



Part III

Which Future? ¹

Prof. Dr. Mihajlo D. Mesarovic ²

Case Western Reserve University
Cleveland, OH 44106-7071

Prof. Dr. Dr. F. J. Radermacher ³

Forschungsinstitut für anwendungsorientierte Wissensverarbeitung (FAW),
Ulm, Germany

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² Prof. Dr. Mihajlo D. Mesarovic, Case Western Reserve University, 10900 Euclid Avenue, Room 605, Olin Building Cleveland, OH 44106-7071, Phone: 1-216/368-4466, Fax: 1-216/368-3123, e-mail: mdm5@po.cwru.edu

³ Prof. Dr. Dr. Franz Josef Radermacher, Research Institute for Applied Knowledge Processing (FAW), Helmholtzstr. 16, D-89081 Ulm, Germany, Phone: +49-731-501-100, Fax: +49-731-501-111, e-mail: radermac@faw.ulm.de

In memoriam Robert Pestel



Dr. Ing. Robert Pestel

* 02. 10. 1941 † 18. 04. 2003

European Commission, Brussels
Deutsche Gesellschaft des Club of Rome
Brussels Chapter of the Club of Rome
Mitarbeit am 2. Weltmodell des Club of Rome
Mitglied des Beirats der Webseite Deutschland.de

This paper is in memoriam Robert Pestel who died on April 18th, 2003. Robert Pestel was a never-waving fighter for a better future. Extending the work of his father, Eduard Pestel, and acting in the tradition of the Club of Rome's work and thinking, he dealt with the global problematic and how to organize a better future for the whole world and its people. He used system-theoretic models to get a better feeling for the dynamics of development and innovation processes, and he networked with hundreds of people around the globe in a most intensive way. He was very stubborn in following his visions and had an unbelievable energy until the end.

Within the European Commission he shaped the thinking about sustainability, its economic, social, cultural, and ecological aspects and the correspondence to a global contract. He also understood the power of the internet and other communication networks for the good and the worse, he was an engineer that took the rebound effect into account, and was always active to have civil society take over a greater role and responsibility in shaping the world's future. Making the best use of the power of insight, networking and communication was one of his biggest hopes. Consequently, he believed in the value of information and open debate. And concerning communication, he was willing to involve science and formal argumentation systems as much as subsymbolic approaches, a reference to emotions and reflections via different forms of art.

The following paper is all through inspired and shaped by his thinking and visions. He was a great co-worker, initiated many projects, achieved a lot and fought until his final hour when he was taken away from us much too soon. He was a great person. We miss him.

Contents

.....	
Abstract / Introduction.....	4
I. Why three/four futures?	7
II. The key stories for the considered futures	11
III. Scenario data concerning all considered futures.....	25
IV. Gap analysis for the business as usual case:	38
Why something fundamental has to change	38
V. First inputs into a cross impact analysis for the considered futures	53
VI. On the role of ICT in the considered futures	57
VII. Architectures and software design issues in the security field: A most crucial issue	61
VIII. Where should Europe go in ICT development and use, to have ICT act as an enabler for the eco-social future?	64
Final Remarks	65
Related References.....	66

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Abstract / Introduction

The following document reflects on work done to a great extent within the EU-sponsored project TERRA 2000 (www.terra2000.org). It has to be seen in the context of two other papers for TERRA of the last 2 authors of this work as well as some basic contributions to the issue of equity. The paper looks into the **future of the world wide information and knowledge society**. It tries to give some indications, to where this society is going. The starting point is the well founded conviction at the authors, that the globalisation process, we witness today, is to be understood mainly as a consequence of the new **technical opportunities that come with ICT**. Globalisation offers enormous chances for participation of people all around the world, but at the same time, ICT could turn out to be the major driver to eventually **destabilise the social contracts** of developed countries, ICT could turn out to be the instrument to create divides where up to now social cohesion was produced and while ICT offers a great potential for freeing people, it could also be a tool for a **gigantic control of people** and taking away citizens' rights. ICT is one of the powerful mechanisms that now "force" cultures and societies all around the globe close to each other, which are very different, which brings with it an enormous stress and potential for future trouble. And in any consideration where ICT will drive us to, the **special dynamics and (power) laws** as well as the connectivity and "explosive" properties of networked societies have to be better understood and taken into account, an issue, strongly advocated by the second author since years in the EU context.

The following document, building on the recently published book by the third author, takes into account new insights from system theory and non-equilibrium thermodynamics to understand better **processes of socio-economic or biological evolution**. Furthermore, it starts from a **global ethics point** of view and asks first whether humankind will eventually be able to integrate the physical constraints of the environment into its economic systems: yes or no. Secondly, it asks whether human kind will achieve that aim or not while respecting, at the same time, human dignity and human rights of all people: yes or no. In **Chapter I**, these considerations are given in more detail, leading to **three/four futures** (called scenarios A–D) which make up the core of this paper. Note that in a certain sense, these cases are disjoint and exhaustive by construction, i.e. in a certain sense, one of these futures will come.

In **Chapter II**, this document develops the key stories and considerations for those three/four futures and translates them into quite concrete scenarios that give a feeling about how many people will live on earth - in the respective future worlds - up to the year 2050 (2100), how the world GNP will develop, how much we will stress the environment, how will be the **social/**

equity situation, whether **peace is to be expected**, etc. Concrete data on many of these topics is summarised in **Chapter III**.

It is one of the central positions and insights of this paper that a future consisting in business as usual, which means in particular **not incorporating adequately the physical limitations of the eco-systems** into the world economic systems, will eventually lead to a **global disaster**. E.g. the present WTO frame of organising the world economy can not be followed for many decades any more! This is because it will create a **horrible overshooting in resource use** as well as concerning **pollution**. Major issues of overshoots or shortcomings will then concern (1) food/water, (2) oil and gasoline, (3) CO₂ emissions and (4) the total photosynthetic product of the earth and its appropriation by humans. This overshooting will bring the globe into a critical state and will probably result in **conflict, resistance, terror, security actions** against terror etc. To get a feeling when and how such a critical situation may happen, some **gap analysis** is done for the business as usual case in **Chapter IV**, for the areas of possible trouble just mentioned. All these analysis show **dangerous perspectives** for the year 2030 and later concerning many dimensions of great importance. This gap analysis means that if humankind will not act strongly on limitation issues, which means essentially going from scenarios A and B to scenario C and D, in the different futures discussed, this world will end in conflict.

Problems are also ahead, if physical limitations and ecological requirements are respected, but only via an **asymmetrically solution**, putting most of the burden of adaptation to poor countries and poor people, which are not really allowed to develop. They or their advocates will with high probability **resist with force and terror**, inducing **counter-force** and so on. This is Scenario D, which will induce extreme security needs and probably not lead to a sustainable future, either. Sustainable, if at all, seems to be only case C, the **eco-social model**, the **European** or **Balanced Way**. It is a model of building and integrating societies as is typical for the developed countries, particularly in Europe, countries that are now under enormous globalisation pressure to reduce their social balance and their environmental orientation.

All in all, it is a very critical question where the world will go. Bringing the world on a better route is **only partly under the control of humans**, as aspects of self-organisation in a **near-chaotic world** have an enormous power to shape the future. **Chapter V** tries in a limited way to work out for some possible events, such as more terrorist attacks in the United States and / or Europe or problems with nuclear facilities somewhere in the developing world, what influence on the future and the route to one of the different futures considered this could have.

Summarising, it is by no way clear, that **ICT as such is the solution for a better world**. It is rather as it has always been with technologies. Technologies are a chance, but where they lead to is very much dependent on how humans on a societal level make use of it. In case of the three/four futures, discussed in this paper, this type of use can look very different, depending on societal decisions. In **Chapter VI** the **role of four categories of major ICT development fields** is discussed in this context, namely (1) promotion on the business side, (2) security systems to control the individual and to be able to always better act militarily, (3) control and monitoring in the environmental field, and (4) empowering on the human side (capacity building). Each of the futures considered is characterised by a major emphasis on two of these four ICT systems' worlds. So ICT will play a major role in the future in any case, but what it will be used for, is a question, that will essentially not come out of ICT development processes themselves, but is part of a broader picture of society, taking its way into the future. In **Chapter VII**, we reflect this aspect even deeper, when asking, which societal philosophy can and should shape **system's architecture and system's design in the security field**, which is gaining strongly in importance since September 11, 2001. We extend these considerations in **Chapter VIII** to finally ask, as a recommendation from a TERRA 2000 point of view, what the **EU could and should do** in any case today concerning promoting ICT use to help that concerning the different futures discussed, our route leads which a probability as high as possible to a **comfortable landing place, e.g. the eco-social model**. What can we do as EU in the ICT field to work against business as usual or instead asymmetric and unfair routes, that are disastrous for the environment but for global security as well. First indications are given.

Some final remarks close the paper.

I. Why three/four futures?

It has never been so difficult as today to say anything about the future 50 – 100 years ahead, in spite of humankind thinking of itself as a world knowledge society. But, though we cannot know the future, it may be possible to say something about the nature of forces that influence this future and about **different alternatives where the world could go to**. If we separate the cases considered in the right way, it may be possible to essentially cover the principal scope of alternatives, if we deal with the issue abstractly enough. Concerning a better understanding of the forces that drive a networked global society, we refer to insight given in [2, 5, 7, 8, 17, 25, 34, 42, 63] with reference to [26, 43]. The issue here is trying to understand better **complexity issues** of modern societal development, building a non-equilibrium thermodynamics and systems theory. These offer new approaches to better understand **socio-economic or biological evolution**. This is particularly true for networked processes. Particularly important insight concerns

- Recognition of 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 obvious predictive power of such approaches concerning the spread of the internet as well as mobile telephony
- The connection of all those issues with building world-wide **human capital** and relations to issues of population growth (cf. [44] for further connections).

More information on those issues are to be found in the references, mentioned above.

Concerning scenarios for analysing the future there are, of course, many ways to do this. Building on the book [48] recently published and other work within the TERRA project or associated with it [11, 26, 27, 28, 29, 30, 31, 32, 33, 37, 43, 44, 45, 47, 48, 49, 56, 57, 60, 64, 66, 69], the present paper takes a **world ethical perspective** [36, 65] as a starting point and asks two questions to classify the “futures” considered, namely (1) whether human kind will eventually succeed or be able to incorporate critical physical limitations into its world economic system regime: **yes or no**, and (2) whether, whatever we do, we will respect human dignity and individual human rights in a symmetric, fair way for all people in this world: **yes or no**. Combining the yes and no answers leads to four cases, which we will call Scenarios A-D in the following, and then study throughout this paper. Note that while today we observe a little bit of all four scenarios in contemporary politics, on the long run the cases AB, C and D are in a sense unavoidable and exhaustive. This is because, on the one side, A and B es-

essentially coincide (we therefore most of time deal with them as case AB), while AB, C and D all have reinforcing attractor properties in the long run, i.e., are definitively different from each other and, on top, these cases as a whole cannot be avoided. So it is not that we just look into some scenarios. Indeed, one of the cases will be realized in principle. The 3 or 4 cases considered are given and somewhat characterised in more detail in the following Fig. 1:

