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## PREFACE

TERRA is a project sponsored by the Directorate-General Information Society of the European Commission in response to the pressing need to align the creation of a global networked knowledge society (GNKS) and its accompanying New Economy with the requirements for achievement of sustainability generally and of sustainable development in general. Specifically, the project seeks to create (by use of formal analytical methods) the insights necessary to inform and guide policy-making<sup>1</sup> leading ultimately towards the optimisation of ISTs contribution to sustainability.

This is a living document that has provided an internal point for reflection on ongoing development - in this case, the scenario development framework and the formulation and structure of theme-specific scenarios. A second purpose is to provide feedstock for TERRA outputs and results.

The project uses several 'living documents' to facilitate its work and the exchange of ideas among the consortium and with interested parties. In addition to this document, these include:

- A Story of TERRA document that presents the overall vision of the project, explains the key concepts, describes the modus operandi and the intended outputs and presents key results from project work.
- A tools document that describes the structure of models, interface tools and databases developed for and used in the project, and serves as a preface to detailed model documentation.
- An integrated modelling platform, comprising the project databases and the integrated IFs for TERRA model (the centrepiece of a range of models developed and used in the project), together with its associated tools and help system.
- An electronic 'weak signals file' that notes and discusses phenomena that may signal emergent aspects of the relation of the GNKS and sustainability.
- Specific thematic scenario analysis reports associated with the three central themes (Human Capital, Equity and Growth, Information Age Sustainability).

In addition, the project produces a range of external results. As discussed in the 'Vision of TERRA' living document, these are three-fold:

- New understandings of its topic areas in general abstracted as TERRA 'Concept Sheets';
- Specific insights into the mechanisms by which sustainability, IST and the GNKS interact expanded in 'Insight Primers'; and
- Summaries of the state-of-the-art in relation to specific decision-making areas (or

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<sup>1</sup> The current explications of the principal concepts addressed by TERRA are presented in the following section. TERRA's understanding of Sustainable Development is discussed in Concept Sheet 1; its understanding of the relationship of Information Age to sustainability is discussed in Concept Sheet 2; and issues concerning policy formation in Concept Sheet 3.

policy issues), presented as TERRA ‘Policy Briefings’ that identify the range of possibilities; show the firmer probabilities within them; and (by way of references to Concept Sheets and Insight Primers) point to any background material that may be needed for evaluation.

In addition, the project has produced a wide range of scholarly papers on various aspects of the central problematique. The final version of the Story of TERRA contains a catalogue raisonnee of these contributions.

This document presents the mature scenario framework, gives conceptual discussions of the type of scenario analysis conducted in TERRA and its inputs and outputs within the project and lays out the narrative structure of the members of the TERRA scenario family.

This document informs the TERRA concept sheets detailing the narrative meaning of such concepts as networking, TERRA Insight Primers containing clearly explicated insights into the impact of scenario assumptions on underlying relations and policy levers and TERRA policy briefings in which the impact of policies under different scenarios (and thus the robustness and adaptability of those policies and the resilience of sustainability) are described.

In view of the living status of this document, its internal function and the cumulative nature of scenario development in TERRA, this document may necessarily be somewhat cryptic to outside readers. Scenario development in such a project inevitably involves some false starts and developments whose full importance and implications become evident only with hindsight.

There are two basic audiences for this document. The proximate audience is primarily TERRA consortium members and an internal policy audience, who are expected to have a detailed knowledge of the relevant literatures and the internal workings of TERRA. In particular, they should be aware of the central problematique (sustainability implications of the global networked knowledge society) and the associated collection of propositions and the division of TERRA work into three overlapping, progressive and cumulative themes (human capital, equity and growth and information age sustainability) for scenario development and analysis. Scenario developers should use this as a place to record their efforts and reflect on lessons learned in the other themes. Theme leaders should use it as a way to ensure a consistent and (where appropriate) cumulative uptake of the scenario framework and phenomena from previous themes and previous scenario development efforts.

A wider audience includes policymakers who need to place the scenario-orientated TERRA reports in context and to relate them to TERRA policy briefings. This audience includes broader scientific and policy research communities interested in seeing how the phenomena identified in TERRA concept sheets (including the themes themselves) are reflected in scenarios, how those scenarios affect the policy analysis or how to extend the scenario analysis framework, enrich the scenarios, or draw comparisons with other scenarios. For this purpose, general acquaintance with the policy domains covered, the principles of scenario analysis and some of the relevant disciplines (e.g. economics) should suffice.

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## EXECUTIVE SUMMARY

This living document presents an integrated scenario framework for the Story of TERRA<sup>2</sup> and summarises the approaches taken in thematic (Human Capital, Equity and Growth and Information Age Sustainability) scenarios.

The scenarios are a collection of voices that together tell the Story of TERRA, an exploration of the uncertain futures faced by the world. The central theme is the TERRA *problematique*:

The unfolding of the Global Networked Knowledge Society challenges assumptions about how policy levers work, what effects they produce and the roles of public, private and civil society stakeholders. This challenge applies particularly to the medium- to long-term unsustainability of a Global Networked Knowledge Society that seems increasingly dominated by short-term dynamics. Sustainability discussions and policies limited to one or two of its economic, social, environmental and cultural dimensions or isolated parts of the GNKS cannot meet the challenge: sustainability is a global property of the whole system. This challenge calls for a holistic approach that looks rigorously at specific aspects of the system, combines quantitative and qualitative methods and considers appropriate combinations of policy levers: joined-up problems call for joined-up thinking to find joined-up solutions.

The Story of TERRA should help European policy makers to analyse the EU's role in the changing global context. The scenario framework helps to redirect and focus the work of TERRA2000. Specific scenarios are a blend of quantitative and qualitative elements used to shed light on the TERRA *problematique*. They are used in combination with various types of models to test the TERRA Propositions.

The concepts of sustainability and its economic, socio-political and environmental 'pillars' lead to a set of propositions requiring demonstration: an overall 'ISP proposition' and constituent sub-propositions relating to the individual pillars together with an additional 'distributional' proposition that recognises the vital distinction among states that may be satisfactory in aggregate (e.g. a high per capita GDP) as to whether or not localised failure (relative poverty within affluent counties, for instance) renders them ultimately unsustainable.' These propositions are as follows:

### **The IST Proposition**

The new technologies of the Information Society (ISTs) seem likely to offer scope to enable economic growth, and to allow a more equitable distribution of wealth, without necessarily increasing consumption, pollution and energy use.

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<sup>2</sup> See TERRA (2002d).

### **Economic Sustainability Propositions**

ISTs can catalyse human capital expansion and thus promote sustainable economic growth

Expansion of the GNKS can sustain and diffuse increases in productivity and market efficiency throughout the globalised economic system.

### **Social Sustainability Propositions**

While initial deployments of ISTs and 'New Economy' dynamics have tended to exacerbate welfare, digital and/or income 'divides,' the unfolding of a GNKS based on open and universal access can harness the same technological, market and social forces to promote greater equality of opportunity compared either to recent experience or the pre-GNKS era.

The GNKS encourages and influences the processes of globalisation and can foster collective awareness of collective problems, mobilise local responses and promote emergence of new governance institutions to balance local and global problems, incentives and powers to act.

While the mere fact of globalisation – the connection of each to all – does not of itself imply either integration or convergence, ISTs can facilitate mutual awareness and respect.

The GNKS can encourage peace and minimise conflict by substituting a complex interlocking maze of global allegiances for previously narrow tribal and racial allegiances.

### **Environmental Sustainability Propositions**

Emergent technologies based on information (from ICTs to bioengineering) can dematerialise production and distribution of goods and services by reducing associated material inputs and waste outputs.

