Forward looking needs systematised megatrends in suitable granularity

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Abstract

Purpose – The purpose of this paper is to inquire about the applicability of the concept of granularity to the necessity of future research or – as often called in the European Union – forward looking (FL). After theoretical deliberation, it uses a planned world-wide information system as a case study for applying the notion of granularity regarding economic sectors, time steps, geographic regions and correlations for energy, water, land use and several other drivers of global change.

Design/methodology/approach – A planet-wide information system might optimally include areas such as human development indicators, water demand and supply and deforestation issues. A short literature analysis on "granularity" shows this concept to have a highly culturally determined and constructivist nature.

Findings – The spatial, temporal and sectoral granularity of data presentation strongly impacts conclusions and considerations while looking forward. Hence, granularity issues are of key importance for the question of which megatrends are ultimately discerned as most relevant.

Practical implications – These findings may impact the regular report on global megatrends authored by the European Environment Agency, as well as world-wide energy and emission scenarios and technological foresight, such as the "Global Change Data Base" as a next step of research.

Social implications – In future research, the step from purely quantitative perceptions towards structural perceptions, pattern recognition and understanding of system transitions might be facilitated. The FL statements of larger companies might be diversified, enlarged in scope and use deeper structural understanding.

Originality/value – Earlier databases tend to have been focused on one or several single disciplines; the present approach, however, attempts transdisciplinarity and a multiparadigmatic approach.

Keywords Foresight, Energy, Economy, Forward looking, Geo-information, Global change, Granularity, Future research, Global studies, Global change database, Technology assessment

Paper type Research paper

1. Introduction: forward looking (FL) as a concept

Future research might enjoy wider usage as a term denoting "a science of the future" or futurology, (Jungk, 1954, 1958, 1987) but the preferred discussion in this paper is about "forward looking" (FL), a term used by the European Union.

FL is defined as "concerned with or planning for the future" (*Merriam-Webster*, 2013), "planning for and thinking about the future in a positive way, especially by being willing to use modern methods or ideas" (Longman, 2013), "favouring innovation and development; progressive" (Oxford, 2013), briefly "ahead of the times" (AE, 2013). On the contrary, Investopedia (2013) sees FL as "a business slang term for predictions about future business conditions" that is regulated by US legislation "requiring public

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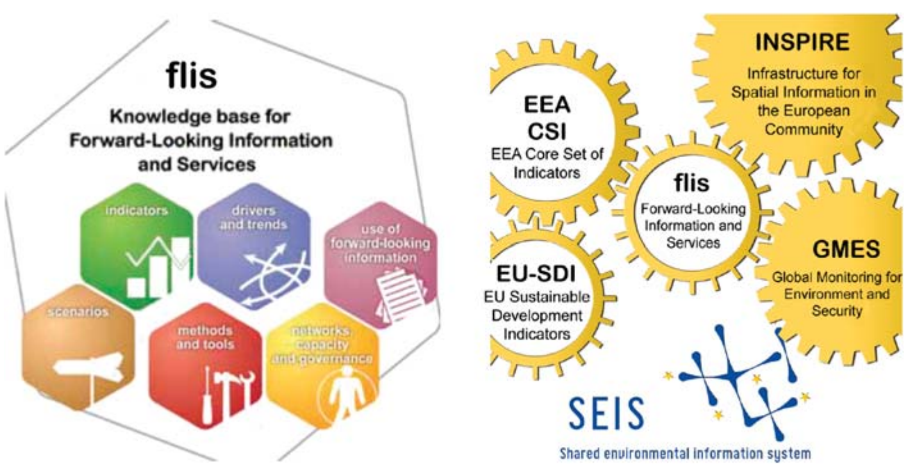
companies to include a disclaimer on all management discussions with investors in order to emphasize this point. When properly emphasized, stockholders generally may not take legal action against company management for forward looking statements which proved to be inaccurate" (Schneider and Dubow, 1996, p. 1071). Myriads of such defensive statements can be found on the web, mainly stemming from large businesses. Such is one possible strategy: to defend oneself strongly against false prophecy and the undetermined nature of the future.

This paper, however, chooses the opposite strategy: try to know as much as possible about the future!

For the author, future research is one of the most appealing and intriguing subjects (Horx, 2006; Rauch, 1985, 1999, 2013, 2014; Korotayev and Zinkina, 2014; Zinkina *et al.*, 2013; Korotayev *et al.*, 2011; Chumakov, 2010, 2014; Matzenberger, 2013; Schwarz, 2012; Wittmann, 2012), including the analysis of megatrends. The European Commission (2013) states that "forward looking activities (mostly foresight and forecast but also technology assessment and horizon scanning) have a large scope and can be used for several purposes: to inspire new EU policies, to assess policies and measures, to anticipate potential disruptive events, and to build contrasted visions of the future" and has triggered a bundle of related activities. In a similarly positive vein, PriceWaterHouseCoopers has issued a "Guide to forward-looking information", subtitled "Don't fear the future: communicating with confidence" (PWC, 2007) and enriched with valuable practical examples.

The European Environment Agency's (EEA's) definition of FL is process-oriented: the "*Knowledge base for Forward-looking information and services* (FLIS) is a platform to support long-term decision-making. The aim of FLIS is to introduce forward-looking components and perspectives into existing environmental information systems and to expand the knowledge base and its use" (EEA, 2011a).