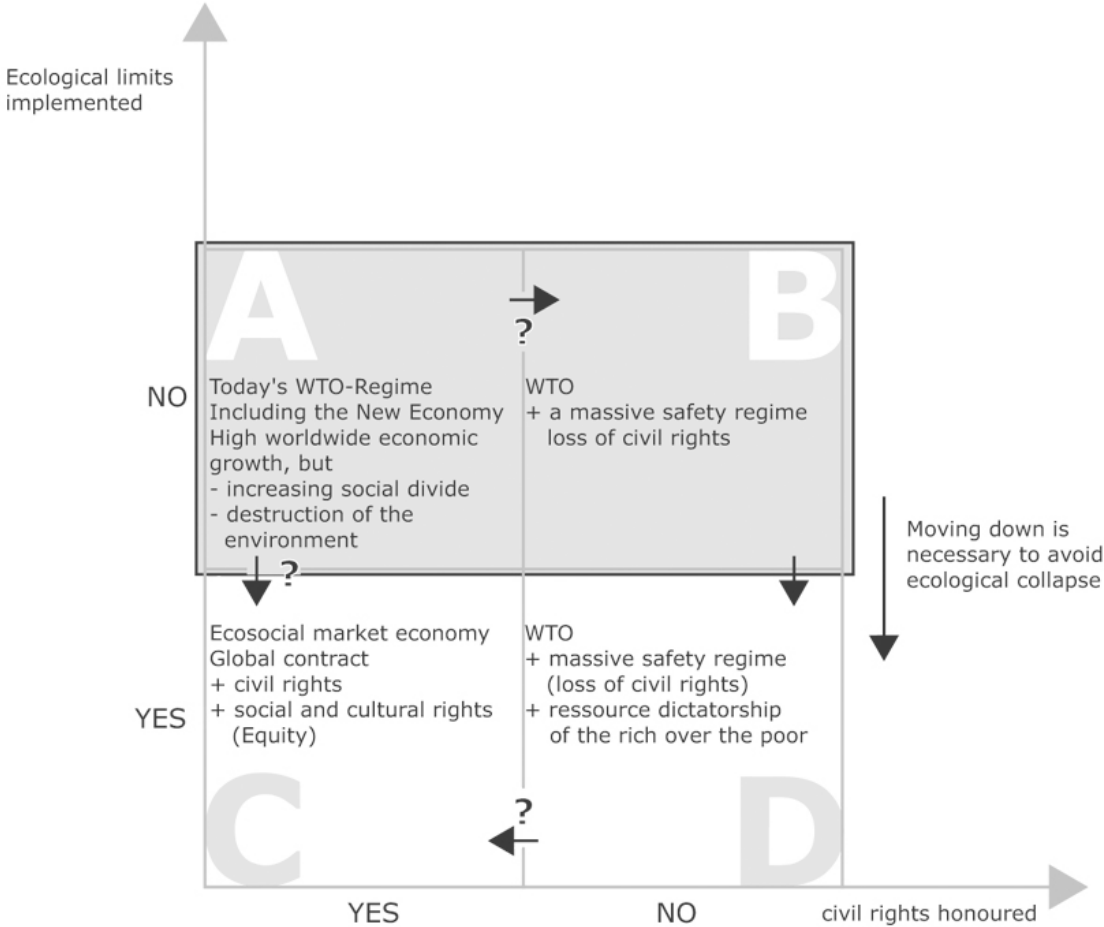


Fig. 1: The futures considered

Scenario A

Scenario A is essentially the **present WTO regime**. Here, the physical limitations of the world are unfortunately not incorporated adequately into the world economy via adjusted prices or other forms of caps or ceilings. We use today too much resources, we pollute too much, and with the growth processes in force all around the globe, the situation will soon become worse instead of better. This also concerns the unacceptable distribution of wealth

between the rich and the poor world and within many countries. **Gaps and troubles are ahead in this scenario.**

Scenario B

Asking, how we will eventually deal in the context of Scenario A with phenomena such as overshooting, fight for resources etc., Scenario B couples the situation in Scenario A with **massive security regimes** to control all people and to be militarily able in the rich world to react to whatever struggle or fight or terror action might result all around the globe, when human kind has to live through the shortages, disasters, fights for resources a. s. o. which will come with the critical situation concerning overshooting, gaps opening always more etc., described in more detail in Chapters III and IV.

Scenario C

Scenario C is the so called **eco-social case**. This balanced future is discussed in a lot of previous publications by the authors and others, particularly see [11, 15, 38, 37, 48,53]. It starts from the example of social market economies, typical for Europe, and extends it by strict rules in the environmental field (**Ökosoziale Marktwirtschaft**). Similar structures one can find in developed Asian democracies, which use **family nets etc. for creating social cohesion**. The most typical realisation of the eco-social market economy philosophy are today the **extension processes of the European Union**, which can be regarded as a successful case of a “**small globalisation**”. Here, less developed partners are integrated into a sophisticated frame of rules and standards and are willing to accept these higher standards, even if it goes against their competitiveness (which results from underbidding social and environmental standards of richer countries), because the richer parts of the EU are willing to **co-finance** this acceptance, thereby making it feasible. So, the **principle “co-financing against convergence of standards”** is a critical element of the eco-social approach. This element is also characteristic for the **Montreal Protocol** for avoiding CFC emissions in order to protect the ozone layer and for the **US Marshal Plan** for Europe after World War II. However, we miss world-wide much more examples following this successful approach which is substantially different to the present WTO philosophy, also very different from NAFTA, Asian and other zones of economic co-operation without a **socio-cultural-ecological dimension**, as in the EU, and with a different logic of funding.

Scenario D

Finally, Scenario D realises the physical limitations on the resource side and the pollution side, but by an **asymmetric regime**, which is **grandfather like**. In this approach the North keeps its present status as a big resource user and a big polluter, and stabilises the ecologi-

cal situation world-wide in spite of his enormous resource use and huge pollutions, by **preventing the South from catching up**. This is called an **eco- or ressource-dictator type** approach. In principal, countries in catch up processes can make **6 % growth a year** and more because they start from a low level. On top, they can do **leap frogging**, they can do copying, they need not to do the innovations, while front running states don't have it easy to make **1 or 2 % growth** [44], as their growth rate is always to be seen in relation to an already very high level of wealth and can essentially only be based on innovations.

So, in principle, (even) under WTO conditions as today the poorer countries could catch up. **Singapore** did this very successfully over the last 40 years and **China** is doing so very successfully since 20 years. A resource-dictatorial regime would somehow have to prevent that, for instance by **de-stabilising the poorer states** and the **states in development** or by forcing requirements onto them in the field of e.g. human rights or with standards imposed onto them without co-financing, which they would not be able to survive economically. An **extensive free trade order system could have the same effect**, for instance, if oil becomes extremely short again and only rich countries can afford to buy the remaining rest of it, while poorer countries stay empty handed. In any case there are a number of options to implant a resource-dictator design in the future. This situation reminds somewhat the **ultimatum game** context, discussed recently in **behavioural economics** (see also [44]). **Big resistance up to terror** are to be expected against this approach, counter terror, public surveillance a. s. o. will follow as answer. The resulting resource-dictatorship regime, coupled with a **massive security architecture** and massive ICT installation into this direction, is certainly not a comfortable scenario or landing place for the future, either.

In this text we will not go so much deeper into stories and aspects but try instead to get a grip on data to make certain development patterns more apparent. To get to this higher degree of insight is seen as a major contribution of the work within TERRA 2000 in this context. In doing so for all four futures, we can build on quite detailed experiences with modelling the **eco-social case**, using the double factor 10 concept and the **future formula 10 → 4 : 34**. by the 3rd author, see [47, 48]. Details on the insights obtained follow in Chapters II and III.

II. The key stories for the considered futures

The stories for the futures, i. e. the scenarios considered (see Chapter I) are treated subsequently in the sequence A to D. All four cases are dealt with in a similar way as has been done before by the 3rd author and others for the eco-social case, e. g. Scenario C. For Scenario C, the core approach is the **double factor 10 concept** and the **future formula 10→4:34** for the global distribution pattern of a ten-fold economic growth [47, 48] until 2050 (2100). This model has already been discussed more extensively in literature. It puts great emphasis on the **equity issue**, which is seen as a key to wealth and peace, see also [4, 9, 11, 30, 44, 45, 47, 48, 50]. Scenario C serves as a reference for the principal approach taken within TERRA for all three/four cases, see the subsequent discussions. Note, that now going into Chapter II, we will refer to complete data sets, given in detail and in a compact form in Chapter III and to a **gap analysis** for scenarios A and B, given compactly in Chapter IV. Results given are for a 2050-2100 target zone in form of the extreme points 2050 and 2100, where later dates than 2050 for achieving the given final value of GNP growth (i.e. a factor 10 in Scenario C) are regarded as more realistic than earlier dates close to 2050. The corner points (either 2050 or 2100) are then used to do a suitable interpolation to get to intermediate values for either the time up to 2050 or alternatively up to 2100.

Scenario A: Continuing the present WTO regime (No global contracts for protecting eco-systems / global consensus design)

The idea for Scenario AB is to assume the following: set a trajectory to a **target state in 2050** (2100) and assume first, that in spite of global resource overuse and in spite of environmental degradation which are part of this scenario and in spite of not having solved resulting world social issues (as in the case of Scenario C), there will be – miraculously - no (total) collapse until the year 2050 (2100). This means, that **without looking to feasibility**, we formulate as an idea, where in crude numbers we would be in 2050 (2100), if, by magic, nothing disastrous happens and inconsistencies are resolved (which would mean we have not one but two to three globes available for our activities). Once we have this trajectory, intermediate points are computed by some adapted interpolation, as already mentioned.

Looking into the resulting numbers (see Chapter III), we then can deduce that w. r. t. Scenario AB something unpleasant must happen at some point of time because of **major and growing mismatches in numbers, volumes, requirements etc.**, called **gaps**. E. g. problems should arise concerning **water and nutrition availability** as a consequence of the high indirect stress concerning required biomass output, resulting from the consumption needs of

a **rich global middle class** as part of this scenario. This may lead to **massive starvation** on the lower side of the global income distribution spectrum, see again Chapter III. This picture was already identified in an earlier work involving two of the authors as part of a the EU-sponsored project **ASIS** (<http://www.faw.uni-ulm.de/asis>) [3, 16]. Following this line of thought, for the water and food issue, we can build essentially on recent insight, developed by M. Mesarovic and his co-workers in the context of the TERRA 2000 project [64, 69]. We will complement this case by looking into other foreseeable mismatches in numbers for this scenario, too. Major problems will probably result from critical shortcomings in **crude oil availability** [22, 60, 69] and could be associated with **shock phenomena** [69], as we have witnessed them recently in the crisis in the world financial markets. This is because of the shrinking contribution of newly identified fields to total oil reserves explored, relative to consumption needs. I. e. these deficiencies come along with major additional requirements on oil availability, e. g. due to fast economic growth in countries with huge population, such as **China and India**. As mentioned, major insight into the issues at hand have recently been obtained by M. Mesarovic and his co-workers [64, 69] in the context of TERRA 2000.

Thirdly, we deal with **CO₂ emissions** in the context of the Kyoto-protocol, a topic of highest significance for world politics in the future.

Finally, looking into the regenerative capacity of the biosphere may give maybe the strongest overall indication of collapse within Scenario A. Here, we can build on recent work by Wackernagel et al. [70]. concerning (1) **biosphere's Net Primary Productivity** (NPP) and its future development and (2) human's appropriation of this huge but still limited potential.

This work [70] tracks the ecological overshoot of the human economy and indicates huge trouble ahead. Here, a major issue is energy, as the authors deal with a future, in which energy is produced only via biomass. With this strict approach, the authors in [70], seen from the point of the view of the present paper, look into advanced concepts of "**societal metabolism**" (for the **superorganism humankind**, embedded into the global living world/GAIA) and issues such as net photosynthetic potential. Concerning the "**ecological footprint**" of humankind, six human activities are analysed in more detail, that all require biologically productive space and that are to a great extend exclusive to each other. The topics are (1) growing crops for food, animal feed, fibre, oil and rubber, (2) grazing animals for meet, hides, wool and milk, (3) harvesting timber for wood, fibre, and **fuel**, (4) marine and freshwater fishing, (5) accommodating infrastructure for housing, transportation, industrial production, and hydro-electric power and (6) burning fossil fuel, where **fossil fuel is translated into an equivalent biomass production**. Aggregating all human inputs shows that humankind is

already **over-stressing global capacity** since some years (at present we would need 1.2 globes to be sustainable; remember, this includes a sustainable total energy production of humankind vial biomass), with sharp increases ahead, eventually undermining the eco-system's production basis of these inputs forever. To give a crude idea for the outcomes, in scenario AB, in 2050 we would need 17 globes to be sustainable, using today' s technologies and lifestyles which, with an assumed factor 7 of higher eco-efficiency in this case, would lead to an overshoot of about 2.4 globes in 2050 in comparison to 1.2 today.

For all four areas of gaps considered (and others imaginable) we expect, as is presented in detail in Chapter IV, trouble ahead. When following Scenario A, we have to be prepared for **dangerous developments of a more or less chaotic nature** between 2030 and 2050. In Chapters III, IV, there are some indications as to the effects possible and time scales to be expected. These insights are derived by looking into the critical development path leading to the year 2050 (2100) within this scenario.

What do we derive from the trajectory we will look into? As a start, we compare Scenario A with Scenario C where we follow the double factor 10 concept (see below). The major difference to this case is that in Scenario A, by definition, there will be **no world contract** and **no alternative (resource-dictatorial) regime** to keep collective human impact onto nature and the eco-systems within sustainable limits. So in spite of a high dematerialization via new technologies (such as ICT) and organisational arrangements assumed within Scenario A we will still **use always more resources and put always more and more stress on the environment** by uncoordinated growth in North and South. This is the result of a **collective free-order WTO-like hype**, which tries to reach by 2050 (2100) not only a factor 10 of growth (as in Scenario C), but e. g. a **factor 14**. (Note that this relates to a much greater world population than today.) And in difference to Scenario C, humankind will and can follow this more growth-intensive, more "aggressive" or dynamic path for some - though limited - time because we can still put in more resources and pollution (**cannibalism**), however with a price to be paid in the future and by **future generations** [61], due to overshooting.