The new technologies and the new forms of human interaction they support can lead to substitution of immaterial goods and services for material production and consumption.

Dematerialisation and immaterialisation reduce the opportunity cost (price) of material inputs and environmental sinks and increase the welfare content of income and wealth. The relative price changes can induce substitution of material for immaterial inputs. Increased purchasing power can stimulate consumption of both material and immaterial goods and services. These substitution and income effects can outweigh the benefits of the original changes.

## The Distributional Proposition

Distributions (e.g. inequalities) matter at least as much as aggregates because: i) welfare and incentives are relative; ii) globalisation and the network economy hold out the promise of greater equity while increasing the likelihood that *laissez-faire* policy will exacerbate divides; iii) different parts of distributions have potentially divergent values, sustainability footprints and responses to policy and scenario forces; and iv) network evolution can lead to small worlds, stable diversity, global convergence, etc. with only minor changes in underlying parameters .

The essence of the story is simply told. The world is evolving, buffeted by shocks, uncertainty and the sometimes ill-intentioned or uncoordinated actions of her inhabitants. For a long time, these actions were based on habit, culture, or narrowly rational choice – more or less enlightened self-interest. Recently, the cumulative effects of that history and the unprecedented expansion of our power and reach have increased our awareness of the global consequences of our actions and the very real possibility of a series of linked global catastrophes. This issue of *sustainability* increasingly occupies public rhetoric; though the lessons have yet to bear substantial fruit, save in limited areas (e.g. ozone depletion).

As part of this growing awareness, scenarios and models have been used to help us *think forward* into an uncertain future, *reason backwards* from desired or feared landing places and, above all, *reason together* about the uncertainties that beset us and our ability to deal with them. Through these efforts, we have learnt that we may be in danger of running out of specific resources, that alternatives can sometimes be found that preserve Earth's ability to sustain (fulfilling, enriching, productive, etc.) life, and that sustainability is inherently multifaceted: at the least, it can be seen in economic, environmental, societal and cultural spheres, each of which is affected by forces arising in the others. We have also learnt that our activities often have unintended consequences, and that these may reverse our original intent (for good or ill).

The basic idea here is to present “a big picture” of global transformations. The Story is not a single narrative. To understand this complex narrative, it is necessary to first delve deeply into parts of the story, drawing out the internal logic of its dominant themes. The project as a whole is pursued three overlapping, progressive and cumulative themes (human capital, equity and growth and information age sustainability) for scenario development and analysis.

This document presents the overall framework for scenario development, together with the essential structures of the thematic scenarios as they are developed.

The main dimensions of the framework are:

- Globalisation/networking: whether worldwide flows (of people, ideas, resources, economic activity, etc.) continue to increase in extent and complexity;
- Integration: whether internalisation and cooperation characterise the world order; and
- Division: whether ‘divides’ based on digital access, income, education, access, etc. increase.

There are many other lines along which the GNKS has been and continues to be analysed. Many of these lines (e.g. linkage, networking, liberalisation) are logically connected to the three identified above). Others (e.g. technological progress, growth, environmental impact, etc.) are to some extent part of the underlying trends common to all scenarios and to a greater extent normative indicators of scenario development.

The historical background to the Story of TERRA includes information concerning current world economic trends, providing a point of departure. This information can be derived from the integrated model, IFs for TERRA and its database. This information is available to all TERRA partners in order to give a common perspective for scenario analyses. This information also provides value added for the European Commission and gives firm ground to baseline scenarios.

Trend analyses and the scenario framework together provide the Story of TERRA meta-level framework. The relationship between the Information Society Technologies (ISTs) themselves, and their wider societal impact in the shape of the New Economy is being elaborated by TERRA's linked series of narrative scenarios and numerical models concentrating on identifying and expanding the most crucial aspects of the picture – the TERRA approach of Dominant Relationships Modelling.

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## 1. INTRODUCTION

The scenario structure described here provides a framework for a communal discussion of the Story of TERRA. This is an exploration of the uncertain futures faced by the world. The central theme of the story is the TERRA *problematique*:

The unfolding of the Global Networked Knowledge Society (GNKS) challenges assumptions about how policy levers work, what effects they produce and the roles of public, private and civil society stakeholders. This challenge applies particularly to the medium- to long-term unsustainability of a Global Networked Knowledge Society that seems increasingly dominated by short-term dynamics. Sustainability discussions and policies limited to one or two of its economic, social, environmental and cultural dimensions or isolated parts of the GNKS cannot meet the challenge: sustainability is a global property of the whole system. This challenge calls for a holistic approach that looks rigorously at specific aspects of the system, combines quantitative and qualitative methods and considers appropriate combinations of policy levers: joined-up problems call for joined-up thinking to find joined-up solutions.

The Story of TERRA should help European policy makers to analyse the role of EU in the changing global context. The scenario framework has helped direct and focus the work of TERRA2000. The specific scenarios blend quantitative and qualitative elements to shed light on the sustainability implications of the global networked knowledge society that is being born out of Information Society Technologies (ISTs), globalisation and networking. They are used in combination with various types of models to test the TERRA Propositions.

The concepts of sustainability and its economic, socio-political and environmental ‘pillars’ lead to a set of propositions requiring demonstration: an overall ‘ISP proposition’ and constituent sub-propositions relating to the individual pillars together with an additional ‘distributional’ proposition that recognises the vital distinction among states that may be satisfactory in aggregate (e.g. a high per capita GDP) as to whether or not localised failure (relative poverty within affluent counties, for instance) renders them ultimately unsustainable.’ These propositions are as follows:

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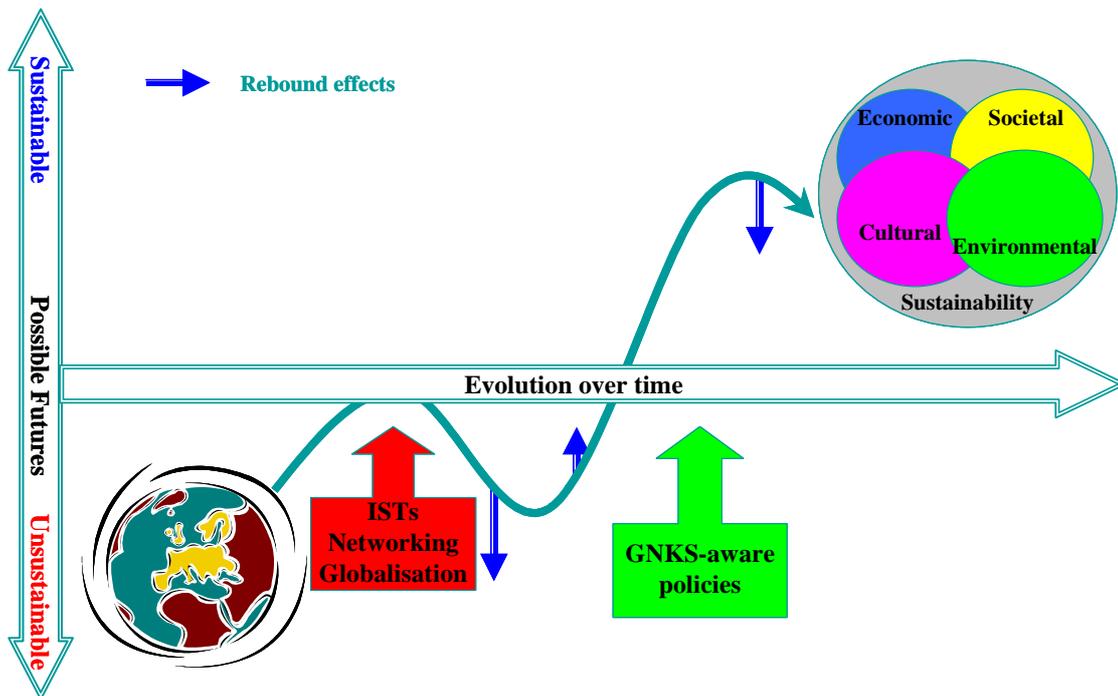
### **The Distributional Proposition**

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The essence of the story is simply told. The world is evolving, buffeted by shocks, uncertainty and the sometimes ill-intentioned or uncoordinated actions of her inhabitants. For a long time, these actions were based on habit, culture, or narrowly

rational choice – more or less enlightened self-interest. Recently, the cumulative effects of that history and the unprecedented expansion of our power and reach have increased our awareness of the global consequences of our actions and the very real possibility of a series of linked global catastrophes. This issue of *sustainability* increasingly occupies public rhetoric; though the lessons have yet to bear substantial fruit, save in limited areas (e.g. ozone depletion).