The EEA understands FL as a cooperative exercise (EEA, 2011a), including the six components "drivers and trends, indicators, scenarios, methods and tools, networking, capacity-building and governance, and use of forward-looking information", symbolised by six hexagons in the FLIS logo (Figure 1 at left). The logistical embedding of FLIS



Source: EEA (2011a, b)

Figure 1.
At left: logo and internal structure of the FLIS endeavour (Forward-Looking Information and Services) as defined by the European Environment Agency EEA; at right: greater embedding of FLIS

into a wider set of activities is displayed at right in Figure 1 (the source of both images is EEA, 2011a, b). One of the first activities in the cooperative process was the study "catalogue of scenarios" (EEA, 2011b). In recent years, EEA staff has cared for a web-based collaboration platform in the EIONET framework (European environment information and observation network: Eionet, 2013), including all 33 current EEA members and six cooperating partners.

An earlier article in this journal has proposed a "Planet-Wide Information System" (Ahamer, 2013b) that takes into account the evolutionary and iterative nature of any human action (Ahamer, 2005, 2008, 2013a).

2. Granularity as a concept

Granularity as a concept has an extremely wide usage, e.g. in astronomy, photography, physics, linguistics, medicine and fairly often in information technology (Rouse, 2005; Kästner *et al.*, 2008; SAP, 2013; OneLook, 2013; Encyclo, 2013; Moskovkin *et al.*, 2014; Watson and Hardaker, 2005; Watson *et al.*, 2007; Lewis *et al.*, 2005; Ahmed and Hardaker, 1999) and may be defined as "the extent to which a system is broken down into small parts, either the system itself or its description or observation" (Wikipedia, 2013). This source sees physicists (and molecular biologists) describing granularity as follows: "A fine-grained description of a system is a detailed, low-level model of it. A coarse-grained description is a model where some of this fine detail has been smoothed over or averaged out". Analogous concepts are used for data sets and in parallel computing. Clearly, the substructure may either be allocated to the object (Bleisch and Duckham, 2012), or to its understanding (Greer and McCalla, 1988, p. 347): "consisting of or appearing to consist of granules" (*Merriam-Webster*, 2013) which highlights the constructivist character of the entire notion (Ahamer, 2008, p. 74; 2012a, p. 328):

- Economists even envisage a "granularity of growth" (Viguerie *et al.*, 2008, p. 20) which provides a link to the theme of this paper; namely global evolution and FL.
- Geography, more specifically the disciplines of Geo-information, GIScience (often based on ontologies: Fonseca *et al.*, 2002, p. 122; Reitsma and Bittner, 2003, p. 13) and Remote Sensing, call for data analysis at different levels of granularity (Abler *et al.*, 1971; Lang *et al.*, 2010, p. 5709; Tiede *et al.*, 2010, p. 194; Hölbling *et al.*, 2012, p. 1331; Breiling *et al.*, 2005). Such approaches (Lang *et al.*, 2004) utilise image analysis (a concrete implementation of "pattern analysis" within a more generalisable "science of complexity") and define geographic units of socio-economic vulnerability (Kienberger *et al.*, 2009, p. 770); practically applicable for GIS tools for site management (Lang and Langanke, 2005, p. 192) and theoretically based on the geon concept (Lang, 2008; Lang *et al.*, 2008). Such research can be used more widely for landscape metrics (Langanke *et al.*, 2007, p. 164), forest stands classification (Hernando *et al.*, 2012, p. 219), ecological monitoring (Blaschke *et al.*, 2002) and refugee camp evaluation (Hagenlocher *et al.*, 2012, p. 33; Tiede *et al.*, 2013) using object-based image analysis (OBIA) for remote sensing (Blaschke, 2010, p. 8). It is possible that purely technologically oriented studies might not always cover aspects of practical policy making (Damböck, 2012, p. 290; Habermann *et al.*, 2012, p. 220; Langthaler *et al.*, 2012, p. 240; Amirabedini, 2014; Sayamov,

2013; Ilyin and Rozanov, 2013; Korotayev, 2008; Zinkina *et al.*, 2013) or transdisciplinary technology assessment (Müller *et al.*, 2013, p. 221; Duraković *et al.*, 2012, p. 263; Bader *et al.*, 2013, p. 118; Ahamer, 2012b, c, p. 2521; Watson *et al.*, 2012).

- In the role of mathematicians dealing with granularity, Greer and McCalla (1988, p. 350) state that "if an object is recognized (either by abstraction or parts recognition) and that object is a member of a more abstract class of objects, then the more abstract class is also recognized" and "we are convinced that granularity hierarchies can be used to solve many other recognition problems"; thus underlining the potential suitability of this paper's intended granularity-oriented approach towards the novel science of FL.

One of the key questions for geo-referenceable data are the choice of suitable granularity (Wu, 1999, p. 381; Wu and Harbin, 2006, p. 6) as it develops after a thorough analysis of approaches towards a science of complexity. The present paper suggests considering not only geographic granularity, but several types of granularity that are defined analogously.

3. Types of granularity

Analyses of the definitions of space-related granularity (Wu and Marceau, 2002, p. 3; Wolak, 2011, p. 248; Keet, 2010) suggest expanding the notion of granularity also to other substrates such as time, (economic) sectors and thematic scopes. The present chapter undertakes to suggest approaches to such untypical types of the notion "granularity".