As there will be no global contract but also no resource-dictatorial regime in place in Scenario A, there is no mechanism available to reward properly or force a massive, sustainable use of telecommunication, tele-working and other solutions offered by new technologies. So the **boomerang (rebound) effect** [23, 41, 48] will not be stopped, e.g. there will not be an economic mechanism in place that promotes e. g. the urgently needed **re-regionalization of the production of goods of relatively low value added**. We will also not achieve the impressive eco-efficiency increase of a factor 10 as in Scenario C. While in Scenario C we

make a factor 10 increase in resource efficiency, for Scenario A we expect for the target point of the trajectory **(only) a factor 7** because the in-built pressures in the market are less powerful. This means that in difference to a double factor 10 approach (Scenario C), the line followed in Scenario A (see also Chapter III) will be a **(14,7) pattern**, e.g. an increase of world GNP by a factor 14 by 2050 (2100) with a **corresponding dematerialization curve** (for instance with regard to the **total photo-syntetical product of the earth**, cf. Chapter IV for more information on that part) over 50-100 years going down by some (exponential) shrinking rate from a level of 100 to approximately a level 14.3 by the year 2050 (2100). In the social field, we expect a **14→ 8:38** pattern in distribution of growth potential as a final point in the trajectory (instead of 10→ 4:34 in Scenario C).

This means that the North with presently about 16 % of people and 80 % of world income will see a factor 8 increase of GNP by 2050 (2100), leaving space for a factor 38 increase of GDP by 2050 (2100) in the South. The North then has 640 of a 1400 volume in total, the South 760 (38 x 20). Overall growth rates within the 14 → (8,38) context will be 5,42 % (2,67 %) in a 50 (100) year development picture, i. e. will be considerably higher than in Scenario C, where the numbers are 4,71 % (2,33 %), respectively. This amounts to 4,25 % (2,1%) for the North and 7,55% (3,7%) for the South of average annual growth rates over 50 (100) years. This is considerably higher for the North than in Scenario C, where the respective numbers are 2,81 % (1,40 %), while for the South the situation is more or less identical. However, the much higher growth in the North combined with the resulting much higher growth for the world as a whole, coupled with a reduced dematerialization speed, will **lead to massive environmental degradation and resource overuse**, with many victims involved, among them people living on a subsistence level [54], whose interests will often be sacrificed for great development projects, e.g. in the area of mining and dams, as is already the case today. At the same time, the equity situation does not improve in the impressive way to be expected in Scenario C, as described next, e.g. we expect an equity in 2050 (2100) of 47% (45%) in the North (today 50%), 40% in the South (today 26%), and, as a result, 30% world-wide (today 11.6%) with corresponding intermediate steps, see Chapter III. Still, in the sense of [44], it improves fast enough (up from around 12% in 2000 to around 30% in 2050 (2100)) to allow for the overall growth rate of a factor 14 for the world as a whole.

Within Scenario A, we expect in the North of today (including migration) a population of 1.6 billion and in the South a population of 8.4 billion for the 2050 case and 1.6 billion people in the North and 9.4 billion people in the South for the 2100 case. This means about 1 billion people more than in Scenario C in the 2050 case and 1,5 billion more in the 2100 case. The massive free order-type WTO-logic of the economy is expected to reduce equity in the North

by 2050 (2100) to 47% (45%) (47% is the US value of today), which will mean a severe loss in social cohesion, while for the South, 40% may be in reach. The present average 21:1 distribution pattern between North and South will roughly improve (only) to about 4.5:1 (3.8:1) (instead of 2.5:1 (2.3:1) for the year 2050 (2100) case in Scenario C for the year 2050 (2100) case), correspondingly, for the world as a whole, to an equity factor of 30%, instead of 44% (45%) in Scenario C for the year 2050 (2100) case. Global equity is thus almost as low as the lowest country values today. **Many tensions** will result from this still very unbalanced social pattern, including all kind of **perpetuated gaps** and a **world population that would grow further beyond 10 billion (11 billion) after 2050 (2100)**. However, the most severe conflicts will probably not be for distribution patterns, but will have to do with a **massive over-shooting in resource use and pollution** within this scenario (see Chapter IV), eventually leading to a breakdown of the ecosystems with all kind of disastrous consequences to be expected in this case.

We just mention, with respect to growth numbers, that in difference to the eco-social and the eco-dictatorial case, **growth rates within Scenario A are not honest**. This refers to other related insight with the TERRA project, cf. [44]. Actually, a (14,7) pattern means overall roughly a doubling of resource use and of environmental stress, including much higher CO₂ emissions by 2050 (2100) and most severe problems concerning e. g. food and water and oil and energy availability and stress resulting from an over-extended human appropriation of biosphere's Net Primary Productivity as described above (and in more detail in Chapter IV), probably **leading to chaos, resistance, and terror**. As on top, the target equity factors will also still not be acceptable from a European point of view and all historical experience, social splits with obvious deficiencies also for the cultural sector and for cultural diversity are to be expected, along with growing resistance concerning this side of the issue, too. That means, in summary, that if we just follow the present WTO development pattern, without major corrections concerning **more social cohesion, promotion and support of cultural diversity** and a **fair exchange among cultures** [50] and **more investment into peace and more protection of the environment**, there will be trouble ahead.

While the free-order regime will improve world social coherence to a certain extent, thus caring for a prerequisite for a high growth [44] and will increase eco-efficiency per unit value created considerably in comparison to today as described, all this progress will still be **too little and too late**. Consequently, the growth in the number of people will not, eventually, be stabilised, but may still grow further, even beyond 10 billion in the 2050 case and beyond 11 billion in the 2100 case (actually, we assume **12 billion as a long-term upper population limit** for this case in Chapter III), with all the corresponding potential for trouble, as was al-

ready indicated. All kinds of social divides will not be overcome too, ICT-technology will not be used to the extent and to the positive impacts possible. Women, globally, will not reach full equity and integration, divides will not be closed.

However, we can, before breakdown due to overshoots, expect (depending on the detailed definition of global middle class chosen, see Tables 8.1-8.3 in Chapter III) hypothetically a world-wide middle-class of may be **2.5-5 billion people**, about 1.6 billion of them living in the North, living a lifestyle as the people in OECD states enjoy today, following the trajectory assumed. As the scenario and gap analysis (see Chapter III and IV) show, already somewhere around 2030 a critical situation could arise, above all from overshooting concerning the resource base of the globe and pollution patterns, if no special means are taken to deal with resource limitations and social needs. If those means would be taken, this would constitute a transition more towards Scenarios C and D, **where a smooth transition becomes always more difficult, the longer world politics waits** and where an eventual transition to D becomes always more probable than a transition to C, if there is such a transition at all. We also expect that sheer need and starvation will materialise themselves in **massive migration**. There is a high probability for fights for resources, maybe even between Europe and the US, e.g. for a special partnership with Russia and its development potentials in Siberia. We may see **fierce troubles between the US and China**, all kind of military tensions and there is a **high chance for massive sequences of terrorist attacks**. All this will probably lead for Scenario A to situations, dominated by security issues, which is essentially the nature of the following Scenario B. I. e. a transition from A to B is easily possible, as Scenario B is, apart from the security issue, almost identical to Scenario A. If humankind stays within Scenario A, and will mean a long-term deterioration of human situation on this earth.

All in all, Scenario A is a quite frustrating scenario, as the numbers indicate. And certainly **no comfortable landing place**. In fact, if humankind stays within Scenario A, this will mean a long-term deterioration of the human situation on this globe.

Scenario B: Continuing the present WTO regime, combined with massive security elements

Scenario B, in its basic outlay, is quite similar to Scenario A. By definition, Scenario B is more or less the WTO regime as of today, i. e. **our present deregulated and optimistic system of self regulation** in the economic field. Here, the **so-called “collective market intelligence”**, that had its “Waterloo” in the recent crisis of the New Economy and in the

world financial markets [48], unfolds itself into the future. However, in contrary to Scenario A, in Scenario B, this development pattern is coupled closely with **massive security elements**; for some ideas what that could mean see [71]. Those security elements are thought to control resistance to the extreme resource overuse and ecological degradation taking place in this scenario, as well as against the high social splits remaining in spite of growing wealth and growing global equity (maybe reaching 30%, see Chapter III). There, the idea of Scenario B is, that rich people can still 'protect' themselves against poor people and the rich world against the poorer parts of the world by massive security and control installations, etc. This has **heavy consequences on ICT systems use**, see Chapters VI and VII, and the nature of the ITC design chosen, and on **military build-up**. Fights against uncontrolled migration, terror, etc. will be major elements dealt with in this scenario.

Looking at a trajectory going to 2050 (2100), we assume that in both cases we essentially follow the same pattern as in the pure WTO model studied before (Scenario A). Therefore, we sometimes deal with scenario A and B jointly as **one future**. Again, we expect to be in the (14,7) case, where the growth share between the rich and the developing world is assumed again to be 14→8:38, with (not honest) growth rates and an equity factor development as already described above for scenario A. The dematerialization curve will essentially be the same as in Scenario A, too, and the implications about population growth, role of women a. s. o are also assumed to be more or less identical. The essential difference is about the security side, which also implies that some space for consumption from Scenario A will now go into the security issue in Scenario B.

The most important distinguishing feature of Scenario B in comparison to Scenario A is the following: With all the trouble and tensions on the horizon due to the social, cultural and ecological differences and **gaps occurring** associated with the (14,7) and 14 → (8,38) pattern and resulting overshoots as described, politics in Scenario B will certainly shift into a situation of **almost complete control of all human activities**, not only in the South but also in the North [49]. And, of course, it seems highly probable, that starting with scenario A and staying within this frame will soon lead to scenario B, anyhow. Consequently, **ICT will be massively used** in the direction of control and reduction of personal liberties (cf. Chapter V, VI, VII). This means that everybody may possibly be connected to a **global control network** that monitors all movements, speech acts, financial transactions, bookings etc. of all people. Hundreds of millions of cameras in the streets will give a second level of control. Powerful satellite control platforms will be installed and there may be even sensomotoric devices, such as (killing-) drones available **to fight individuals, classified as dangerous, autonomously** in case of terror attacks expected or unfolding. Resistance of human right activists in the de-

veloped countries is to be expected against such total control, creating another front of an eventual 'terrorist' resistance, now by citizens of the developed world themselves.

A major question will be, whether on this way the developed world, in particular Europe and the US, will stay and act together as allies or whether resource shortages and troubles with pollution and social and cultural issues will lead to a split (as it became already visible in the recent Iraq War and was foreseen as a possibility by the third author in his basic book on these issues [48]) or even cause massive tensions between the Western powers with all consequences. Conflicts of that nature of the West with **India and China** are to be expected in any case.

Altogether, for this scenario, we also expect a clash on the route towards 2050 (2100) coming from the overuse of resources and corresponding gaps as well as from pollution with all consequences on nature and humans, and from social needs, e.g. with respect to the nutrition or the energy topic or the overuse of nature's Net Primary Production Potential, not different from Scenario A. At least there is the potential for fights for resources, fights for good air, for clean water etc. Also, we expect **massive migration** to the richer countries and resistance within these countries to **total control**, as described.

In addition to all that, strong counter measures against any kind of resistance and a **loss of civil rights even** within our democracies are part of this scenario. All in all, it is not clear what this will mean concerning the time of an eventual point of breakdown, which is to be expected in Scenario B, in line with Scenario A. It could be that the final crash will take place a few years later than in Scenario A, because with this massive security control, the final clash may be postponed, but only for a certain time. However, it could also be, that the final clash comes even earlier, namely because of massive resistance, terrorist activities etc. even within the North, against this situation, which in the **end might prove to be uncontrollable**. This would mean that trying to enforce security within the lines of a not sustainable global design makes the world an even less safer place than not making use of an intensified security option would bring about in this case.

Scenario C: The eco-social model

The **eco-social model** is the **landing place** identified and recommended by the authors and others in many opportunities, consistent with positions of the **Club of Rome** and the **Eco-social Forum of Europe**, and also argued for within the TERRA 2000 Project as an orienta-

tion line for European politics [10, 11, 18, 19, 20, 21, 24, 26, 38, 37, 38, 43, 48, 50, 51, 52, 53, 59, 62]. It is a route into the future where innovative and intelligent means of technology and organisation, in particular the potential of ICT, are used to achieve a **factor 10** increase in global GNP (of course, for a much bigger world population than today), combined with a **tenfold increase in eco-efficiency**, resulting from technological and organisational progress. This double factor (10, 10) approach requests a better and fairer world order (**Eco-social Market Economy / Balanced Way**), achieved in consensus between the countries of this earth and within the **global triangle of power**, constituted by politics, multinational companies and world civil society.