As part of this growing awareness, scenarios and models have been used to help us *think forward* into an uncertain future, *reason backwards* from desired or feared landing places and, above all, *reason together* about the uncertainties that beset us and our ability to deal with them. Through these efforts, we have learnt that we may be in danger of running out of specific resources, that alternatives can sometimes be found that preserve Earth’s ability to sustain (fulfilling, enriching, productive, etc.) life, and that sustainability is inherently multifaceted: at the least, it can be seen in economic, environmental, societal and cultural spheres, each of which is affected by forces arising in the others. We have also learnt that our activities often have unintended consequences, and that these may reverse our original intent (for good or ill). Figure 1 shows this uncertain evolution in diagrammatic form, and indicates the two main characters in the story of TERRA: the perturbing influence of the global networked knowledge society and the possibly countervailing influence of “aware” policy.



**Figure 1: The Story of TERRA**

## 2. THE SCENARIO FRAMEWORK

### 2.1. SCENARIOS AS USED IN TERRA

“The” future is always a lottery – a set of possible futures sharing a common starting point, and subject to both quantifiable and unquantifiable uncertainty. To help understand the policy choices confronting us, we make use of scenarios. A scenario is a partial description of a set of possible futures based on: a description of the *status quo ante*, a set of actors with motivations, powers, and information; a system with well-defined boundaries and mechanisms; and specific dimensions along which it is described or tracked. The narrative core of the scenario constitutes an implied or explicit storyline about future evolution, which may include branches and critical uncertainties. Scenarios should be described in concrete terms, be internally and logically consistent, and illustrate the major issues. As predictors of the future, they are all false in detail. As a result, multiple scenarios are preferable, and their construction is not only non-trivial, but may prove to be more important than the end result. Ultimately, therefore, they must be experienced interactively and the descriptions provided in written documents are introductions to the worlds that can be explored by means of the associated tools.

A set of scenarios can be described by a common *status quo ante*, and variations on four main elements<sup>3</sup>.

- Exogenous or uncontrolled *uncertainties* that are at least potentially important - these are the main features distinguishing different scenarios. In some instances, the scenario development is orientated along policy lines, or expressed in terms of success (or otherwise) in attaining specific policy targets, but this implies uncertainties relating to the underlying mechanisms or drivers.
- Policy levers that can be adjusted or debated by scenario users - in most cases, and particularly for the Growth and Equity and Information Age Sustainability frameworks, the emphasis is on the effects of policy or the endorsement of policy targets rather than specific policy mechanisms, but this implies the use of specific policy instruments.
- Mechanisms or relationships among the factors – these range from aggregate-level descriptions of the necessary logical connections among the main indicators to specific behavioural models and from relationships calibrated to or estimated from real data to paradigmatic or theoretical models. The responses of other actors to policies and the resolution of uncertainties should be seen as part of the underlying mechanism.
- Indicators by which scenario evolution is tracked and performance evaluated.

The inclusion in all scenarios of important factors whose values are known or can be predicted is important to ensure acceptance and relevance. Less important known

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<sup>3</sup> This framework owes much to the XLRM framework developed by Lempert, Popper and Bankes (2003).

factors can be included to make the scenario seem more concrete and relevant. The factors that are at the same time uncertain and important define the dimensions of ‘scenario space’ – they differentiate the scenarios from one another. Uncertain factors of minor or narrow importance are included to give colour and life to the scenario and to serve as the springboard for ‘weak signal’ analysis of developments whose likelihood and importance can be imagined but not assessed.

**Table 1: Elements of the main scenario frameworks**

<i>Scenario Framework</i>	<i>Uncertainties</i>	<i>Policy levers</i>	<i>Mechanisms</i>	<i>Indicators</i>
Human Capital [Section 3.2]	Output, consumption growth, population	Investment, education, migration, outsourcing, labour productivity	Aggregate dominant relations focusing on global ICT sector, paradigmatic model of network economy.	Skills supply and demand, consumption, unemployment, population (size, migration), GNP growth, trade balance, social support.
Equity and Growth [Section 0]	Internalisation of ecological constraints, consensus/human-rights-based governance	Market mechanisms, co-financing, global contract, security measures, trade/aid requirements.	Dominant relations among prosperity, equity, human domination of the earth, ‘Information Age’	Equity value, GNP growth, Global Hectare Equivalent, carrying capacities
Information Age Sustainability [Section 3.4]	Dematerialisation, rebound, economic growth	Factors affecting dematerialisation, immaterialisation, rebound effects, welfare productivity of GDP, IS development	Indicator-based models of interrelated economic, population and material intensity changes, Macroeconometric growth model, paradigmatic agriculture model	GDP, environmental stress, population; dematerialisation, immaterialisation, ASA-sustainability, energy use, land requirements
TERRA apocrypha [Section 0]	Separating weak signals from noise, emergence	Potentially, all.	Coevolution of network structure, flows, behaviour of networked entities; emergent behaviour, innovation	New indicators relating to network structure, efficiency, equity, resilience

## 2.2. INTRODUCTION TO THE SCENARIO FRAMEWORK

This document presents the scenario frameworks used in telling the Story of TERRA and thus to help European policy makers analyse the role of EU in the changing global context.

The basic idea here is to present “a big picture” of global transformations. The historical background includes current trends in the world economy, which provide a point of departure for the Story of TERRA. The information is provided mainly on the basis of the IFs for TERRA model and its databases<sup>4</sup>, and is available (on CD) to all interested parties in order to give a common perspective for experiencing, using and extending scenario analyses.

Trend analyses<sup>5</sup> and the scenario framework together provide the Story of TERRA meta-level framework.

Because scenarios are experienced individually, but identified and interpreted collectively, the relationships among a set of scenarios (or ‘scenario space’) distinguish scenarios from projections. Scenarios do not completely describe the future, but partially describe many possible futures. Ideally, scenarios should differ along a few dimensions or possibilities that highlight important features of the analysis.

Of course, the phenomena with which the propositions are concerned involve other important developments, especially technological progress, economic performance, welfare growth and environmental impact. These are not treated as uncertainties – to highlight the policy implications, they are largely treated as common factors (esp. technological progress), ways of describing policy levers (especially for the initial aggregate-level consideration) and performance indicators.

Globalisation: the process of ongoing and often rapid increase in worldwide flows of various kinds, including people, traded goods and services, finance and ideas. In particular, we recognise differences in globalisation patterns for:

- Markets - which have global or local supply and/or demand sides?
- Governance - which decisions are taken at which level?
- Civil society - where are people’s identities and what is the scope of the groups through which they express themselves?

