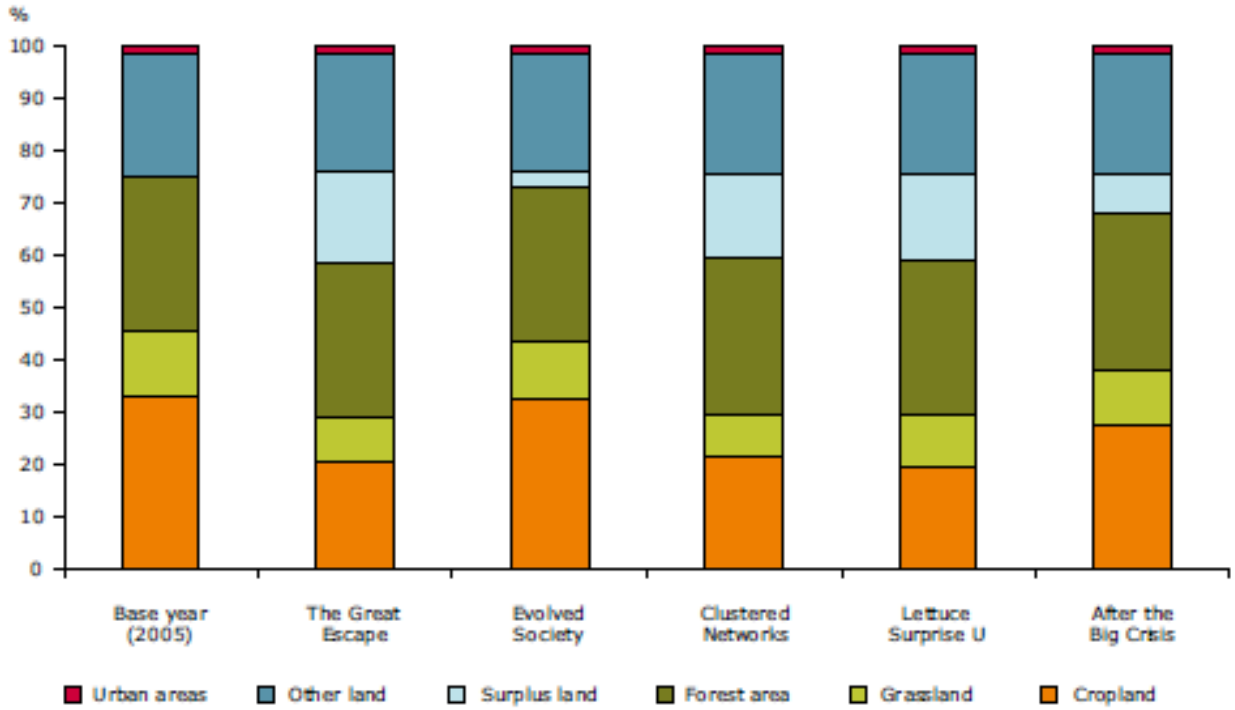


Figure 7. Summary land use changes for the five scenarios in the PRELUDE study (EEA, 2007)

Stress factors		Great Escape	Evolved Society	Clustered Networks	Lettuce Surprise U	Big Crisis
Land abandonment		++	O	++	+	+
Agricultural intensification		++	–	+	–	O*
Habitat fragmentation		+/–	+	–	+/–	+
Protected areas		–	++	+	+	+
Effects						
Biodiversity	general	+/–	+	+	+	+
	HNV farmland	–	O	–	–	–
Water quality		+/–	+	+/–	++	O*
Soil quality		+/–	+	+/–	++	O*
Air quality (agri-related)		+/–	+	O	++	O*
Landscape identity		–	O	+/–	+/–	O

Note:
++ : increases substantially.
\+ : increases.
O : remains approximately the same.
– : decreases.
–– : decreases substantially.
../.. : differentiated regional effects.
* Discontinuous development where initial pressures are relieved.

Table 4. Summary of major changes in the PRELUDE scenarios (EEA, 2007)

2.3 Critique of large-scale LUC SCENARIOS

As with the socio-economic scenarios, inconsistencies in LUC scenario development have been noted by reviewers (e.g. Houet et al, 2010; Busch, 2006). Therefore although the scenarios may be appropriate for European-level analysis they have important deficiencies to be noted when downscaled to a landscape or catchment level. A key problem has been that validation against current trends or patterns of LUC is often poor or absent from the analysis (often due to data verification problems). At the landscape/catchment level, social and cultural factors influencing land

use patterns are often equally important (e.g. skills, tradition etc.) and these have not been included in the modelling process. At worst, this rather implies a form of spatial 'determinism' in the projections that conflicts with the multitude of influences that have shaped the heterogeneous features of European landscapes. A key point is that in many landscapes, land use is not 'optimised' or determined purely on economic criteria, particularly in marginal areas. In essence therefore, an approach that is solely 'top-down' cannot account for these factors and this strongly implies that LUC scenario development and analysis also needs to consider 'bottom-up' processes and to combine them together using an integrated framework (Verburg & Overmars, 2009; Houet et al., 2010).

A general inference from such criticism is that conclusions of widespread 'land abandonment' across all scenarios for a future Europe are premature, with some of these results being a product of the large-scale analysis rather than a full consideration of all alternative future worlds. Particularly for assessments of LUC at landscape or catchment level, the distinctive local characteristics of that area also require to be built into the analysis in order to understand present and future trajectories of change. Scenario development can help to do this by distinguishing which of the 'top-down' or 'bottom-up' elements may dominate in future worlds, and therefore to distinguish uncontrollable from controllable aspects of future change (i.e. the controllable element may be associated with adaptive management or policy interventions). This inference is supported by the recent renewed emphasis on issues of 'food security' or 'energy security' in policy agendas. The influence of these 'security' issues on future land use is likely to be profound, not only related to actual shifts in global trade patterns but also perceptions of that shift by national and local decision makers. These issues also show just how quickly the emphasis can change from issues of land or commodity 'surplus' to become issues of 'deficit'. They are very likely to have a particularly strong influence on future changes to marginal agricultural land, particularly in zones where climatic amelioration brings new opportunities for crops and livestock. Some marginal areas may also gain a competitive advantage over areas that are currently higher quality agricultural land because the latter may encounter new climatic restrictions in the future (e.g. water supply).

In the context of the REFRESH project, these distinctions are especially important as climate change adaptation (planned and unplanned) is context-specific: hence, potential measures will be strongly influenced by local land use patterns. To ignore an understanding of this context means that key barriers and enablers for adaptation strategies will be overlooked. Construction of scenarios for the demonstration catchments therefore needs to consider these 'bottom-up' contextual factors (biophysical and socio-economic) in addition to the 'top-down' drivers of change identified by large-scale scenario studies. For this reason, a model interface based upon the LandSFACTS toolkit has been developed that can include both sets of factors in constructing LUC scenarios at catchment scale (Deliverables 1.8 and 1.9).

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