Within a global contract this approach incorporates **physical limits of collective behaviour of humankind into the world economic system**. At the same time, this approach organises patterns of co-financing in exchange to achieving a global consensus on limits to collective human (economic) activities in order to reach a sustainable development, while at the same time it allows to **overcome global divides**. This fair and balanced approach, in turn, makes a future-oriented contract between North and South possible [48, 62]. This allows a global distribution pattern, described by the **future formula 10→4:34**, with respective honest average annual global growth rates of 4,71 % (2,33 %) in a 50 years (100 years) perspective, as already mentioned above. This corresponds under assumptions described in detail in the literature [30, 44, 45, 47, 48] to an average annual growth rate of about 2,81 % (1.40 %) in the North and of about 7,31 % (3,59 %) in the South. Here these growth rates are **honest and real**, i. e. compatible with a sustainable development. Note that because of the balanced situation in this Scenario, particularly because of the considerable investments into **education, women's rights** and into **reproductive health, world population stabilises soon in this scenario**. Including migration we expect 1.4 billion people in the North and 7.6 billion in the South for the 2050 case and 1.6 billion in the North and 7.9 billion in the South in the 2100 case with an inherent upper limit for world population in this case of **10 billion people**. This fast limitation of world population growth that will later even lead to a shrinking of world population [48], is one of the biggest advantages of eco-social growth. Note that within the approach, today's 21.1 average distribution pattern between North and South would change into 2.5:1 (2050) and 2.33:1 (2100), compared to an equity of 44% (2050) and 45% (2100), respectively (see below). And assuming an internal equity for the North of 59% (today 50%) and for the South of 50% (today 28%) leads to a world-wide equity of 44% (45%) in 2050 (2100) (today 11.6%) which is close to the present US value and would mean that the route to **world civil rights** and a **world democracy**, as we witness it in Europe, is open [48].

To achieve a situation as in Scenario C, requires a global economic design, where massive investments into **good governance, infrastructure build-up** and **education** world-wide are co-financed by the North, where women **everywhere are empowered, powerful social systems built up** world-wide and where eventually critical innovations from a social, cultural of ecological point of view are being slowed down in the end via the economic incentive structures [40, 48]. Obviously, this incorporates a special view on social balance, as developed in detail in [45] as part of the TERRA project, and closely related to the present paper. **Social balance is primarily about the full development of all human potentials**, not about subsidizing consumption's of the poorer part of a society. To this an equity level of at least 45 – 50 % must be reached. Achieving this makes they world richer not poorer.

Particularly, the rigid **incorporation** of ecological constraints into the **price structures** will lead to a **re-regionalization** of the production of goods of low added value. This will e.g. solve many problems of today's unsustainable mobility [51] and also overcome many unpleasant developments in the field of agriculture, where supporting 9 - 10 billion people in the end at a high level of food quality will be a major but solvable challenge within this scenario [48, 64,74]. It means a **re-invention of politics** over the economy to stabilise the development of humankind, that becomes an intelligent **human-technical integrated superorganism**, but **respects individual autonomy and freedom**. Obviously, tele-work will play a much bigger role in this future world than today. And there will be a chance to finally take fully into account the interests of people, living on a subsistence level [54].

The **security elements** installed will be sophisticated, economically efficient, lead to a high security level and to robustness, but are balanced and still **respect individual freedom and informational rights of humans** (cf. [49] and Chapter VII). China and India will become even much more important factors of world politics than today, due to their economic weight, being a direct consequence of their huge populations and of the world eventually approaching an equity factor of about 44% (2050) and 45% (2100) in this scenario. In the end, **Europe will significantly overcome the US** in economic weight, too, and when taken together with Russia, Europe may be on par with China as the economically strongest societies at that time (2050 to 2100). The eco-social model is interesting, but a challenge in itself. Things will certainly not be easy. But Scenario C is a case, where the hope is for eventually reaching a **world democracy, world civil rights** and a **long-term sustainable development** on a stable and robust route [48].

Scenario D: The eco- or resource-dictatorship model with massive security control

Scenario D, as Scenario C, will incorporate physical limitations of collective human behaviour strictly into the economy. So, at least in principle, it has a chance for **avoiding an ecological breakdown and for reaching long term stability**, which Scenarios A and B don't have. So the resource-dictatorship model with security control is the other (possibly) stable alternative in sight for the future. In this approach, when looking to a trajectory to the year 2050 (2100), **physical constraints for collective human behaviour will be incorporated into the world economic system, too**. This will, however, not be done by contract and consensus among the states and people of the world and agreed upon among the relevant triangle of partners today in this issue consisting of (1) **politics**, (2) **multinational companies**, and (3) **world civil society**, but by using power structures of the **Rich against the Poor** on a country level and of the **rich nations of the North against poorer nations of the South** in the international area. Tools used may be **excessive free market approaches** in situations of total asymmetric starting points, a continued and massive **brain-drain** without compensation, a massive **instrumentalization of intellectual property rights, control of resources, imposition of high standards without co-financing**, whatever the outcome for poorer countries, **control of technology flow, double standards** concerning human rights between North and South, fight against **reproductive health programs** by the UN (at least in the beginning) and "fuelling" **internal unrest in countries such as China** to limit their growth potential. **Human right issues might be instrumentalized** in this context to generate **arguments for interference**. This will mean resource control, it will mean the imposition of high standards onto poor countries without co-financing as a way of exclusion etc.

Note that when this material was first presented in the 2nd TERRA review in 2002, the renewed Iraq War was not yet on the horizon. But building on [48], a US-backed attack war without proper international legitimation, a split between Europe and the US, etc. were already pointed at as possible indications of a resource dictatorship approach, as is the fight of the present US administration against the **Kyoto accord**, the **international criminal court** and against efforts to **implement a global Marshall Plan**.

The way the Israeli government under President Sharon deals (until recently) with the Palestinians falls into the same picture. Here, a possible unpleasant future for the world becomes visible and an idea, what the price could be in terror, suicide attacks etc., if the rich world follows the kind of approach discussed as Scenario D.

Looking into that model we assume with view to 2050 (2100), that a factor 6 of growth is realised. This is again to be seen in the context of a much greater world population than today.

The reduction of growth indicated in comparison to Scenario C results from the fact, that the enormous growth potential of the poorer countries is by far not activated within this scenario, due to **missing co-financing of development**. Therefore, world GNP increases (only) be a factor 6 instead of a factor 10, when compared to Scenario C. This corresponds to the main observation in [44] that not implementing a world social program, i. e. not fully developing all human potentials, **keeps the world poorer than it could be**, though exactly this seems to be attractive from the point of view of certain groups among the Rich, in particular from a relative wealth point of view and with regard to the availability of **cheap personal services**.

By implementing the resource-dictatorship side of the issue, it might be possible to synchronously increase eco-efficiency by a similar factor 6 at the same time, not more though. So we have a double factor 6 perspective, i. e. a (6,6) pattern. For the North we assume the same growth then in the eco-social case, which is a factor 4, which leaves for the South a factor 14, i. e. (4,14) is the respective growth share between North and South. This means that the North with presently 16 % of people (of 6 billion today) and 80 % of world income will see a factor 4 increase of GNP by 2050 (2100), leaving space for a factor 14 increase of GNP by 2050 (2100) by the South. The North then has 320 of a 600 volume in total, the South 280 (14x20). Overall global average growth within the **6 --> (4,14) context** will be 3.65% (1.81%) in a 50 years (100 years) development picture, i. e. will be clearly less than in Scenario C with 4.71% (2.33 %) and in Scenarios A and B with 5.42 % (2.67%). This amounts to 2.81% (1.40%) for the North as in Scenario C and 5.42 % (2.33%) for the South of average annual growth rates over 50 years (100 years). This is the same for the North as in Scenario C, but much less for the South, due to missing co-financing of development, which again, makes the world as a whole poorer, but can be attractive for certain groups among the Rich that like the availability of cheap personal services of all kind. Remember growth rates for the South have been about 7.55% (3.7%) in Scenarios A - C.

Growth rates in the North might actually be somewhat higher in the beginning and less later. On top, parts of GNP now will have to go into security elements instead of consumption.

Growth rates will all be honest in Scenario D, because eco-efficiency increases synchronously in this approach by a factor 6 until the year 2050 (2100). The respective efficiency curve will thus develop from 100 down to 16.7 over time. Because the South is developing comparatively slowly, even in the year 2050 (2100), the **global situation concerning equity would be unacceptable**.

For instance, the present average 21:1 distribution pattern between North and South will improve to (only to) about 7.1:1 (5.9:1) for the 2050 (2100) case, i.e. will be clearly much worse than in Scenario A, not to speak of Scenario C. Equity will stay around 23% for the 2050 and the 2100 case, nothing comparable to the eco-social model (about 45%) and also clearly worse than Scenarios A and B with about 30% of equity. Instead, assuming the North to have 1.4 billion people (less than in Scenario AB because of expected migration control to the North) and an internal equity of 52% in 2050 (today 50%) and the South to have 8.6 billion people and an internal equity of 40% in the 2050 case (today 28%) and 1.5 billion people and an internal equity of 52% in the North in 2100 and the South to have 9.5 billion people and an internal equity of 40% in the 2100 case at that time leads to an overall equity factor for the world in 2050 and accidentally also in 2100 under Scenario D of 23%, as already mentioned, i.e. not even yet as high as in the worst equity situations within countries today, e. g. Brazil and South Africa (27%/28%). Consequently, **population growth will not get under control in this case**. For some additional insight into the issue of population growth see [1, 12, 34, 46, 67, 75, 76, 77, 78]. However, we assume that within a resource dictatorship approach, the US would eventually change its present position and the rich world would force population control onto the poorer world, eventually. Therefore, as in Scenario AB, we work with an inherent upper limit for world population of **12 billion people** for this case, too (cf. Chapter III).

In summary, the ecological situation (also for the South) is better in Scenario D in comparison to Scenarios A and B, but instead the equity situation is much worse – no reasonable alternative.

Massive tensions will result from this kind of development, particularly concerning the equity issue, i.e. with view to an ultimate game [44] point of view, **insufficient equity will be the main reason for resistance and terror in this scenario**. We assume that resistance to this development pattern will be high, which will have to be compensated for massively by security instruments. It means that ICT technology is not so much used to close gaps but is used more to implement security (cf. also Chapter VII). However, there is a huge resistance problem to be expected, **so this model is not really stable**. It pays a high price in form of eventual collapse, while not achieving a higher growth for the North on the long run than the eco-social model, and also not achieving more support for the environment. However, by being less growth creative, at the same time less eco-efficient, balance is kept by a relatively higher use of resources by the North in comparison to the share reached by the South. **Military**, of course, will play a big role in this approach, so the GNP levels per person have to be

reduced by a certain amount concerning the real life situation of people due to that kind of “investment”.

Scenario D is clearly not an attractive landing place, but there is a reasonable probability, that this is where the globe will end. Actually, the authors regard **Scenario D to be the most probable case**. This case will be our future, if not politics, in particular **European politics**, does act in a very intelligent way to avoid that situation and manoeuvres the globe more into direction of Scenario C, the European Way, the Balanced Approach, the eco-social market model for a global economy that is imagined and designed to be sustainable. But this aim seems now to be even more difficult to reach after the US-triggered attack war on Iraq and the resulting split between the EU members. Hopefully, the resulting **feeling of humiliation among Europeans drives Europe towards more unity and a stronger self defence capacity** [48]. Overall, the personal estimates of the authors concerning the future of the world remained unchanged since the TERRA review in 2002 as given next.

Personal estimate of the authors concerning the three/four futures described (with additional North:South average distribution patterns for 2050 (2100) starting from 21:1 today:		
Scenario A and B 4.5:1 (3.8:1)	15%	(WTO-like)
Scenario C 2.5:1 (2.3:1)	35%	(eco-social)
Scenario D 7.1:1 (5.9:1)	50%	(resource-dictatorship)

Table 1: Personal estimates concerning the futures considered

III. Scenario data concerning all considered futures

In the following, we give for all considered scenarios, under the framework conditions, mentioned in Chapter II, for the world divided in **Rich and Poor** and the **world as a whole** the following values, obtained by a suitable interpolation between extreme data points and by approximating **equity values**. The **equity values** are, of course, crucial for the approach chosen. Population values contain **massive migration** from South to North. All essential values are set from an overall best judgement of the authors, so **they are not derived from a model**. Given the nature of the scenarios, arriving on such values internally for a quite chaotic group of futures, seems almost impossible. We mention, however, that building on a good understanding of recent population trends as given in [14, 73], there are some efforts on the way by the authors of [14, 73] to come closer to a more internal insight on prognostic numbers for the futures considered here.

Though important data was set within this paper, the results obtained have, at least, been checked as far as possible for **consistency among each other**. Also, they are more to be seen as data points in **parameter variations**, e. g. concerning the target date 2050 or 2100 or something in between. Note that the authors regard the year **2100 case to be considerably more probable than the year 2050** for the target growth given to be achieved. Interpolated data is given for each 5 (10) years for the North, the South, and the whole world, until the year 2050 (year 2100), respectively.

In the following, we give crucial input parameters for global development for the years 2000-2050 (or 2000-2100) for the different futures dealt with in this paper. Input parameters are given in Table 3 for the year-2050 case and in Table 5 for the year-2100 case. These fixed values, the logic behind them etc. has to a considerable extent already been discussed in Chapter II. In fact, in order to do the computations for the deduced data, the given data, that characterize scenarios, had to be fixed. Note further that the computational methods used to derive at the deduced data strongly builds on the following papers that, to a great extent, were developed within the TERRA 200 project [27, 28, 29, 30, 31, 33, 33].