This necessarily leads to more possibilities, but they can be trimmed down using consistency and explained in the scenario narrative.

Integration<sup>6</sup>: This is a complement to globalisation. Where globalisation talks about how much we affect each other, integration addresses:

- Cooperation: are decisions collective and based on mutual interest, or are they non-cooperative or power-based?
- Internalisation: Do our individual and collective decisions take (separate) account of spill over effects?

Division: there is much evidence of widening income, welfare, access to the information society, etc. divides. Rather than simply accepting these or rejecting

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<sup>4</sup> See [Tools and Models document]

<sup>5</sup> See [Living Integrated Sustainability] and the background sections in each thematic report.

<sup>6</sup> Alternatively, integration could be defined in terms of convergence - whether we do the same thing or different things.

them, we need to understand how they are linked, differentiating equality of opportunity/access from equality of outcome, and local (within-country, say) inequality from global inequality<sup>7</sup>.

The logically possible alternatives are not all equally relevant – in particular, it seems likely that globalisation will proceed, although its equity, inclusiveness and efficiency are open to debate and analysis. Moreover, scenarios developed for specific thematic analyses (Human Capital, Growth and Equity and Information Age Sustainability) framed and interpreted these dimensions in slightly different ways. This is a natural consequence of the role of scenario space in highlighting relevant features.

Beyond more-or-less measurable factors lie other domains in which we can discern major trends that are not direct results of policy choices. Some can be treated as exogenous or at least common to all scenarios. Others may be used to define “scenario space.” These trends are briefly discussed below.

Liberalisation: reducing barriers to entry (market access liberalisation), deregulation (market conduct liberalisation) and/or controlling ‘tipping’ (which may, paradoxically, entail re-regulation in some form.

- Market access liberalisation is related to globalisation - especially liberalisation of trade, which at the moment seems to be suffering severe setbacks in both the developed and developing worlds - but also the advancing liberalisation of labour and some other markets. Other specifics include IPR protection and universal access provisions.
- Market conduct liberalisation<sup>8</sup> is related to integration and such specifics as pricing, takeovers, standardisation and co-ordination or networking among firms.
- Market structure liberalisation has to do with mitigating the winner-takes-all tendency and the concentration it engenders and also with the possible emergence of sectors involving a mix of public and private entities. This is connected to the human capital and equity themes, as the following scenario description<sup>9</sup> indicates: “High-friction ... is a winner-takes-all economy where small knowledge elites capture most of the economic value. The economic structure rewards a few and leaves the great majority behind. The resulting social friction of a two-tier society consisting of ‘knows’ and ‘know-nots’ consumes much of the economy’s potential in a vicious circle.”

If liberalisation means *laissez-faire*, it is not obvious that it is (or should be) a trend; the income distributions in 'market dominance' countries are far more skewed than they are in the less-liberal 'social market' countries, especially after taxes and benefits are taken into account. Liberalisation varies in sub-scenarios - market liberalisation strongly affects the human capital theme (economic sustainability). In a way, it is part of globalisation, since market access can lead to global markets.

Dematerialisation, immaterialisation: these terms refer to the ongoing impact of ISTs

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<sup>7</sup> In particular, if the whole world became like the US, international inequality clearly falls and interpersonal inequality just as clearly increases.

<sup>8</sup> It should also be mentioned that the trajectories towards liberalisation might not be straightforward: for example, privatisation of state-owned utilities (telecom, etc.) involves several steps (privatisation, corporatisation of the dominant provider, introduction of competition, etc.). In this process, the privatisation usually needs to be accompanied by regulation, with some hope of ultimate deregulation. In many cases, however, things ‘get stuck’ one way or another.

<sup>9</sup> Peter Schwarz in *The Structure of the Global Economy*, OECD (2000).

in reducing the material input requirements of production and the substitution of immaterial (e.g. informational) goods and services for material ones in consumption. Particularly in the Information Age Sustainability theme, they are treated as drivers of impact indicators.

Demographics: the demographic transition and accompanying changes in age structures primarily form part of the underlying trends – while some analyses in the literature treat them as endogenous, this goes beyond the current scope.

Growth: It is true that the pace, scope and drivers of growth appear to have changed in recent times, particularly as regards productivity of different inputs, but the potential impact of policy justifies the decision to treat economic growth as an indicator of scenario development.

Linkage: This is a refinement of integration to represent the extent to which considerations arising in one sustainability domain are taken into account in others. Linkages to the economic dimension are of particular importance, since economic incentives and mechanisms exert such profound influences on GNKS development.

Network structure: Many aspects of the GNKS are sensitive to the way people are connected rather than simply the number connected. In particular, it is useful to distinguish three generic structures: a ‘fully connected’ single network in which (almost) everyone is connected to everyone else; a ‘small worlds’ single network in which local clusters of fully connected individuals are linked by the connections of a smaller number of ‘cosmopolitans;’ and a ‘virtual patchwork’ made up of overlapping multiple networks. This gives a more precise expression to the micro-level description of globalisation, and supports paradigmatic modelling that tests the logical consistency of assumptions about integration and division.

Satiation: We have grown accustomed to measuring success by increase – indeed, one axiom of neoclassical economic utility theory is that *more is better*, economic sustainability is often equated to rising production, incomes, and welfare. Though growth and change are ‘wired into’ the economic system, it is possible to imagine a world in which welfare levels have stabilised, rather than rising (or falling) inexorably. This is a characterisation of possible scenario outcomes.

Technology: the march of technology has proven so robust that we are reasonably safe in treating it as exogenous. We do, however, pay attention to different rates and directions of change across countries and sectors. This is clearly related to intellectual property rights, and more fundamentally to the relation between people and technology: whether technology serves us (well or poorly) or whether it transforms us (as individuals, as societies and in relation to the planet).

### **2.3. EMPIRICAL HISTORICAL ANALYSES FOR THE STORY OF TERRA**

The starting point for fleshing out the Story of TERRA with historical data is the use of the IFs for TERRA model and its data files. In keeping with other benchmarking studies<sup>10</sup>, specific data have been identified as forming a common basis for analysis. These include the original IFs for TERRA data, additional data collected during the project and indicators derived from them. To set the stage, the system has been used

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<sup>10</sup> e.g. Peter Dicken, Global Shift. Transforming the World Economy, Paul Chapman Publishing 1999.

to conduct an analysis of the potential for a global transition to sustainability in the 21<sup>st</sup> century<sup>11</sup>. It reviews progress in defining the sustainability transition across three dimensions: human life condition, social capacity, and environmental quality, and analyses the potential for transition across them. The results suggest that five key pillars support human grappling towards a successful transition: human condition knowledge, increasingly clear goals, dynamic system understanding, enhanced levers for action, and socio-political engagement. The first four are used to assess prospects for success.

## 2.4. THE MATRIX

The dimensions described above the following 2 x 2 x 2 scenario framework. This is a conventional methodological way to build scenarios (see e.g. Kaivo-oja 2001). The eight scenarios form a point of departure to frame the most important Stories of TERRA. Sustainability dimensions presented in Section 3.4.1 and the other dimensions mentioned above provide conceptually related taxonomies that can be used to assess the sustainability of a modest number of coherent stories.