3.1 Granularity regarding economic sectors

When dealing with information systems including economic data, one of the important questions might be the level of differentiation into economic sectors. World-wide economic data sets know about three main levels of disaggregation (Ahamer, 2014):

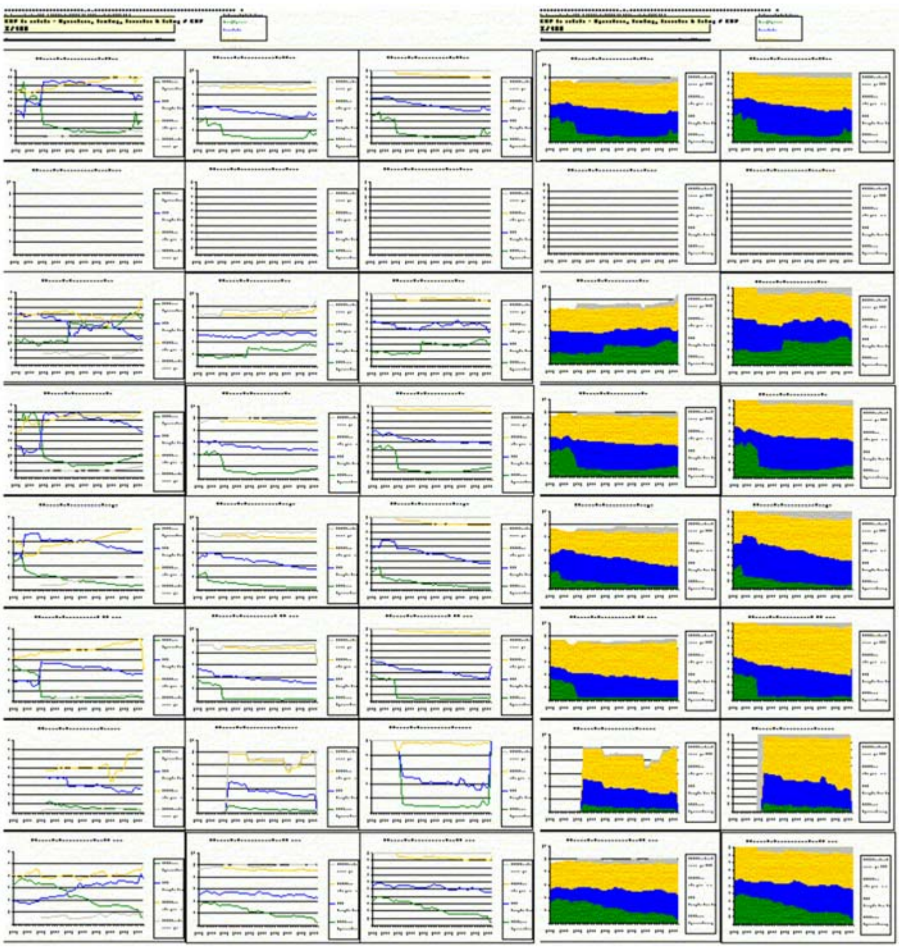
- Three main sectors (Figure 2): agricultural (first, in green), industrial (second, in blue), and service sector (third, in yellow).
- Ten sectors: agriculture, mining, manufacturing, electricity and gas, construction, commerce, transport and communication, finance and insurance, communal and social services (Ahamer, 2013c, p. 278).
- Some 40 sectors as used by the UN Statistics Division (UNSTAT, 2013).

Case studies for the harmonisation of national economic data and national environmental data were provided by Wolf *et al.* (1998, 2000) and are now widely applied within Eurostat and UN-ECE for the targets of official national reporting.

3.2 Granularity regarding geographic regions

An analysis of long-term techno-socio-economic trends may be performed quantitatively by a planet-wide information system, e.g. the planned "Global Change Data Base" (GCDB) (Ahamer, 2001, 2013b) (see Figure 3).

The perception of trends, their stability, longevity and significance towards real-world development can suitably be read from plots of time series at different



Source: GCDB

Figure 2. Example for coarse granularity of economic data: GDP shares are depicted by three sectors by area

levels of geographical disaggregation (Ahamer, 2014). Changes in data availability along time might give wrong impressions of changes in trends; however, the introduction of previously uncovered countries is likely to produce jumps in data graphs (as principally conceivable from Figure 2). In order to sort out influences of such changes in data coverage, an illustration of data availability (measured in per cent of regional and global population covered by data) is provided (Figure 3 below right), using the example of "irrigated area per agricultural area" with generally good data coverage. It is self-understood that meteorological or biospheric models principally call for higher spatial resolution (Figure 4) than economic, energy or social models.