The three essential futures that we will look into were characterized in Chapter II by the following overall growth and distribution patterns and the overall development of eco-efficiency as follows: (14,7) and 14 -> (8:38) for Scenario AB, (10,10) and 10 -> (4:34) for Scenario B and (6,6) and 6 -> (4:14) for Scenario D. In line 1 in Tables 3 and 6, these values are translated into **average economic growth rates** for the North, the South and the world as a

whole. Here, the annual growth rates are $\sqrt[50]{\frac{\text{Value 2050}}{\text{Value 2000}}}$ or $\sqrt[100]{\frac{\text{Value 2100}}{\text{Value 2000}}}$ for the year-2050 and the year-2100 cases. The respective values given in Tables 3 and 6 thus result directly from the imposed assumptions on growth and distribution patterns of type either 14 -> (8:38) or 10 -> (4:34) or 6 -> (4:14) over 50 or 100 years.

Similarly, in line 5 in Tables 3 and 6, we get to dematerialization values over 50 or 100 years, resulting directly from the assumed (14,7), (10,10) and (6,6) patterns in the respective scenarios. Again, the annual shrinking rates are computed from the formula $\sqrt[50]{\frac{\text{Value 2050}}{\text{Value 2000}}}$ or $\sqrt[100]{\frac{\text{Value 2100}}{\text{Value 2000}}}$ for the year-2050 and the year-2100 cases. Note that in the two latter cases, i.e. the cases (10, 10) and (6, 6), world economic growth rates and world dematerialization rates are identical, i.e. **growth is honest** in the sense of [44], while for Scenario AB with its 14:7 pattern it is clearly not.

Concerning world population and its distribution between rich and poor world, the following assumptions have been made. The starting point is the often cited claim that 20 percent of world population today owns 80 percent of wealth, leaving only 20 percent of wealth for the rest of the world. Within TERRA [32], the **world income distribution** has been determined as given in Table 2 and Figure 2, to better clarify this claim. The computation is complicated, builds on the World Development Report data set [75] and will be a reference point in the following. Note that this work within TERRA took place parallel to other (rare) approaches and results [55], where data is, however, not generally available, also not on request, also not to the authors of this paper.

Quantile in %	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	40-45	45-50
Share in %	0,10	0,18	0,21	0,24	0,31	0,36	0,38	0,41	0,51	0,70
Average income in US\$ per Quantile	99	179	209	238	308	358	378	407	507	696
Quantile	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100
Share in %	0,80	0,95	1,01	1,54	1,81	2,86	6,5	13,35	20,77	47,01
Average income per Quantile	795	944	1004	1530	1798	2842	6458	13265	20637	46710

Table 2: World income distribution in 2000

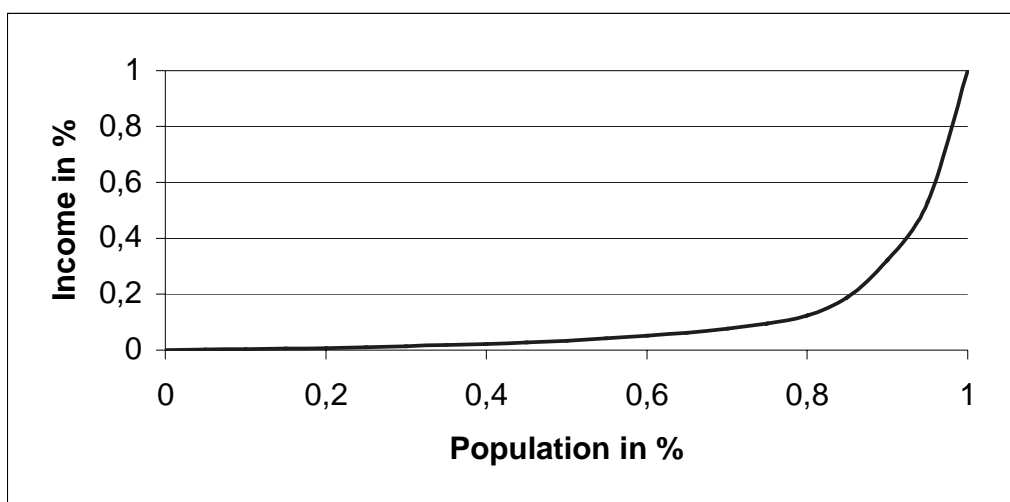


Fig. 2: World Lorenz curve

Collecting as many rich countries as needed to accumulate 80 percent of global wealth (so-called **rich world**) leads to all countries having in the year 2000 an average income roughly greater or equal 8,000 \$ (7,900 \$). These are the **OECD countries (without Mexico, Turkey, Poland, Hungary, Czech Republic and Slovakia) and, in addition, Kuwait, Slovakia, and Saudi Arabia**. Note that the richest people making up for 80 % wealth globally amount for only 14.3 % of world population. These are for the time being all people with an income higher than 10,600 \$ a year. Looking for countries with the highest average income and summing up their population to account for 80 % of world's income yields the lower value of **7,900 \$ average income** as a reference point and leads to **16%** of world population instead of the often cited 20 %. Actually, this 16 % amount for roughly **1 billion people** (958 million). This approach is more difficult than to refer to the 14.3 % of rich people, directly. As, however, rich countries offer certain public services to their citizens that are in part not reflected in the income distribution, and as world politics is still dominantly shaped by nation states and the experiences made and the aims followed there, the country-oriented approach may still give more insight.

So, if wealth is computed in \$ terms, the global equity situation today is even worse than 20 percent of people having 80 percent of all wealth which corresponds to an average 16:1 pattern, as is known from literature. In fact, it is about 16 percent of people having 80 percent wealth which means an average **21:1 pattern concerning average income differences between North and South**. Note further that the number of people in all other countries with income higher than 7,900 \$ a year is, for the time being, only about 50 million people. In any

case, the 7.900 \$ income level seems to be a good starting point to define the rich vs. the poor world for the moment.

In the following, we use the division of the world into these two parts to develop assumptions for the future of the globe. We can do this with a certain justification, as there is a quite good feeling about the development trends in these two parts. In this line of thinking, for all scenarios we did already in Chapter III develop ideas about **GPN growth, dematerialisation rates, equity situation** and **population growth**. The development concerning population growth will be further detailed below.

With all this input data, we then want to arrive at two kinds of critical information that has to be deduced: (1) **world equity values** (as already reported in Chapter II) and (2) **number of people on a high consumption level for particular years**. We will define the number of people on a high consumption level as having, in the future years considered, an income higher than 7.900 \$, the line that we just used to define the rich world for the time being. Note that our approach is **inflation free**. However, as we have a **non-honest growth situation** concerning GPN development and resulting overshoots in Scenario AB, prices of goods that are **nature-intensive** or **resource-critical** (such as food or oil) will certainly adjust, i.e. prices will go up. This would even happen with honest growth rates, but will certainly be a major factor in this case. Therefore, we will additionally look into the number of people in the respective cases having an income of at least two or three times 7.900 \$. On top, we will also look how many people will account, in the respective cases, for 80% income. These are "**rich people**" for the years and scenarios considered in a relative sense with a comparably high income and thus with a **comparatively strong purchasing power** in the markets.

The resulting values of people with high purchasing power will be given in Tables 5.1-5.3 for the year 2050 and in Tables 8.1-8.3 for the year 2100. For Scenario AB, these numbers are an essential input into the **gap analysis in Chapter IV**.

Finally, we need the **world income distribution** in the futures considered to actually compute the numbers just discussed. We will do this by trying to determine the **world income distribution** from the respective income distributions for the rich and the poor world. Having set information about GNP growth, population growth and development of equity for the North and South, this is a complicated but quite straightforward computational task. However, unfortunately near the year 2000, where income differences between North and South are very high and equity parameter values are very different as well, any straightforward approach leads to significant data inconsistencies with presently available data (cf. Table 2),

e.g. world equity goes up from about 11.5% to 19%, when merging the equity cases for North and South with present data, instead of determining the full Lorenz curve as given in Table 2.

Therefore, a much more involved approach has to be taken. In [32] (ist das die richtige Referenz???) the one-parametric Lorenz approach usually referred to in this paper [30] is replaced by a **two-parametric version** that **gives a much better fit**. This two-parametric approach reflects the observation that the relative share of relatively poor people in relation to the average of all people with higher income is **comparatively lower** than the relative share of richer people relative to the average of all even richer people, cf. Fig. 3. This observation makes it clear once more that **social balance has to do with the ability to defend one's own interest**.

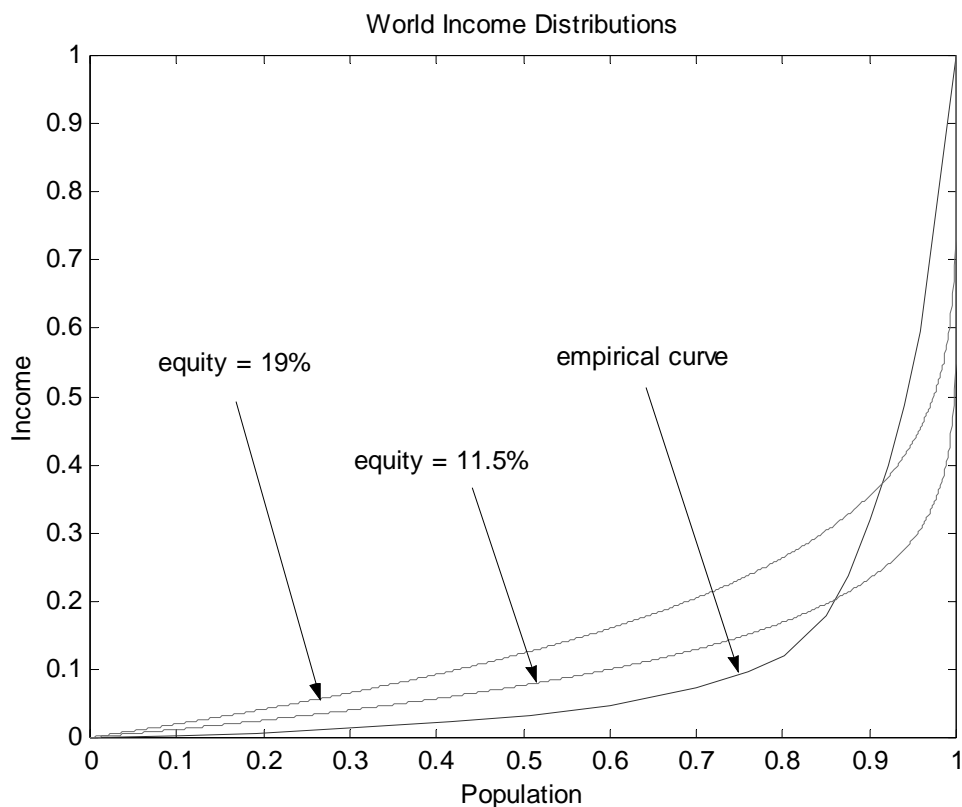


Fig. 3: A two-parametric instead of a one-parametric approximation of a Lorenz function

Fig. 3 gives the situation concerning the world income distribution in the year 2000, cf. Table 2 and Fig. 2 in this Chapter. When doing a two-parametric approach for the year 2000 for the North and South and then combining this straightforwardly, the best one-parametric fit for the year 2000 is an equity of 11.5%, almost the same as 11.6 oder 7%????????????, the best

one-parametric solution for the empirical curve (Fig. 2). Unfortunately, the value is 19%, if it is reconstructed from separate best one-parametric fits for the North and the South in 2000, therefore this approach cannot be followed.

Looking into the future, we have as best fit in 2000 the two-interval points 13%-63% for the North and 5%-35% for the South. As we have no empirical Lorenz curve available for the future to adjust the two-parametric curves, we can do no more approximation. Instead we linearly shrink towards the respective years 2050 or 2100 the interval between the upper and lower values and have it converge towards the target values of equity set for these years in our scenarios. I.e. when going from 2000 to 2050 or 2100, the lower (upper) values for the used two-parametric approximation will e.g. (linearly) approximate 13->45% and 63->45% for Scenario AB. The resulting data biases should be limited, as the effect is already limited in the year-2000 case and the approximation situation becomes considerably better towards the years 2050 and 2100, because there is a much smaller gap between North and South and because equity values in the South get closer to those in the North.

The resulting values concerning people with high purchasing power for all cases considered are given in Tables 5.1-5.3 and 8.1-8.3 and give a feeling for the development of global equity and for the number of people with considerable income (being a first approximation to what is sometimes called the **global middle class**).

In the following, the yet missing detailed data to be set concerning **population growth** is given. It will have to take account for **massive migration** for the South and the North. The ability to live the lifestyle of the global middle class is positive from an individual point of view but in aggregated form is not without problems for the globe, particularly in an dishonest growth situation as in Scenario AB. As already mentioned, the respective numbers will play a key role in the **gap analysis** in Chapter IV for Scenarios AB. Note that those values are deduced from the other assumptions.