**Table 1: The Story of TERRA scenario framework<sup>12</sup>**

Inequality 	<b>GC: <u>Global Cities</u></b> (Global Inequality Camps) => Neo-liberal development with overlapping specialized networks	<b>WFT: <u>World of Fragmentation and Terrorism</u></b> => Insecure world of globalisation
Inequality 	<b>GV: <u>Global Village</u></b> (Global Equality Camps) => Global compact for sustainability	<b>SW: <u>Small Worlds</u></b> (Glocal Welfare States) => <u>Glocalisation</u> creates welfare nations
	Integration 	Integration 
	Globalisation 	
<b>Globalisation Scenarios</b>		

Inequality 	<b>NEC: <u>National Inequality Camps</u></b> => National Business emphasis in regionalised world	<b>CIN: <u>Chaotic Inequality Nations</u></b> => e.g. Afghanistan, open conflict between all social groups
Inequality 	<b>NWS: <u>National Welfare States</u></b> => "old fashioned" Nordic welfare nations, national consensus	<b>LEC: <u>Local Equality Camps</u></b> => Japanese type of society, national consensus
	Integration 	Integration 
	Globalisation 	
<b>Anti-globalisation Scenarios</b>		

<sup>11</sup> [Living Integrated Sustainability]

<sup>12</sup> Adapted from Luukkanen, Kaivo-oja & Malaska 2002.

### **2.4.1. Strategically important scenarios and future alternatives**

This section provides slightly more complete descriptions of the globalisation scenarios. It includes discussions of: policy objectives in terms of general governance, economic, social and environmental policy; key actors (including the EU, discussed separately); main developments concerning the policy levers; a summary of expected evolution till 2050; and a description of the way networking unfolds.

### **2.4.2. Global Cities**

There is a lot of global interaction in this "middle way" scenario, but more through the overlap of networks specialised around work, business, interests, languages, culture, etc. than through a unified global network. Problem identification and solution attempt to strike a strategic balance between local and global institutions (e.g. to preserve effectiveness while respecting and encouraging local value differences). Moreover, there is a conscious attempt to blend the roles of public, private and civil society institutions in new (hopefully better) ways. The overlap of differentiated networks means, first of all, that the global fabric is like an appliqué piece - not a patchwork of separated regions sharing a common space, but interpenetrating areas with complementary concerns and values. Individual identity is similarly complex: as citizens of X, members of Y on-line community, interested in Z, etc. we make many different connections. As a result, diversity is much more pervasive: most 'virtual neighbourhoods' contain many people with differing experience, knowledge and even powers of persuasion. The scenario can combine the attractive features of each of the others without necessarily veering towards a (self-defeating) global paternalism or hegemony or descending into mere anarchy. In terms of integration, this scenario involves successful internalisation of environmental constraints in the economic system, but without a consensus-based approach as to how this is achieved. This is perhaps the most difficult to treat with formal modelling tools.

### **2.4.3. Global Village**

Here, the global aspect dominates - everyone can (and frequently does) communicate with people all around the globe on a wide range of subjects, and this communication is central to all aspects of life (work, consumption, cultural expression, social life, political life/collective decision, etc.). The downside is a tendency to homogeneity (less economic diversity due to winner-take-all, less cultural diversity due to excess of cultural production over cultural expression, etc.). The upside is mutual awareness of collective problems and economies of scale and scope. With most markets (labour, resources, outputs) operating on a global scale, the potential for highly effective policies working through the market is enhanced. The scenario does not necessarily lead to greater social equality or inclusiveness. There may be greater scope for treating most GNKS problems as global problems and tackling them through global governance institutions (a sort of 'New World Order'). It is equally possible for global free riding to crowd out local action that, even if it misses many important linkages, is at least something. By the same token, some local regulatory mechanisms (especially in the economic sphere) may be critically weakened by the predominance of truly global businesses beyond the scrutiny and reach of national authorities. Of course, these possibilities are not hardwired foregone conclusions. This scenario involves successful internalisation of environmental constraints in the economic system on the

basis of shared consensus. People probably also see themselves as citizens of the world to a large extent, and old allegiances may be weakened. As a partial consequence, perceptions of inequality may be sharpened over and above any actual changes in inequality due to globalisation.

#### **2.4.4. World of Fragmentation and Terrorism**

In this scenario, environmental constraints are not internalised, integration fails and inequalities of all sorts widen. The tools of the GNKS serve at the same time to enforce hegemony and to provide the means for resistance and division. This scenario is unlikely to be sustainable in any dimension, but that does not make it less likely, unless growing awareness of its limitations directs evolution towards one of the other possibilities.

#### **2.4.5. Small Worlds**

In this scenario the global network operates, but local interactions are 'more important' for most aspects of life. This is the 'polar opposite' of the global village scenario: long-range communication is mainly via limited-access 'trunks'<sup>13</sup>, as compared to the more peer-to-peer nature of the global village. The upside is considerable scope for diversity, and a restraint on the 'tipping' tendency to global monopolies. The downside is the likelihood of greater inequality - more 'pockets' of isolation and poverty, and greater difficulty in mobilising global solutions to global problems.

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<sup>13</sup> This does not refer simply to telecom networks, of course.

**Table 2: Globalisation scenarios: a table of future alternatives**

	GC	GV	WFT	SW
<b>Policy objectives</b>				
<b>Governance</b>	Reducing the role of the state: voluntary agreements, privatisation	Sustainability of societal development by integrated social, environmental and economic policy, involvement of civil society in decision process.	Global war on terrorism led by USA, supported by EU. Security driven policies and increasing citizen control, military expenditure	European council and thus member states get stronger control over EU politics, leading to renationalisation rather than deepening integration
<b>Economic</b>	Market dominance, international competitiveness, deregulation, lower taxes, free trade, and globalisation.	International development co-operation, competitive economy	Barriers to free movement of human capital, protectionism	Social market
<b>Social</b>	Reforming the social safety net	Reduction of digital divide, social cohesion, gender equity	Reduced social resources	Enhanced social resources
<b>Environment</b>	Damage repair	Healthy environment	Reduced environmental resources	
<b>Role of key actors</b>	Public authorities minimise their activities. The business sector is a key actor. Unions are forced to minimise their activities. Civil society has a reduced power and role.	Public authorities define regulation framework. Business sector focused on innovation-based competition. Unions focus on salaries and working hours. Civil society networks nationally and internationally increase influence.	Public authorities strengthen control esp. military and security. Security legislation limit non-defence business. Unions tightly controlled. Civil society has reduced power and role.	Public authorities increase activities. Business sector focuses on home markets. Unions guarantee political consensus. Civil society remains independent but co-operates with authorities and business.
<b>Role of EU</b>	Partner of neo-liberal powers	Partner of United Nations	Active partner of NATO	Partner of EU member countries

	GC	GV	WFT	SW
<b>Policy levers</b>				
<b>Human capital:</b> education/training; mobility of workers; mobility of work; supporting investment; job quality	Increased private investment in ICT education, but human capital deficit rises in some areas and occupations.	“Information Society for All”	Human capital deficits due to the decreasing mobility of labour	Local skill development. Balanced human capital development.
<b>R&amp;D and knowledge policies</b>	Private investment dominates R&D and knowledge policies	Green investments funds dominate R&D and knowledge policies	Military sector dominates R&D and knowledge policies (“Star Wars”)	“Small is Beautiful” R&D and knowledge policies
<b>Internalising externalities:</b> prices, taxation, etc.		International ecological tax reform.	Taxation increases considerably for security reasons.	International Tobin tax and increased natural resource use taxation.
<b>Redistribution:</b> taxation, benefits, investment, etc.	Increasing capital incomes, falling labour incomes Taxation favours capital incomes			
<b>Value change:</b> leadership, education, etc. raise awareness – esp. of sustainability issues				
<b>Migration</b>				
<b>Expected outcomes on thematic lines till 2050</b>				
<b>Human capital (economic)</b>	Polarised economic development in and outside Europe	Balanced income development.	Harmonised economic development in and outside Europe	Balanced income development.
<b>Equity (social)</b>	Widening inequality within and among countries. Rapid, uneven economic growth	Greater equality within and among countries. Moderate, even economic growth	Falling equality within and among countries Moderate to poor uneven economic growth due to decreasing global trade, insecurities	Communication, participation improve cohesion of Eur. societies. Equality rises within countries, falls among countries. Growth prospects uncertain.
<b>Environmental</b>	Little control of rebound effects or compliance with international agreements	Dematerialisation, immaterialisation and effective international co-ordination.	Unsustainable environmental development	Dematerialisation of production and immaterialisation of consumption due to local production, reduced transport
<b>Communication and networking</b>	Global communication thrives among affluent countries. Increased dependence on communication infrastructures. [global cities]	Global communication will thrive between all the countries of the world. [global village]	Global communication are controlled by military and security officials [small worlds]	Local communication networks are developed and utilised including different types of communication.