3.3 Granularity in correlations

Earlier "classical" scenario writing (SRES, 2000; Grübler *et al.*, 2012) suggests that correlations between parameters (mostly intensity parameters such as quotients) with the (easily computable, even if disputable proxy for) economic level GDP/capita

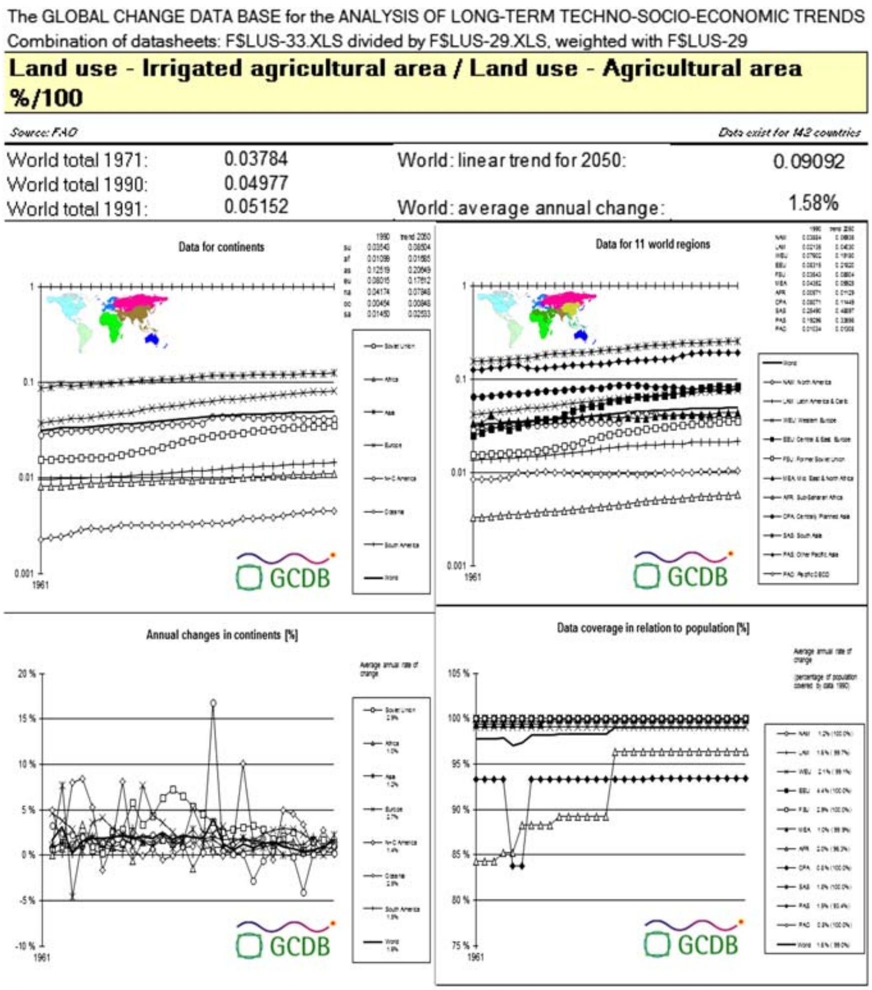


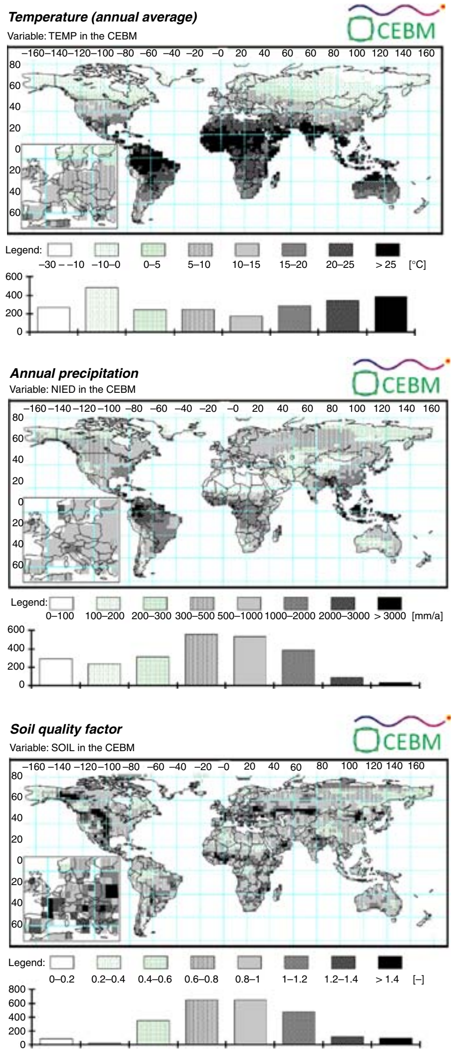
Figure 3.
Low-granularity example of raw data for a planet-wide information system: irrigated area per agricultural area for each of 147 countries world-wide

Notes: Computation of annual chang rates (below left) and of geographic aggregates (regions or "continents", above, according to the map insert) must take into account data availability (plot of data coverage, below right)
Source: GCDB

are better strategies for data analysis than pure time series. Such correlations (with economic level instead of time) promise to better describe structural qualities of complex socio-economic systems (Birkmann *et al.*, 2013; Ahamer, 2014).

However, the analytical tool of the GCDB (Ahamer, 2013b) should allow still more sophisticated types of correlation. Figure 5 uses as an example the correlation of the two following parameters that were chosen in line with classical scenario analysis:

- on the horizontal axis, a proxy for cereal production efficiency per area: "production of cereals/harvested area of cereals", measured in tons per hectare; and
- on the vertical axis, a proxy for irrigation intensity: "irrigated agricultural area/total agricultural area", as displayed in Figure 3 and measured in %/100.