Obviously, a crucial role plays **population growth** and the size of the **world population** (see again [1, 12, 34, 46, 67, 75, 76, 77, 78]). Starting from the year-2000 situation, with about 1 billion people in the rich world and about 5 billion in the poor world, we see (cf. line 3 in Tables 3 and 6) the estimates made for the population in the North, the South and the world as a whole in 2050 vs. 2100. The numbers result from assumptions concerning **future population growth**, where, also in line with Kapitza [34], certain **inherent limitations to further world population growth** are incorporated into our projections. Here, for methodical reasons, we chose a slightly different approximation scheme than Kapitza, but follow essentially

a similar line of thinking. So, world population in each scenario in the long run **approximates an upper limit**, according to a modified sigmoidal function type with a Scenario-dependent upper limit, see Fig. 4. Here, the population development is not made dependent on the concrete target date between 2050 and 2100, when target growth is reached, because this influence is seen as minor. As already pointed out in Chapter II, the assumed upper limit is **12 billion** in Scenario AB (resulting from **societal breakdown** due to gaps according to IV), **10 billion** in Scenario C (resulting from **social balance**) and **12 billion** again in Scenario D (resulting from **forced population control** in the long run under this scenario).

Population growth, under all scenarios, actually only takes place in the South and it significantly overcompensates a (in times heavy) shrinking of population in the North, if migration is not considered. For the study, we have set the overall development of world population. The values given for the North incorporate **shrinking plus migration**. The remaining population then forms the population in the South.

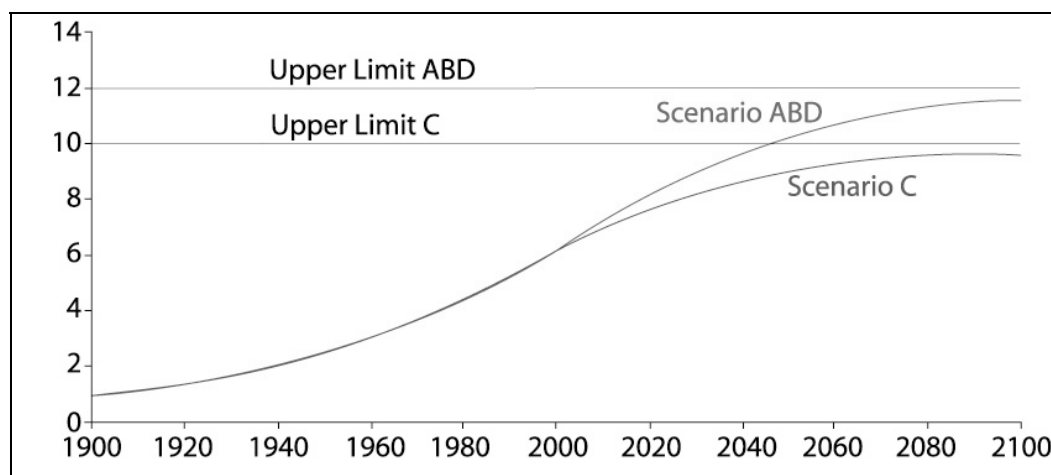


Fig. 4: Assumed limitations to and actual world population growth for scenarios

For each Scenario and for the years 2050 vs. 2100, considerations for the **equity situation** in North and South have been done and lead to the values in line 4 in Tables 3 and 6. With the mathematical tools developed in [30, 32] and being an essential contribution to this paper, the equity values for the world as a whole can then be deduced approximately for all six cases considered. These values make clear that under Scenario D, the equity situation will remain critical and stay that way – a great indication towards **terror and unrest**.

Tables 4.1-4.3 and 5.1-5.3 (and 7.1-7.3 as well as 8.1-8.3) finally give all intermediate data up to 2050 (2100) in steps of five (ten) years. The values are computed as straightforward interpolation steps.

Basic assumptions for the Futures considered 2050									
	Scenarios A, B			Scenario C			Scenario D		
	North	South	World	North	South	World	North	South	World
1. Average GNP annual growth till 2050	4,25%	7,55%	5,42%	2,81%	7,31%	4,71%	2,81%	5,42%	3,65
2. Economic Growth Factor over 50 years	8	38	14	4	34	10	4	14	6
3. Population in 2050	1,6 billion	8,4 billion	10 billion	1,4 billion	7,6 billion	9 billion	1,4 billion	8,6 billion	10 billion
4. Equity in 2050	47%	40%	30%	59%	50%	44%	52%	37%	23%
5. Average dematerialisation rate over 50 years			-3,97%			-4,71%			-3,65

Table 3: Parameters set for the 2050 case (the shaded values were computed)

The otherwise resulting development paths for the time 2000-2050, depending on the scenario considered, are then as follows:

Scenario AB 2050 14 → 8:38												
Time	1			2			3			4	5	6
	Population in million			GNP in billion			Equity			Economic Growth	dematerialization	Average Income
Year	World	North	South	World	North	South	World	North	South	World	World	World
2000	5728	958	4770	27940	22750	5190	11,6%	50%	28%	1,00	1,000	4878 \$
2005	6406	1022	5384	35460	28000	7460	11,3%	50%	29%	1,30	0,823	5535 \$
2010	7011	1086	5925	45210	34480	10730	13,2%	49%	30%	1,70	0,678	6448 \$
2015	7552	1151	6401	57890	42450	15440	14,4%	49%	31%	2,21	0,558	7666 \$
2020	8033	1215	6818	74490	52270	22220	15,5%	49%	32%	2,87	0,459	9273 \$
2025	8462	1279	7183	96320	64350	31970	17,8%	49%	33%	3,74	0,378	11383 \$
2030	8844	1343	7501	125210	79220	45990	19,9%	48%	35%	4,87	0,311	14158 \$
2035	9186	1407	7779	163700	97530	66170	22,6%	48%	36%	6,34	0,256	17821 \$
2040	9491	1472	8019	215280	120080	95200	24,5%	48%	37%	8,26	0,211	22683 \$
2045	9762	1536	8226	284800	147830	136970	27,3%	47%	39%	10,75	0,174	29174 \$
2050	10000	1600	8400	379220	182000	197220	30,3%	47%	40%	14,00	0,143	37922 \$

Scenario C 2050 10 → 4:34												
Time	1			2			3			4	5	6
	Population in million			GNP in billion US \$			Equity			Economic Growth	dematerialization	Average Income
Year	World	North	South	World	North	South	World	North	South	World	World	World
2000	5728	958	4770	27940	22750	5190	11,6%	50%	28%	1,00	1,000	4878 \$
2005	6305	1002	5303	33510	26130	7380	12,5%	50%	29%	1,26	0,794	5315 \$

2010	6805	1046	5759	40520	30020	10500	14,6%	51%	31%	1,58	0,631	5954 \$
2015	7237	1091	6146	49420	34480	14940	15,4%	53%	33%	2,00	0,501	6829 \$
2020	7611	1135	6476	60860	39610	21250	19,4%	53%	35%	2,51	0,398	7996 \$
2025	7934	1179	6755	75740	45500	30240	22,3%	54%	37%	3,16	0,316	9546 \$
2030	8213	1223	6990	95290	52270	43020	26,2%	55%	39%	3,98	0,251	11602 \$
2035	8454	1267	7187	121260	60040	61220	30,4%	56%	42%	5,01	0,200	14344 \$
2040	8664	1312	7352	156070	68970	87100	35,0%	57%	44%	6,31	0,158	18014 \$
2045	8844	1356	7488	203150	79220	123930	40,2%	58%	47%	7,94	0,126	22970 \$
2050	9000	1400	7600	267320	91000	176320	44,2%	59%	50%	10,00	0,100	29702 \$

Scenario D 2050 6→4:14												
Time	1			2			3			4	5	6
	Population in million			GNP in billion			Equity			Economic Growth	demateriali- zation	Average Income
Year	World	North	South	World	North	South	World	North	South	World	World	World
2000	5728	958	4770	27940	22750	5190	11,6%	50%	28%	1,00	1,000	4878 \$
2005	7406	1002	6404	33250	26133	6757	10,5%	50%	28%	1,20	0,836	4490 \$
2010	7011	1046	5965	39590	30019	8798	12,0%	50%	29%	1,43	0,699	5647 \$
2015	7552	1091	6461	47227	34483	11455	13,1%	50%	30%	1,71	0,584	6258 \$
2020	8033	1135	6898	56330	39610	14915	14,1%	50%	31%	2,05	0,488	7012 \$
2025	8462	1179	7283	67270	45500	19419	15,7%	51%	32%	2,45	0,408	7950 \$
2030	8844	1223	7621	80390	52266	25284	16,5%	51%	33%	2,93	0,341	9090 \$
2035	9186	1267	7919	96180	60038	32920	18,0%	51%	34%	3,51	0,285	10470 \$
2040	9491	1312	8179	115160	68965	42862	19,9%	51%	35%	4,19	0,238	12134 \$
2045	9762	1356	8406	138030	79220	55806	21,6%	51%	36%	5,02	0,199	14140 \$
2050	10000	1400	8600	165610	91000	72660	23,3%	52%	37%	6,00	0,167	16561 \$

Tables 4.1-4.3: Scenario data for 2000-2050 in five-year steps

The resulting development of the global income situation, above all the number of people with a high purchasing power, is given in Tables 5.1-5.3 for the year-2050 case for all scenarios considered. Note that one up and down in world equity in Scenarios AB and D has to do with the comparatively higher growth rate of world population relative to world GNP growth at the beginning for the time period considered.

Number of good earners (in million) Scenario AB 2050 (14 → 8:38)						
Year	Equity	Number of people with income ≥7900 \$	Number of people with income ≥15800 \$	Number of people with income ≥23700 \$	Number of rich people having 80% of wealth	
					#	Income line in \$
2000	11,6%	859	659	430	801	9268
2005	11,3%	993	737	525	896	9410
2010	13,2%	1157	841	631	1086	9350
2015	14,4%	1359	982	755	1283	9583
2020	15,5%	1607	1125	924	1526	9273
2025	17,8%	1946	1493	1100	1819	9106
2030	19,9%	2476	1725	1415	2211	9911
2035	22,6%	3491	2067	1745	2755	11227
2040	24,5%	4840	2563	2041	3037	12929
2045	27,3%	7517	3914	2636	3660	16046
2050	30,3%	10000	4800	3500	4200	19719

Number of good earners (in million) Scenario C 2050 (10 → 4:34)						
Year	Equity	Number of people with income ≥7900 \$	Number of people with income ≥15800 \$	Number of people with income ≥23700 \$	Number of rich people having 80% of wealth	
					#	Income line in \$
2000	11,6%	859	659	430	801	9268
2005	12,5%	694	662	473	946	7973
2010	14,6%	1089	817	544	1157	7145
2015	15,4%	1230	926	651	1303	6829
2020	19,4%	1484	1066	761	1865	5357
2025	22,3%	1825	1269	912	2341	5632
2030	26,2%	2382	1560	1109	2891	6381
2035	30,4%	3382	1860	1437	3593	7602
2040	35,0%	5285	2426	1819	4029	9547
2045	40,2%	8579	3538	2388	4687	12404
2050	44,2%	9000	5670	3240	5130	16633

Number of good earners (in million) Scenario D 2050 (6 → 4:14)						
Year	Equity	Number of People with income ≥7900 \$	Number of People with income ≥15800 \$	Number of People with income ≥23700 \$	Number of rich People having 80% of wealth	
					#	income line in \$
2000	11,6%	859	659	406	801	9268
2005	10,2%	926	667	481,4	896	8980
2010	12,0%	1052	750	546,9	1017	8809
2015	13,1%	1208	868	641,9	1148	9324
2020	14,1%	1325	1004	723,0	1293	8765
2025	15,7%	1472	1151	837,7	1498	7553
2030	16,5%	1680	1371	1017,1	1742	6818
2035	18,0%	1929	1470	1194,2	2085	7224
2040	19,6%	2278	1613	1471,1	2363	7523
2045	21,6%	2704	1806	1561,9	2704	8060
2050	23,3%	3360	2050	1750,0	3120	8612

Tables 5.1-5.3: Numbers of people with high income in 2000-2050 in the respective futures

Basic assumptions for the Futures considered 2100									
	Scenarios A B			Scenario C			Scenario D		
	North	South	World	North	South	World	North	South	World
1. Average GNP annual growth till 2100	2,10%	3,70%	2,67%	1,40%	3,59%	2,33%	1,4%	2,67%	1,81%
2. Economic Growth Factor over 100 years	8	38	14	4	34	10	4	14	6
3. Population in 2100	1,6 billion	9,4 billion	11 billion	1,6 billion	7,9 billion	9,5 billion	1,5 billion	9,5 billion	11 billion
4. Equity in 2100	45%	40%	30%	59%	50%	45%	52%	35%	23%
5. Average dematerialization rate over 100 years			-1,95%			-2,33%			-1,81%

Table 6: Parameters set for the 2100 case (the shaded values were computed)