Table 2 provided the research team with an analytical perspective on different storylines of TERRA. This table of future alternatives did not constrain the thematic analyses, but the dimensions highlighted in those contexts are related to these overarching themes:

- The Human Capital scenarios are largely defined in structural<sup>14</sup> and quantitative terms. However, the migration and outsourcing scenarios are consistent with Global Cities and Global Villages (depending on institutional arrangements) and the education scenario is consistent with Small Worlds.
- The Equity and Growth scenarios are defined along the axes of internalisation of environmental constraints and use of consensus in achieving global solutions to collective problems. These align fairly closely to the integration and division axes, respectively.
- The Information Age Sustainability scenarios (See Section 3.4.1) are defined along the evaluative axes of environmental stress and economic and welfare growth. These are not directly aligned with the above axes, but it is possible to place them using necessary conditions for attaining the indicated changes. Thus it is possible to relate Global Villages to “Strong Sustainable Development”; Global Cities to “Happiness in a Polluted Stone Age”; World of Fragmentation and Terror to “Doomsday”; and Small Worlds to “Deep Ecology”.

#### **2.4.6. The possibility of satiation**

We are accustomed to thinking of sustainability in monotonic terms: increasing welfare; increasing production; decreasing environmental pressure. At the same time, we recognise that current trajectories do not meet these conditions: production may be increasing, but not to the same degree everywhere; welfare may be increasing, but is certainly falling in relative and even absolute terms in major parts of the globe. Environmental stress is monotonic – but in the wrong direction. Some of this monotonicity is built in to the system: accelerator effects and ‘creative destruction’ illustrate the way modern macroeconomies are tied to continual innovation and growth. The sustainability analysis should also consider whether this form of perpetual increase is feasible or desirable. Just as a natural population can stabilise within an environmental niche, so one might envisage a world in which welfare levels (in particular levels of consumption) stabilise, to match the emergent stabilisation of population trends. In the environmental sphere, any increases in consumption of resources must be matched by proportionate increases in eco-efficiency, suggesting again that stabilisation may be a long-run consequence of diminishing returns to innovation. This does not mean that we are anywhere near such a landing place, or indeed that we can reach it without continued growth in some areas – if only to reward necessary efforts, fund necessary innovation and close the gaps that currently threaten sustainability.

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<sup>14</sup> Extent of the problem, robustness, stakeholder involvement.

### 3. THEME-SPECIFIC SCENARIOS

#### 3.1. INTRODUCTION

This section provides a record of scenarios developed in TERRA's thematic analysis activity. These reflect specific themes rather than the general schema outlined above.

#### 3.2. HUMAN CAPITAL SCENARIO FORMULATION

##### TERRA'S WORK ON HUMAN CAPITAL

As an example, the following policy issue, scenario computations and policy recommendations are paraphrased from the TERRA report on 'European Policy Options for Human Capital Enhancement'.

A defining characteristic of the first half of the 21<sup>st</sup> century is an exponential growth in knowledge and information. Human capital is overtaking physical capital as the predominant source of growth in developed countries. "*Knowledge and information is being produced today like cars and steel were produced a hundred years ago.*"<sup>15</sup> Intellectual rights are increasingly traded instead of physical products.

A recent study by *Alfred Herrhausen Gesellschaft*, AHG, using data on annual costs of education, computed German human capital at €12.4 trillion in the year 2000; and predicted that it "will never be the same", declining to €8 trillion by 2050. By way of comparison, using the estimated German capital output ratio of 2.5 and GDP in 2000 of €1.8 trillion, physical capital is €4 trillion Euros. Human capital per capita thus amounts to about €250000.

The European Union's demographic reality constrains the availability of human capital and therefore economic growth. This is particularly acute for the ICT sector and other knowledge-based sectors needing a labour force with tertiary education. Innovation rather than skill alone is the key to success in such sectors<sup>16</sup>. According to the Volker Jung, President of BITKOM, "*Computer companies in Germany are unable to fill some 75,000 jobs and the demand for specialists is expected to increase to 300,000 by 2003. At the same time, the German educational system produced just 10,000 qualified people in 1999.*" The situation is exacerbated by the fact that human capital is in short supply not only in Europe but globally as well. According to Indian Government sources, for example, shortages extend even to science and mathematics teachers with professionals migrating to ICT specialisations in the country and abroad<sup>17</sup>.

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<sup>15</sup> Stiglitz (1999).

<sup>16</sup> See Cave (2003b) for more detailed treatment of the implications of knowledge intensity for growth.

<sup>17</sup> This is an example of a negative feedback; today's demand destroys tomorrow's supply.

## Scenario Analysis of EU Policies in the Global Context

To give a flavour of the approach and relevant results, this section analyses EU policy options to secure human capital necessary for domestic development and growth of Information Society Technology. The EU policy objectives addressed include:

- Secure human capital to achieve desired EU development and growth objectives.
- Take advantage of foreign human capital investment<sup>18</sup>.
- Reduce unemployment.
- Monitor and rationalise outsourcing of high-level ICT R&D and innovation akin to widespread outsourcing in manufacturing.
- Enhance social capital as the “*glue that holds society together.*”<sup>19</sup>.

Progress towards these objectives is measured by the following:

- ICT human capital deficit
- Immigration of highly skilled professionals
- Acceptable level of ICT industry R&D outsourcing
- Social contract
- Unemployment
- Economic growth
- Balance of trade
- Sustainability

The time horizons used for analysis are 2025 and 2050. Because the problem stems from a mismatch in the level and location of work and skills, the policy levers can be framed as follows:

- Bring skilled people to the work – this is essentially a ‘*business as usual*’ (BAU) scenario in which labour productivity grows at 1%/year<sup>20</sup>;
- Increase local supplies of skilled personnel – this is the *education scenario*, in which, following IIASA<sup>21</sup> tertiary education is assumed to rise from 17% in 2000 to 34% in 2050;
- Increase investment in innovation that raises productivity (e.g. by deploying ‘smarter’ and less skill-intensive technologies) – in this *labour productivity scenario* investment in knowledge acquisition based labour productivity is increased to the level needed to remove the need for ICT human capital import by the end of the time period; and
- Send the work to the people – in this *outsourcing scenario* up to 35% of ICT sector activity is relocated outside the EU to achieve the same objective of eliminating the need to import human capital by the end of the period.

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<sup>18</sup> Competition for human capital in the first half of the 21<sup>st</sup> century will be as intensive as was the competition for financial capital in the second half of the 20<sup>th</sup> century.

<sup>19</sup> Puttnam (2000).

<sup>20</sup> This reflects detailed assumptions about the pace, type and profitability of innovation based on recent experience. Cave (2003b) discusses the foundations in terms of a Schumpeterian view of growth slowed by the need to adapt as well as adopt.