Notes: Temperature, precipitation and soil quality factor (from top to bottom) at a 2.5°′2.5° grid cell level; frequency distribution diagrams see below
Source: Ahamer (2001)

Figure 4.
Higher-granularity example of raw data for a "Combined energy and biosphere model" CEBM

Depending on which regional aggregate is chosen, the overall trend might be interpreted differently in the three sections of Figure 5. Such decisions are also known as the MAUP problem (Modifiable areal unit problem) which arises when spatial phenomena are aggregated into geographic units of variable size (Openshaw, 1983). Data per country suggest looking at hundreds of single correlations of timelines (at left, strongly affected by annual meteorological variability); the granularity level of FAO agricultural data (cf. FAO,

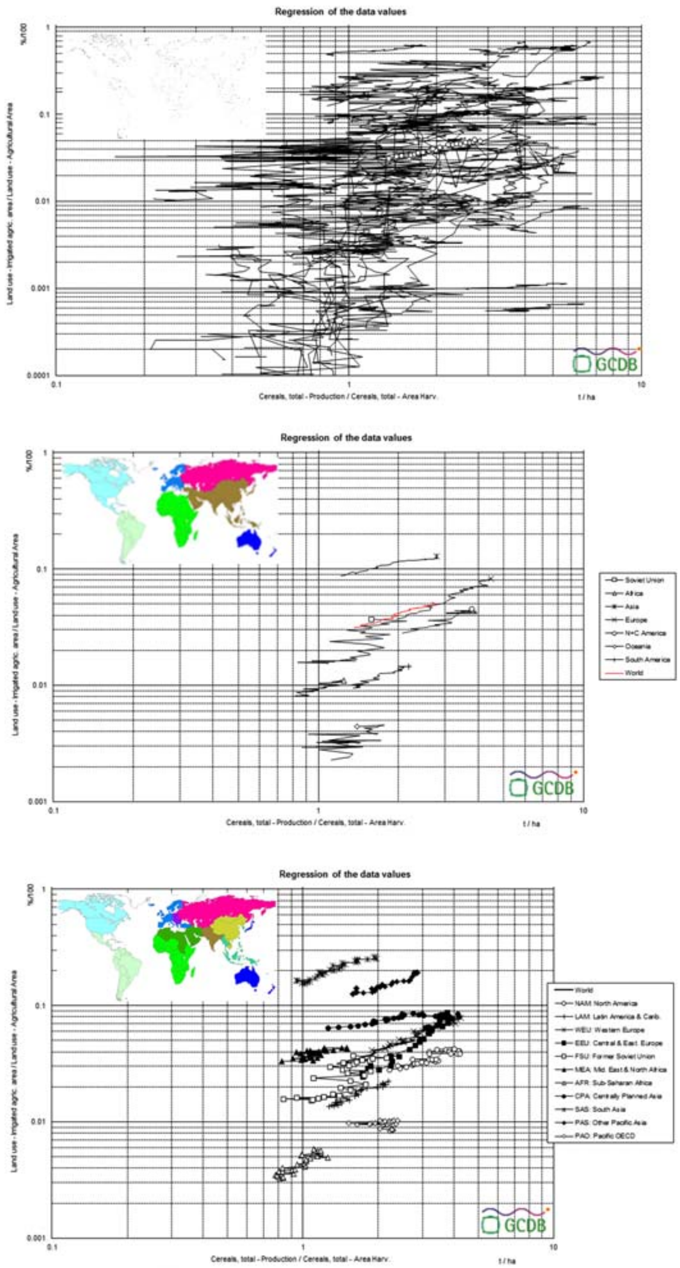


Figure 5.
Granularity is relevant for correlations of global data sets; here between two quotients: "production of cereals/harvested area of cereals" with "irrigated agricultural area/total agricultural area"

Note: Granularities according to map inserts, namely at top: per country, at centre: per "continent" (+ former USSR), at bottom: per region
Source: GCDB

2013) suggest looking at continents (with a former USSR area singled out, at centre); and granularity chosen in traditional economic modelling tends to define eleven regions (e.g. the "11R model", at right, see Messner and Schrattenholzer, 2000).

3.4 Granularity regarding time steps

The present subchapter uses the global theme of "water" to inquire about the effects of selection of different time intervals on the presentation of global data and resulting conclusions. The more complex the meaning of data is, the less complete their timelines might be (Figure 6).

The GCDB should also allow comparisons between countries (with all other countries and regions) numerically and graphically, as one of its purposes. Because geo-referenced data on a very local scale (such as altitude, temperature, precipitation, Figure 4) are not easy to combine with data pertaining to economic activities (e.g. energy demand, water demand), a suitable algorithm has to be used for substantial transdisciplinary scenario writing (Ahamer and Wahliß, 2008, p. 29).

When it comes to computing trends, geographic and temporal completeness is dearly needed. The more data relate to easily measurable positive science (such as areas, Figure 7 at far left), the easier a reliable trend can be computed (Figure 7 at near left). However, social parameters such as accessibility of services for population are often only provided for OECD countries, and incompletely at that (Figure 7 at right).