Scenario AB 2100 14 → 8:38												
Time	1			2			3			4	5	6
	Population in million			GNP in billion			Equity			Economic Growth	Dematerialization	Average Income
Year	World	North	South	World	North	South	World	North	South	World	World	World
2000	5728	958	4770	27940	22750	5190	11,6%	50,0%	28,0%	1,00	1,000	4878
2010	6961	1022	5939	35468	28008	7460	11,0%	49,5%	29,0%	1,30	0,823	5095
2020	7909	1086	6823	45210	34480	10730	11,6%	49,0%	30,1%	1,70	0,678	5716
2030	8633	1151	7482	57890	42450	15440	12,6%	48,4%	31,2%	2,21	0,558	6706
2040	9180	1215	7965	74490	52270	22220	14,5%	47,9%	32,3%	2,87	0,459	8114
2050	9588	1279	8309	96320	64350	31970	16,2%	47,4%	33,5%	3,74	0,378	10046
2060	9778	1343	8435	125210	79220	45990	19,1%	46,9%	34,7%	4,87	0,311	12805
2070	10161	1407	8754	163700	97530	66170	20,6%	46,4%	35,9%	6,34	0,256	16111
2080	10484	1472	9012	215280	120080	95200	23,4%	46,0%	37,2%	8,26	0,211	20534
2090	10761	1536	9225	284200	147830	136370	26,6%	45,5%	38,6%	10,75	0,174	26410
2100	11000	1600	9400	379070	182000	197070	29,9%	45,0%	40,0%	14,00	0,143	34461

Scenario C 2100 10 → 4:34												
Time	1			2			3			4	5	6
	Population in million			GNP in billion			Equity			Economic Growth	Dematerialization	Average Income
Year	World	North	South	World	North	South	World	North	South	World	World	World
2000	5728	958	4770	27940	22750	5190	11,6%	50,0%	28,0%	1,00	1,000	4878
2010	6329	1166	5163	33510	26130	7380	12,9%	50,8%	29,7%	1,26	0,794	5295
2020	6782	1275	5507	40520	30020	10500	15,1%	51,7%	31,4%	1,58	0,631	5975
2030	7241	1433	5808	49420	34480	14940	17,4%	52,5%	33,3%	2,00	0,501	6825
2040	7659	1592	6067	60860	39610	21250	20,4%	53,4%	35,3%	2,51	0,398	7946
2050	8041	1750	6291	75740	45500	30240	23,9%	54,3%	37,4%	3,16	0,316	9419
2060	8389	1800	6589	95290	52270	43020	27,2%	55,2%	39,7%	3,98	0,251	11359

2070	8706	1850	6856	121260	60040	61220	31,2%	56,1%	42,0%	5,01	0,200	13928
2080	8996	1900	7096	156070	68970	87100	35,6%	57,1%	44,5%	6,31	0,158	17349
2090	9260	1950	7310	203150	79220	123930	40,2%	58,0%	47,2%	7,94	0,126	21938
2100	9500	1600	7900	267320	91000	176320	45,0%	59,0%	50,0%	10,00	0,100	28139

Scenario D 2100 6 → 4:14												
Time	1			2			3			4	5	6
	Population in million			GNP in billion			Equity			Economic Growth	Demateriali- Zation	Average Income
Year	World	North	South	World	North	South	World	North	South	World	world	World
2000	5728	958	4770	27940	22750	5190	11,6%	50,0%	28,0%	1,00	1,000	4878
2010	7172	1012	6160	33250	26133	6757	10,5%	50,2%	28,8%	1,20	0,836	4636
2020	8096	1066	7030	39590	30019	8798	10,8%	50,4%	29,6%	1,43	0,699	4890
2030	8821	1121	7700	47227	34483	11455	11,7%	50,6%	30,4%	1,71	0,584	5354
2040	9393	1175	8218	56330	39610	14915	12,8%	50,8%	31,3%	2,05	0,488	5997
2050	9842	1229	8613	67270	45500	19419	14,0%	51,0%	32,2%	2,45	0,408	6835
2060	10195	1283	8912	80390	52266	25284	15,5%	51,2%	33,1%	2,93	0,341	7885
2070	10474	1337	9137	96180	60038	32920	17,1%	51,4%	34,0%	3,51	0,285	9183
2080	10692	1392	9300	115160	68965	42862	19,2%	51,6%	35,0%	4,19	0,238	10771
2090	10865	1446	9419	138030	79220	55806	20,8%	51,8%	36,0%	5,02	0,199	12704
2100	11000	1500	9500	165610	91000	72660	23,0%	52,0%	37,0%	6,00	0,167	15055

Tables 7.1-7.3: Scenario data for 2000-2100 in ten-year steps

The resulting development of the global income situation, above all the number of people with a high purchasing power, is given in Tables 8.1-8.3 for the year-2100 case for all scenarios considered. Note that one up and down in world equity in Scenarios AB and D has to do with the higher growth rate of world population, relative to world GNP growth, at the beginning of the time period considered.

Number of good earners (in million) Scenario AB 2100 (14 → 8:38)						
Year	Equity	Number of People with income ≥7900 \$	Number of People with income ≥15800 \$	Number of People with income ≥23700 \$	Number of rich People having 80% of wealth	
					#	income line in \$
2000	11,6%	859	659	430	801	9268
2010	11,0%	905	654	452	919	9171
2020	11,6%	1147	791	609	1084	8860
2030	12,6%	1355	950	777	1295	9053
2040	14,5%	1561	1148	872	1561	8114
2050	16,2%	1918	1409	1103	1918	8037
2060	19,1%	2542	1711	1340	2445	8835
2070	20,6%	3252	1931	1687	2794	9989
2080	23,4%	4823	2569	1992	3355	11704
2090	26,6%	7210	3444	2475	3982	14261
2100	29,9%	11000	5280	3410	4620	17575

Number of good earners (in million) Scenario C 2100 (6 → 4:14)						
Year	Equity	Number of People with income ≥7900 \$	Number of People with income ≥15800 \$	Number of People with income ≥23700 \$	Number of rich People having 80% of wealth	
					#	income line in \$
2000	11,6%	859	659	430	801	9268
2010	12,9%	981	701	475	949	7943
2020	15,1%	1153	780	543	1187	7170
2030	17,4%	1340	905	615	1484	6006
2040	20,4%	1570	1072	766	1953	5324
2050	23,9%	1930	1327	885	2453	5651
2060	27,2%	2517	1678	1133	3020	6361
2070	31,2%	3482	1959	1393	3657	7521
2080	35,6%	5218	2564	1889	4273	9368
2090	40,2%	8334	3565	241	4815	12505
2100	45,0%	9500	5653	3373	5463	16039

Number of good earners (in million) Scenario D 2100 (6 → 4:14)						
Year	Equity	Number of People with income ≥7900 \$	Number of People with income ≥15800 \$	Number of People with income ≥23700 \$	Number of rich People having 80% of wealth	
					#	income line in \$
2000	11,6%	859	659	430	801	9268
2010	10,5%	968	681	466	897	8808
2020	10,8%	1.052	769	526	1.052	8558
2030	11,7%	1.191	882	617	1.164	8834
2040	12,8%	1.315	986	704	1.362	7316
2050	14,0%	1.476	1.181	837	1.624	6357
2060	15,5%	1.682	1.376	969	1.886	6150
2070	17,1%	1.938	1.519	1.205	2.200	6244
2080	19,2%	2.299	1.657	1.443	2.566	6570
2090	20,8%	2.705	2.053	1.630	2.966	6987
2100	23,0%	3.300	2.101	1.815	3.410	7829

Tables 8.1-8.3: Numbers of people with high income in 2000-2100 in the respective futures

IV. Gap analysis for the business as usual case: Why something fundamental has to change

This chapter deals with the ‘**business as usual case**’, i. e. a way into the future, following the present day WTO philosophy (Scenarios A and B). The approach chosen is developed for other versions of that case concerning other growth rates and other equity factors as well. Here, however, we **restrict to the precise setting of scenarios A and B**. The gaps identified in this chapter are crucial for the whole view on the different futures, followed in the paper as a contribution to the TERRA project. That is because the central topic is the observation that business as usual will ‘**run against a wall**’, be it complimented with security regimes or not because there will be gaps concerning essential needs and resources as well as the pollution potential available which somehow will have to be filled or bridged (which would somehow mean a transition to either Scenario C or D) or otherwise will end in **tensions, conflicts, terrorism or even war with all their consequences**.

In the following we exemplify the gap analysis for four types of critical resources, namely (1) food and water, (2) crude oil and gasoline, (3) the issue of CO₂ emissions and, as most important in this context, (4) the gross photosynthetic product, where the latter, in a certain sense, incorporates cases (1) and (2). The numbers chosen concern a future between 2030 and 2050, where the target growth rate lies simulatively between 2050 and 2100. Looking into Tables 5.1 and 8.1 leads to a group of people with high purchasing power of 2-3 billions instead of 1 billion today. This pattern is reflected accordingly in all four areas of gaps considered.

1. Food and water

Food and Nutrition are central issues for humans. Here the topic is **survival**. Presently **every day at least 24,000 people die of hunger** (cf. [1, 12, 46, 67, 75, 76, 77, 78] for more information on the population issue). This is not because we would not produce enough food on this globe or not be able to produce enough food on this globe to have everybody supported sufficiently, it is more about **income distribution or about purchasing power in markets** or about **priorities in world politics**. Too many people on that globe are not equipped with enough purchasing power to buy the food they need, consequently other people with more purchasing power can buy more of the food available (usually in form of higher

qualities, such as meat or milk products that require significantly more biomass input), with the result that we have this high number of people starving. Now, the **golden billion**, the richest billion of the world, alone uses about **1/3 of the food available today**, i.e. 16% use 1/3 of food, leading to an average distribution pattern between North and South concerning food of 2.5:1, cf. also below. The question is again how that can be, because people can not eat indefinitely.

The point here in place is **lifestyles**. That means there is nutrition of different type and value. There is more healthy, more varied and protein richer food than other. In particular it is **meat and milk products** that make the difference. And it is to be seen as a positive achievement for humankind, that such food is available, though unfortunately not for enough people – and here lies the problem.

Higher-level food makes a difference, because animals have to be fed and more and more they are fed with nutrition coming from soils which alternatively could be used to produce cereals like wheat or rice for humans. Often today **even the same cereals are used to feed animals which otherwise humans could eat**. So, there is very often a direct competition between animals and humans for food. And nowadays, this is sometimes also true for **renewable energy from biomass**. And with wealth growing, always more good soils get lost for infrastructures and housing. The essential point here is, that first transforming cereals through animals to get milk and meat, is a very resource intensive process. Depending on the type of animal and the type of meat, the factor of input needed is somewhere between 3 and 15, with steaks from the cow giving the highest value and with an illness such as BSE and the subsequent killing of 100,000s of cows severely increasing the factor to get an 'equivalent' in meat and milk nutrition than in eating cereals from the very beginning. (Note as a scurly side remark, that for **crocodiles** as predators grown for skin and steaks, the factor can be even 50). In the following we will assume an average factor of higher input needed of 5. A question then is, to what extent humans in the developed world feed themselves on cereals directly or on this higher valued nutrition? We assume here a 50 – 50 situation. On average then this means that **people in the rich world are feeding themselves on average with 2.5 times as much biomass input** then if they would live on cereals alone, which corresponds to the numbers given above for the **golden billion**.

Of course, instead of arguing via the animal life cycle one could also go directly to **hectares of land used by people in the developed world** when compared to people in the developing world, to feed themselves as is often done in the literature [70].

Summarising the present situation, we have today the food available to feed 1 billion rich people on a really high level. We assume further that higher level nutrition for other people around the globe sums up to saying that another 1 billion people world-wide (so-called compensation group) in other countries feed themselves on the level of the rich world, so we assume that the global picture today is roughly described by 2 billion (1 + 1 billion) people living on the 2.5 nutrition level while the other 4 billion live on the unit level. Of course, this is only a rough simplification for a more varied, but (for our purposes) mathematically equivalent situation. That means, what the rich use would be basically enough to feed 5 billion people, in accordance with what was already mentioned above for the **golden billion**. There are four more billion people which essentially live on cereals, so the production of food today would be the '**cereal-equivalent**' to feed **9 billion people**. Of course, this is only a rough simplification for a more varied, but mathematically equivalent situation.

Now, looking into the future, from literature there is the assumption, that by 2050 (2100) we might at best be able to **extend food production by another 50 %**, make it the nutrition equivalent for 13,5 billion people on the unit level. In the same time (under Scenario AB), a **global middle class** of people with high purchasing power might (if this scenario was sustainable) consist of 2.75 billion people using different definitions of global middle class in the sense of Tables 5.1-5.3 and 8.1-8.3. Depending on how huge the world population will then be, we will have additionally about 7.25 billion or more people more operating on the unit level. We assume, in summary, extra food requirements world-wide by those other people to be equivalent to another 1.25 billion people eating on the level of the rich countries, compensation group (instead of 1 billion such people equivalent in 2000). So, essentially 4 billion people (2.75 + 1.25 billion) have then to be counted on a high level of nutrition, which requires a 10-billion unit equivalent, where another 6 billion people (at times before 2050) on the unit level have to be supported, too. It is easily seen, as Tables 9 and 10 below show, that all in all there will be a **gap of about 3.5 billion unit equivalence** to be handled, one way or another.