<sup>21</sup> Lutz and Goujon (2001).

For quantitative scenario analysis using the dominant relations model<sup>22</sup>, four scenario families were considered, corresponding to the following questions:

- How difficult is the problem?
- How robust are the policies; i.e., how will they perform if some contingencies take place outside of those originally envisioned?
- How can stakeholders become involved in policy development?

### **3.3. GROWTH AND EQUITY SCENARIO FORMULATION**

It has never been so difficult as today to say anything about the future 50 – 100 years ahead, in spite of our world knowledge society. But though we cannot know the future it may be possible to say something about the forces that influence it and alternative courses of evolution. Particularly important insights driving this analysis are:

- The ubiquity of self-organization into scale free power-law, small-world networks in society, the economy, business and research;
- The important role of power laws and fat hubs;
- The predictive power of such approaches concerning the spread ISTs; and
- The connection of all those issues with building world-wide human capital and relations to issues of population growth.

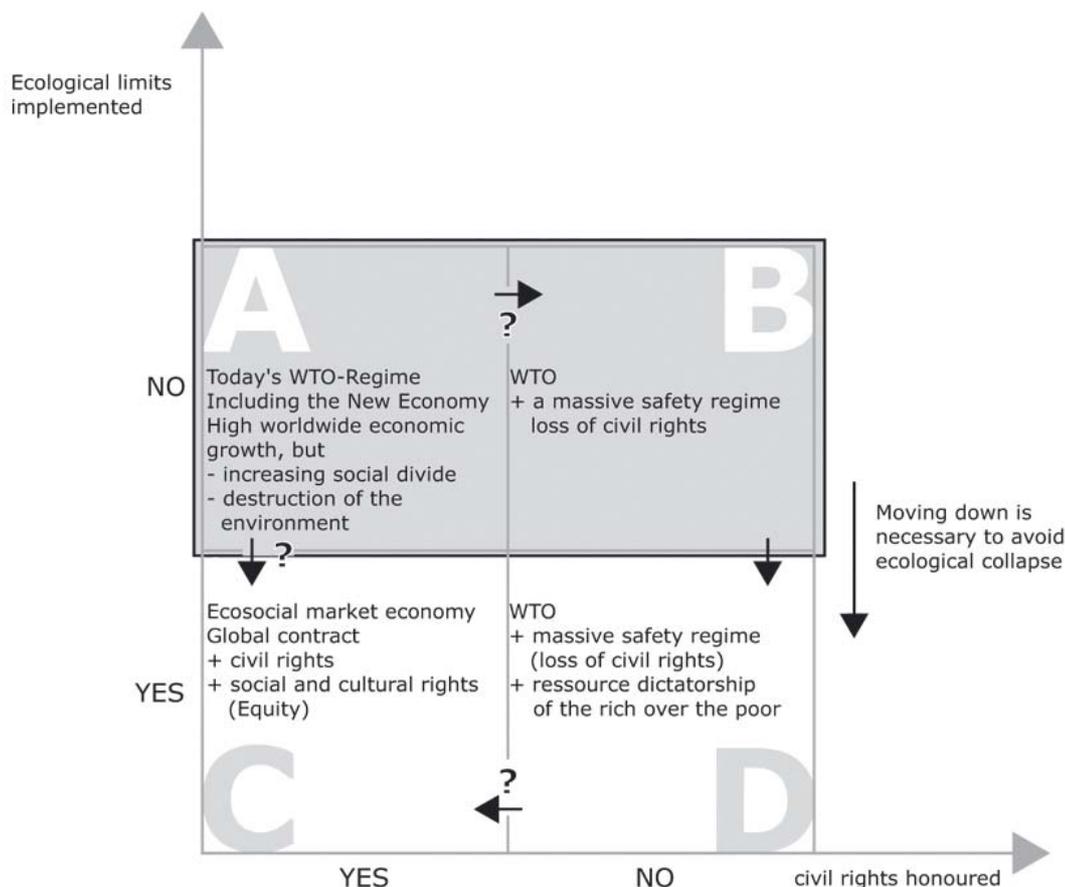
The scenario development takes a world ethical perspective and asks two questions:

- Whether humankind will eventually incorporate critical physical limitations into its world economic system regime; and
- Whether, whatever we do, we will respect human dignity and individual human rights in a symmetric, fair way for all people in this world

The four cases are shown below.

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<sup>22</sup> See Sec. **Error! Reference source not found..**



**Figure 1: Equity and Growth Scenarios**

Scenario A is essentially the present WTO regime. The physical limitations of the world are unfortunately not incorporated adequately into the world economy via adjusted prices or other constraints. We use too many resources, we pollute too much, and under prevailing growth processes, the situation will soon become worse instead of better. This also produces unacceptable asymmetries of wealth among and within many countries. Gaps and troubles are ahead in this scenario.

Scenario B: Asking how we will eventually deal with phenomena such as overshooting and resource competition, Scenario B couples the situation of Scenario A with massive security regimes to control all people and to be enable the rich world to react to conflicts and terrorism around the globe as a result of the implied shortages, disasters, etc.

Scenario C is the so-called eco-social case. This balanced future has been discussed in many publications. It starts from the European social market economic model, and extends it by strict environmental rules. Similar structures can be found in developed Asian democracies, which use family nets etc. for creating social cohesion. The most typical current aspiration towards eco-social market economy philosophy is European Union accession process, which can be regarded as “small globalisation.” Here, less developed partners are integrated into a sophisticated frame of rules and standards which they are willing to accept, even if at the cost of economic competitiveness, in exchange for co-financing by their richer future partners. This element is also

characteristic for the Montreal Protocol for avoiding CFC emissions to protect the ozone layer and for the Marshall Plan.

Scenario D incorporates physical resource and pollution limits by an asymmetric regime. The North keeps its present status as a big resource user and a big polluter, and stabilises the worldwide ecological situation by preventing the South from catching up. Note that countries in catch up processes can make grow at more than 6%/yr because they start from a low level. In addition, they can imitate developed states, and need not rely so heavily on innovation. So, in principle, (even) under current conditions the poorer countries could catch up. A resource-dictatorship regime would somehow have to prevent that, for instance by destabilising poorer states or enforcing expensive requirements or standards without co-financing. An extensive free trade order system could have the same effect, for instance, if rich countries can monopolise supplies of a bottleneck resource (e.g. oil). Considerable resistance extending to terrorism is to be expected, leading to counter-terrorism, public surveillance etc. The resulting resource-dictatorship regime, coupled with massive security architectures, is certainly not a comfortable landing place for the future.

### 3.4. INFORMATION AGE SUSTAINABILITY SCENARIO FORMULATION

#### 3.4.1. The sustainability analysis framework

Prior work (see Kaivo-oja, Luukkanen and Malaska 2001a and b) identified a three-dimensional framework for sustainability analysis. The dimensions are: production, welfare and environmental stress. These are related (but not identical) to economic, social and environmental sustainability – production and welfare are important aspects of economic and social sustainability while environmental stress *is* an indicator of environmental sustainability. Roughly, sustainability is currently viewed as requiring improvements along all three dimensions. The thematic analysis refined this to focus on welfare (by linking welfare and economic growth) and environmental stress. This raises two questions:

- Can we find trajectories meeting this condition?
- Are there sustainable trajectories in which one or more dimensions stabilise?

A summary of possible paths based on previous analyses is presented in Table 3, in approximately decreasing order of sustainability. The shaded paths were not directly examined.