The completeness of data series can become a severe issue when it comes to correlating two parameters in such a way as is shown in Figure 5. While land use data tend to be complete (Figure 7 at left), energy-related data tend to provide full coverage only for the most recent decades but not for earlier decades (Figure 8). Displaying the variable "hydro electricity output" (cf. IEA, 2013) per continent (far left in Figure 8) shows seemingly unexplainable jumps in data series. These produce exceedingly high change rates in only one year which should be cut away in charts (arrow in chart at near left in Figure 8). When displaying the same data disaggregated into regions, it becomes apparent that large groups of states are missing which might have provided incomplete data to the data base; namely non-OECD countries (near right in Figure 8). This condition is easily visible from the coverage plot (far right in Figure 8).

When it comes to producing correlations, it becomes evident that incomplete data sets (e.g. as in Figure 8) mathematically yield regression coefficients and regression plots that are disturbed by irregularities in data coverage. These will have to be handled with care and only after specific verification in each single case.

3.5 Granularity regarding global megatrends

This subchapter uses the widely known example of "population growth rate as a function of GDP/capita" in order to discuss principal questions of data analysis and interpretation. This theme is known as decrease of population growth in high-income countries or as population transition.

Granularity of information (regarding time and space) can be intentionally changed. Figure 9 provides information about the difference in perception when highly oscillating data series are depicted in a correlation plot (at left) or left out (at right). The structure of the issue seems to appear much clearer in the right picture, i.e. when restricting to aggregated (regarding time periods) information. Each country might intuitively be understood as moving on an evolutionary path along which it might be hypothesised to follow a more or less stable trajectory. However, a paradigmatic

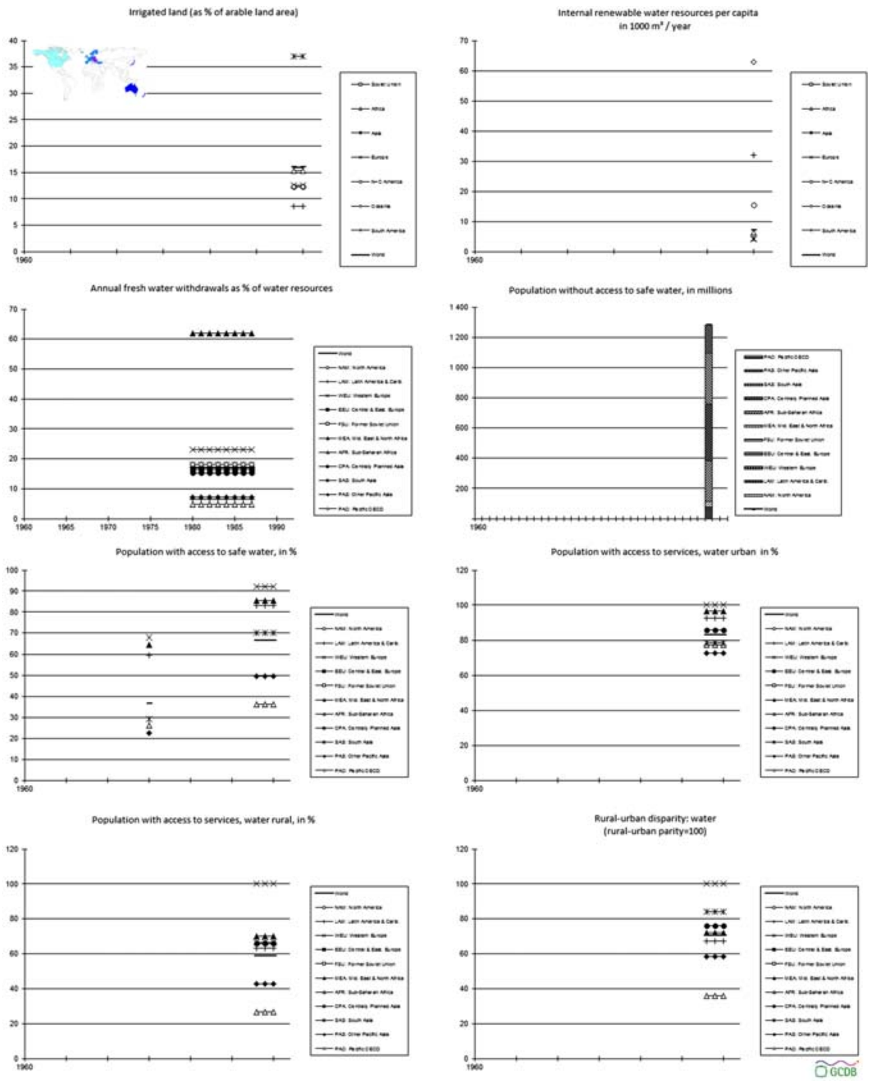
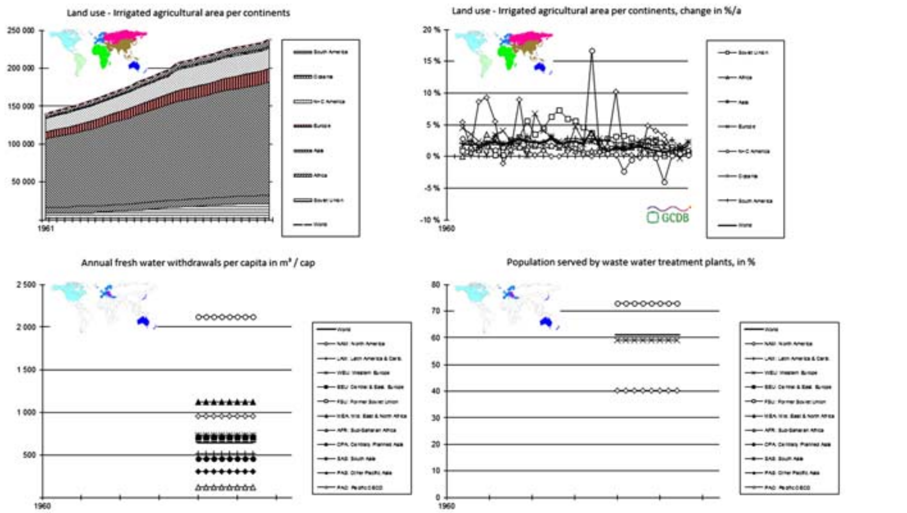


Figure 6.
Human Development Indicators (HDI) are often only available for selected years, and mainly for OECD countries

Notes: From left to right, starting above: irrigated land as per cent of arable land area, internal renewable water resources per capita, annual fresh water withdrawals as per cent of water resources, population without access to safe water in millions population with access to safe water, population with access to urban water services, population with access to rural water services, rural-urban disparity regarding water in per cent

analysis unveils the high degree of ideologically driven preliminary assumptions of such a type of evolutionary reasoning (see Ahamer, 2008).

When increasing geographic granularity by showing a coarser plot, the over 100 data lines of Figure 9 might seem to slip into "better" graphic order. A "global megatrend" might become more visible (Figure 10). However, the author recalls the "highly constructive nature" of such meaning and critically asks whether the notion



Note: At far left: irrigated agricultural area. Land-use data are usually very complete and allow for producing data series of the first derivative (i.e. the change rates, at near left). Contrarily, social data are often restricted to OECD countries, are less precisely measurable and do not easily allow the computation of change rates, such as annual fresh water withdrawals per capita (near right) and population served by waste water treatment plants (far right)

Figure 7.
Only data sets with reliable time steps can yield reliable (derived) data sets of annual change rates

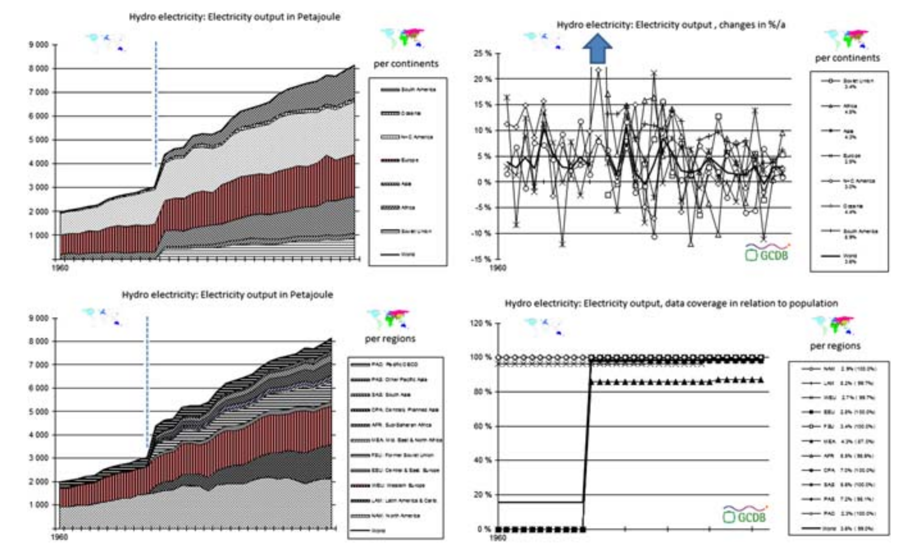


Figure 8.
Hydro energy statistics (electricity output) provided by the IEA covers 99 per cent of the population recently, but much less (<20 per cent) in earlier decades (mainly OECD countries, as symbolised by the inserts)

of "trends" is applicable at all here. Actually, the emergence of "paths of development" in the spectators' eyes and conscience strongly depends on the level of disaggregation, thus reiterating careful decisions regarding what is commonly called the MAUP problem.

Future research and the steady development of a consistent GCDB promises sound experimental and theoretical insight.