**Table 3: Possible Welfare-Economic growth-Environmental stress trajectories<sup>23</sup>**

Economic growth	Welfare	Environmental Stress	Description
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<sup>23</sup> Kaivo-oja, Luukkanen & Malaska 2001.

↑	↑	↓	“Strong Sustainable Development”
↑	↑	↑	”To Eco-destruction in First Class”
↑	↓	↓	“Social Misery with Growth and Nature”
↓	↑	↓	“Deep Ecology”
↑	↓	↑	“Destructive Growth”
↓	↑	↑	“Happiness in a polluted Stone Age”
↓	↓	↓	“Hard life with Nature”
↓	↓	↑	“Doomsday”

Three specific scenarios were developed in this theme. The Business-as-usual scenario was a “forward scenario” – the starting point is the present, and the values of the variables are unfolded by using an information system based on trends or other assumptions concerning the development of the driving forces. The Factor 4 and Factor 10 scenarios adopted a normative or backwards scenario analysis approach starting from future targets or landing places and reasoning backwards to the present.

### 3.4.2. The BAU scenario

The construction of forward scenario needs assumed time series for three driver variables. The rest of the variables are calculated according to the ASA information system logic<sup>24</sup>. The drivers selected for the BAU scenario are change rates of GDP, CO<sub>2</sub> emission intensity (CO<sub>2</sub>/GDP) and population.

The results indicate that gross rebound effects pose significant sustainability problems in the EU. The likely scale of dematerialisation cannot counterbalance the gross rebound. As expected in the case of the EU, the partial rebound effect of increased standards of living is more problematic than that from population growth.

### 3.4.3. Factor 4 and Factor 10 sustainable growth scenarios

Various prior analyses<sup>25</sup> have indicated the need to reduce environmental stress in its different forms. It is customary to reduce the issue of reducing environmental stress through dematerialisation to resource productivity. Thus one may equally well claim that advancing sustainability requires a mean dematerialization rate of 2%/yr, or a 2.7-fold increase in resource productivity in 50 years. The Factor 4 and Factor 10 catchwords have become familiar in sustainability discussions. Such a Factor 4 or Factor 10 scenario is not necessarily ASA-sustainable<sup>26</sup> or not; this study considers only sustainable scenarios. The drivers are; (1) the ASA-sustainability condition that growth not exceed the maximum level consistent with non-increasing environmental stress, (2) the landing place target, i.e. 4-fold or 10-fold improvement in resource

<sup>24</sup> See FFRC (2003).

<sup>25</sup> e.g. UNEP 2002, Weizsäcker et al 1997, Carnoules Statement 1997.

<sup>26</sup> I.e. offering increasing GDP and reduced environmental stress.

productivity, and (3) the targeted time period for the landing place<sup>27</sup>, which determines the starting point of the backwards scenario calculations.

### 3.5. WEAK SIGNALS OF GLOBAL CHANGE

Global change is frequently disruptive across a wide front and may appear to ‘come from nowhere.’ However, the forerunners of global disruption can often be found in small, localised ‘leading indicators’ – these may be termed weak signals. They are important to scenario analysis because the implications of such indicators form the interesting and novel ‘storyline’ for the scenario.

Weak indicators relating to the TERRA scenarios can be related to a widely used framework for studying technologically driven disruptive change – so-called Kondratieff cycle analysis. The scenarios do not assume that the analysis is exactly correct, still less endorse the more extravagant uses of the analysis to relate all sorts of phenomena. However, the analysis does help to identify the qualitatively different phenomena at different points in the cycle and the consequences of acceleration. Analysis to date has identified five cycles or waves of economic development, each lasting some forty to sixty years.

Kondratieff wave 1: Early mechanisation

Kondratieff wave 2: Steam power and railway

Kondratieff wave 3: Electrical and heavy engineering

Kondratieff wave 4: Fordist mass production

Kondratieff wave 5: Information and communication technology

TERRA is concerned with the 5<sup>th</sup> cycle and possibly the beginning of the 6<sup>th</sup> wave. The elaboration of TERRA scenarios draws on conceptual and empirical analysis of this question aided by TERRA’s Insight-, Strategic- and Policy-level models.

The cycle-based perspective forces a deeper understanding of sustainability. In the domains affected by cycles, sustainability does not – cannot – imply continuity in literal terms such as profit levels, use of resources, institutional structures, etc. Any such conservation must be sought in derived indicators like welfare, carrying capacity.

As part of the general acceleration of life, some commentators have suggested that the period of Kondratieff cycles is shortening. Although the shape of the next cycle is not obvious, some ‘weak signals’ suggest that the next phase of economic development may be characterised by “the extension of humanity.” In every previous cycle, the opportunity to meet existing needs in more efficient ways led to new goods and services and sometimes-profound social disruption. The harbingers of the next cycle of changes can, possibly, be seen in such weak signals as:

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<sup>27</sup> Here, 50 years for Factor 4 scenario and 100 years for Factor 10.

- Saturation of ICT penetration in large corporations
- Growing evidence that ICT *per se* is not a sufficient condition for stock market or business success
- Productivity studies suggesting that the impact of ICT narrowly defined is either encountering diminishing returns or 'hidden' in e.g. increased utility that is not captured in market transaction values
- The 'fine print' of the Shell scenarios, which demonstrate that energy consumption 'tops out' as income rises, etc.

The potential shape of a 6<sup>th</sup> cycle can be seen in other weak signals:

- The growth of 'enhanced reality' and its uses - human-machine interfaces (e.g. 'wearable' computing equipment, medical monitors, etc.)
- Certain aspects of drug use:
  - New synthetic drugs and patterns of drug use aimed at enhancing particular experiences
  - Performance-enhancing drugs including 'smart drugs.'
- Greater complementarity in work profiles
- Powered exoskeletons being developed for agricultural and warehouse workers
- Robot surgery devices
- Computers directed by thought
- Eugenic genetic manipulation and other biotechnologies
- Diffused and overlapping concepts of identity supported by particular technologies including shared VR - like on-line computer gaming.

Others signals even stretch to changes in governance and emerge as a natural adaptation to the end of the oil era: if we cannot so easily travel for personal or shared experiences, we will use information technology and other means as a new thing in itself that drives progress in all areas.

The question whether we are in the maturing 5<sup>th</sup> wave or the beginnings of a 6<sup>th</sup> wave carries thematic implications as indicated in Table 4.

**Table 4: Thematic implications of “human extension”**

Thematic Area	Implications of early-stage 6th wave of human extension
Human capital	Transformation of skill formation and use: human-machine combinations or other 'extensions' can greatly enhance individual productivity in physical tasks and symbol-manipulation tasks
Equity and growth	Both ICT and biotechnology weak signals raise troubling questions of division between the 'enhanced' and the 'ordinary.'
Environmental sustainability	Obvious dematerialisation and immaterialisation aspects, possibilities for enhanced engagement with and solution to global problems

In scenario terms, this type of 6<sup>th</sup> wave seems fully consistent compatible with progressive globalisation. Within the main scenarios, we can distinguish sub scenarios associated with different types of progression: i) spending the next 20 years with all

the human-extensions stagnant, perhaps inhibited by institutional problems or failure of social consensus; ii) a complete failure of global control and many mad and bad things happen (esp. in the GC and WFT scenarios); and one with greater focus on positive aspects and emergent consensus about appropriate directions and safeguards on a global (GV) or local (SW) level.

A closely related theme that could enrich the story concerns the extent to which continued growth (whether in economic or welfare terms) is even feasible – let alone desirable. What's wrong with good enough? True, markets depend on growth - and look where that's gotten us! This enters into the sustainability analysis (see Section 3.4.1) and can be addressed explicitly in scenario modelling.

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