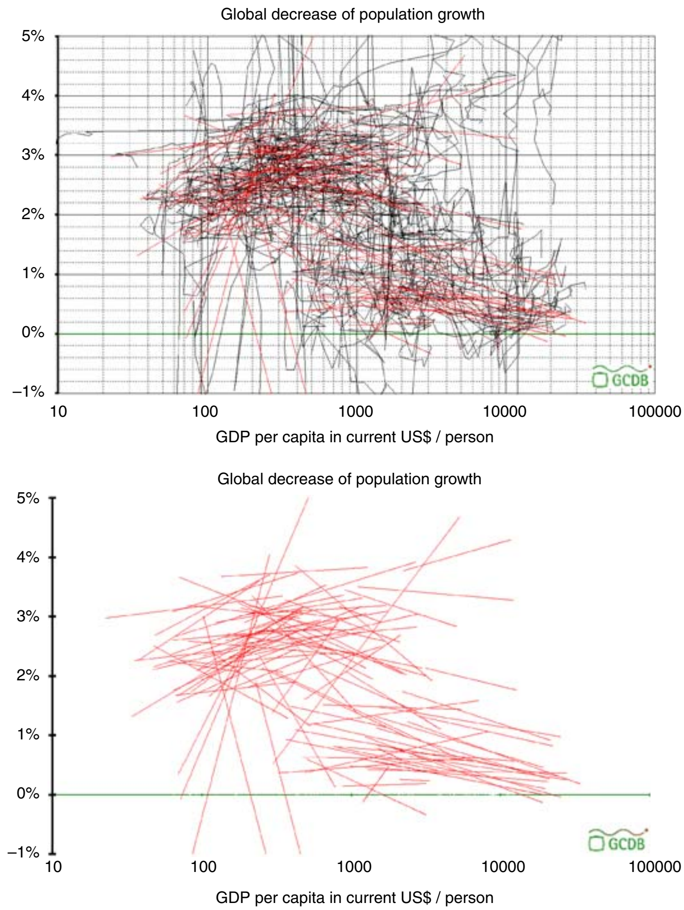
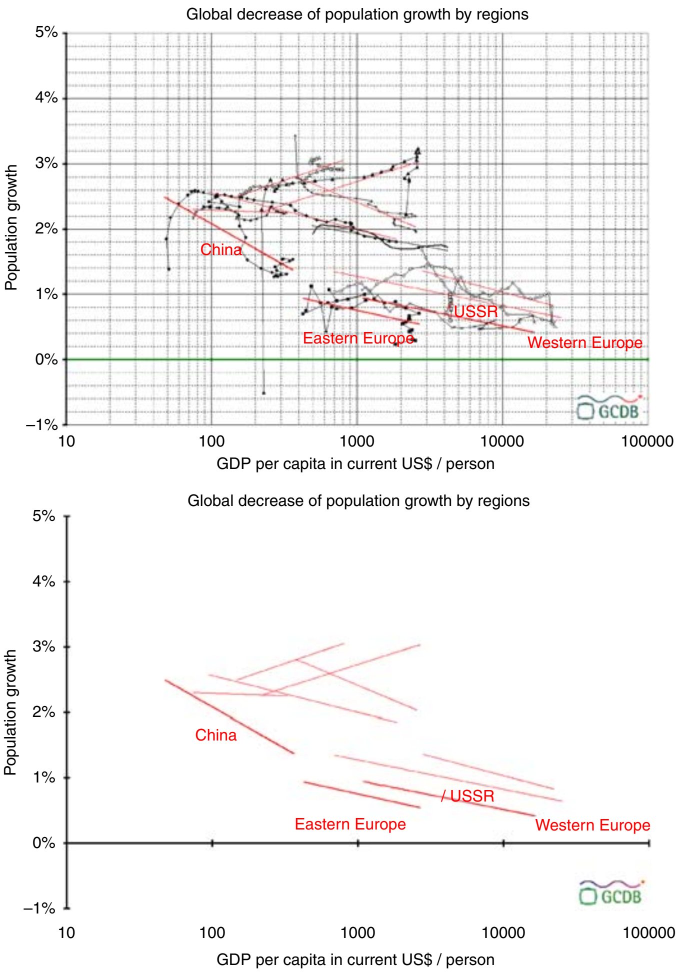


Figure 9.
Population growth appears to decrease with increasing GDP/capita

Note: Details of such an "assumption of high granularity" can be revealed or veiled (top and bottom)
Source: GCDB

A comparison of Figure 9 with Figure 10 (i.e. the differences in graphical emergence of well-correlated paths of development) and a comparison within both figures, a comparison of the image at left with the image at right suggests that:

- suitable aggregation in the sense of averages across suitable periods of time may enhance the information content of data display;
- suitable aggregation in the sense of averages across suitable geographic areas may enhance the information content of data display; and
- applying a concept of "paths of development" might partially enhance the information content of data display but need not harmonise with theoretical deliberations on the subject of global evolution (Ahamer, 2012a, p. 321), possibly making use of the concept of "blossoming evolution" (Ahamer, 2008, p. 67).



Notes: Some "paths of development" seemingly become more visible. Care should be applied, however, when speaking of "paths" as an evolutionary concept at all

Figure 10.
The same images as in Figure 9, only aggregated to 11 world regions

Therefore, any technology or strategy of data display (including "growth curves" such as suggested by Rosling, 2013 through Gapminder) should take into account the underlying theoretical situation in a sufficiently multidisciplinary manner.

4. Conclusions

The data sets presented above can not only be suitably used for teaching and e-learning, but may also constitute essential building blocks such as planet-wide information systems or a future consistent "GCDB". Further understanding of the degree of path dependence in global evolution and economic development (which is presently heavily contested among researchers) can be achieved by the quantitative and graphic approaches presented in this paper, thus contributing to progress in futurology and "FL". Institutions such as the European Commission, the European Environment Agency and UN divisions might incorporate the resulting deliberations in their own approaches.

The above literature analysis has shown that "granularity" as a concept is highly dependent on underlying paradigms. This paper suggests that care should be applied when selecting a given degree of granularity to data, correlations and conclusions because they may have an important effect on both further theorisation and practical strategies to cope with globalisation.

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