What will happen here of course, is that market pressures will change the distribution patterns. We will see reductions in using animal food and milk in the rich world. We will see reductions of that type for the richer people in the poor world, too. But, of course, **if there is no emphasis on more social equity world wide**, there is obviously the danger, that the rich part of the world will in the end, via sheer purchasing power, be able to **dislocate too much cereals from humans into animals**, which would be heavily needed to feed the poorest people on the globe. So, if there is no **compensation measure** on the world level, of the

type of a global social – or even better empowering – system as characteristic for Scenario C **real trouble is ahead** at that point.

Urgent changes in the life styles of rich people seem to be needed **as the amount of high quality food can not arbitrarily extended**. For we have to take into account, the **land quality is deteriorating** already today and that by 2050 (2100), much more (good) land will be needed for all kind of other purposes for the then 9 to 10 billion people, than expected, with maybe 2.75 billion people forming a global middle class on a living standard as the rich 1 billion have it today. This will require the use of very much good soil for building infrastructures, streets, houses etc. To this have to be added the **foreseeable problems with sweet water**. And water availability is essential for more food production and for all kind of other elements of a good live, including the corresponding industrial production, as maybe 2.75 billion instead of 1.25 billion people today will try to enjoy it. **Water itself might therefore become the biggest crucial issue in itself**, as described in [64] as a contribution to TERRA and into this paper. The diet composition or the eating habits in the rich part of the world will consequently have to change considerably, if massive disruptions are to be avoided. Consequently, the part of the diet per (rich) person composed by meat and milk products, certainly and over all, has to be **halved** in comparison to the situation in the rich countries today.

(As a side remark, the role of agriculture will change dramatically. Food will be scarce. The potential of the EU to produce huge amounts of high-quality food could turn out to be one of the **biggest geopolitical assets of Europe** [48], while today, agriculture is often regarded as a burden. Note further that the **extension processes of the EU** to Middle and (South)Eastern Europe may be helpful in this respect, too, as maybe a much closer cooperation with **Russia in the field of agriculture**.)

Summarising, we see the following picture: The human population of 6 billion is (mathematically) assumed to be partitioned into two groups, equivalently describing a more complicated real distribution pattern.

Nutrition 2000	Number of people	Factor	Total need in unit value	Available	Gap
High level (North and compensation group)	2 billion	2.5	5	-----	-----
Essentially only cereals (South without compensation group)	4 billion	1	4	-----	-----
Total / Gap	6 billion	1.5	9.0	9.0	0

Table 9: Today's situation concerning nutrition

Here, it is assumed that the carrying capacity of the world concerning food today is 3.6 billion at Northern consumption standard, i.e. at consumption level of 50 % animal products such as meat, milk, eggs etc. and 50 % of cereals where the exchange factor of the higher level inputs is 5. The exchange rate to pure vegetarian nutrition on average therefore is 1:2.5.

Conclusion: If 2 billion people remain at Northern standards, and if full use is made of 1:2.5 ratio for the others, an additional $(3,6 - 2) \cdot 2.5 = 4$ could be fed. Thus, **there need not be malnutrition today**, to the contrary, millions more of people could be supported but only with other distribution pattern and life styles.

The assumed human population of 10 billion is assumed to fall into two groups.

Nutrition 2000	Number of people	Factor	Total need in unit value	Available	Gap
High level (North and compensation group)	4 billion	2.5	10	-----	-----
Essentially only cereals (South without compensation group)	6 billion	1	6	-----	-----
Total / Gap	10 billion	1.6	16	13.5	2.5

Table 10: Situation 2050 concerning nutrition

Further assumption: the carrying capacity of the world concerning food in 2050 (2100) is then 5.4 billion at Northern consumption standard. The exchange ratio to a pure vegetarian nutrition is still 1:2.5.

Conclusion: If 4 billion people live at Northern standards and it is full use made of the 1:2.5 ratio, an additional $(5.4 - 4) \cdot 2.5 = 3.5$ billion can be fed. Thus, there is a crucial gap of 2.5 billion people that cannot be fed, if things develop along this pattern.

Note that the assumptions concerning efficiency gains, number of rich people etc. are cautious and optimistic, when compared with the paths into the future as described in Chapters II and III for Scenarios A and B. A total increase in the production of food of 50 %, as assumed, is optimistic. One has to take many factors into account, soil quality and soil losses due to other uses being two of them. As pointed out in [64] **the most crucial single limiting factor in this respect will probably be sweet water needed for irrigation.** And this water need has to be seen in **competition** to all the other additional water needs arising from 2.75 billion people building a global middle class with the lifestyles which we have today in the rich world (and additional growth for all those rich people to be taken into account). These life-

styles are very **water intensive**, not only with respect to housing, but very much so also concerning industrial production etc.

2. Oil and energy

In the following, we give a short analysis of the oil and energy situation which is another crucial issue, building on [22, 34, 60, 69]. In [69], a **shock situation** in markets concerning oil and energy is expected for the year 2015. A crucial role play the foreseeable additional market requests, if global frameworks do not change, coupled with **deteriorating oil reserves**, according to the broadly accepted Hubbert Curve [22], see Fig. 5, which shows **rapidly diminishing oil availability** from 2010 onward. This curve is generally accepted today also by the oil industry. If it does not refer to oil reserves explored or discovered but to **what can physically be produced at a particular year**. And these volumes will shrink massively, soon.

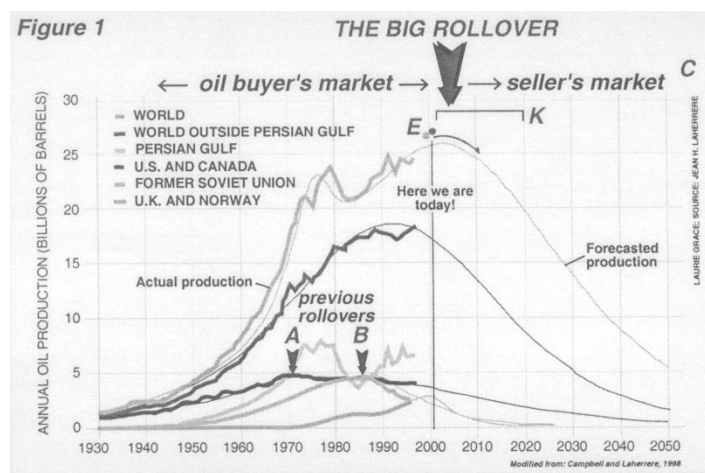


Fig. 5: Hubbert curve

The human population of 6 billion today for the present issue is assumed to be partitioned into two groups. Here, in accordance with the nutrition situation, we have about 1 billion rich people, while a compensation group of 0.5 billion rich people is chosen to make (mathematically) up for extra energy used among the 5 billion low-level consumers, 4.5 million of which are treated with the factor 1.

2000	Number of people	Factor	Total need	Available	GAP
High level with compensation group	1,5 billion	6	9 bill. T SKE ⁴		
Low level without compensation group	4,5 billion	1	4.5 bill. t SKE		
Σ	6 billion	2.3	13.75 bill. t SKE	13.75 bill t SKE	0

Table 11: Today's situation concerning oil

Further assumption; comparable with the considerations in Chapters II and III: the carrying energy capacity of the world is 2.4 billion at Northern consumption standard. 40 % of the energy consumption 2000 was satisfied by oil. The exchange rate of oil to SKE is 1:1.5. Thus $(13.75 \cdot 0.4)/1.5 = 3.7$ billion t or $3.7 \cdot 7.35 = 27.2$ billion barrel⁵ oil had been produced.

Energy 2050	Number of people	Factor	Total need	Available	GAP
High level with compensation group	4 billion	4	16 bill. t SKE		
Low level without compensation group	6 billion	2	12 bill. t SKE		
Σ	10 billion	2.9	28.7 bill. t SKE	17.8 bill. t. SKE	10.1 bill. t SKE

Table 12: Situation 2050 concerning oil

Further assumptions:

The shares of the energy carriers (natural gas, coal, nuclear, etc) will be equal than in 2000, that means that oil will not be substituted by other energy sources. Thus, oil would have to satisfy the remaining 40 %. That is $(28 \cdot 0.4)/1.5 = 7.41$ billion t oil, because the exchange rate of oil to SKE is 1:1.5. We see that this amount is more than twice the production in 2000, but the oil production decreases after reaching the Depletion Mid Point of the Hubbert Curve, which is expected to happen between 2005 and 2015 [22]. The Hubbert curve describes the amount of production over time, which follows a bell shaped curve.

7.4 billion t oil will be needed, but only a fifth of the production level of 2000 can be produced in 2050 to all estimates available. The consequence is a gap of 10.1 billion t SKE if we cannot substitute oil by other energy carriers. The question is if it is possible to substitute oil to a sufficient degree by other energy sources.

⁴ 1 kg SKE is the energy of 1 kg hard coal.

⁵ 1000 litre oil = 7.35 barrel oil

Considerations in [60] show that it will be difficult to have higher substitutes of oil by natural gas, coal, nuclear energy (today 10%), geothermal, solar and wind energy, biomass and waterpower, than was assumed with a 50 % increase in Table 4 anyhow. Even under strong assumptions on growth rates for alternative energies, a considerable gap will probably remain.

Obviously, only massive changes in the energy carrier shares or massive reductions in energy input needed per unit GNP would offer a chance to handle this situation. If there are no major changes in the North, then prices may rise dramatically, forcing certain changes but **primarily hurting poorer countries which have no chance to compete in the oil markets, then.**

3. CO₂ Emissions

CO₂ emissions are a topic of highest importance. CO₂ emissions today are closely coupled to wealth. They cannot be reduced easily and comfortably. And they might bring about climate change with most **severe consequences**. Many people are concerned that we are already living through consequences, particularly with **always more devastating floods** in one place and draughts in others. Adaptation to reduced levels of CO₂ emissions is hard. And what is the right pattern of adaptation:

- (1) **grandfather-like**
- (2) **same rights per person, coupled with global CO₂ trading?**

In 20-30 years, millions of people might lose their home, if not their lives, in coastal regions, such as in Bangladesh due to rising sea levels caused by climate change. But also, due to more blizzards and tornadoes, the US might lose the ability to feed itself, which would have severe consequences for the world food markets and the poorest countries and people who cannot compete against the US on global nutrition markets.

- Is it an **aggression** of the US against Bangladesh, not to join the Kyoto contract or not otherwise do much more to reduce emissions or at least be willing to pay for emission rights?
- Is it an aggression of the Indians and Chinese against the US to change a delicate status quo in the climate field and increase their CO₂ emissions heavily when further industrialising, even if, per person, they still keep much below the US level?

Who will decide on that issue? The **international criminal court**, if its mandate is enlarged to deal with aggression, or the US itself? And is preemptive defence an answer in this case, which would hint to the **resource-dictatorial case with security regime**, as did the renewed Iraq war by the US and its partners (Scenario D)?

If climate change really turns out to be a dramatic issue, then **extreme trouble may be ahead**, if we not soon go over to the eco-social approach, e. g. Scenario C [15, 34, 48, 53], which would involve equal emission rights for all people and trading those rights, thus inducing a **global eco-taxation scheme** [48], that increases tariffs over time continually by itself, thus would really work and change life-styles and mobility patterns and the **structure of global trade** dramatically.

a = Rio average target value

2000	Number of people	Factor	Total emission	Allowed	Gap
High level	1 billion	10 a	10 a	6a	6a
Low level	5 billion	2/5 a	2 a		
Σ	6 billion	2 a	12 a		

Table 13: Today's situation concerning CO₂ emissions

The world of 6 billion people today is, as a coarse approximation of the status quo, divided into two groups, 1 billion **high polluters** equivalent, 5 billion **low polluters**. The high polluters on average do 5 times the average emission value of today and 10 times the average value possible according to the long term Kyoto target (called a), which is a reduction of 50 % in comparison to the Rio summit status quo of 2a (1992). The 5 billion low polluters use on average 1/5 of the average today and 2/5 of the Kyoto target. So the rich world today pollutes 25 times the average of the South per person. The gap today is 50 %. This is summarised in Table13.

Assume for 2050 about 3 billion high polluters including appropriate compensation group as introduced for the food and energy topics above (which is a conservative estimate for the (unsustainable) Scenario AB), cf. Tables 5.1-5.3 and 8.1-8.3. For this high-emitting group we expect, due to efficiency gains and other measures, that they will operate on a 100% improved efficiency scale in comparison to 2000, e.g. 5 a emissions instead of 10 a on average today, while 7 billion more people, doubling on average their life quality and due to an assumed 100% improvement in CO₂ efficiency, stay on an average usage of 2/5 of a. The picture then is as follows, i.e. the gap of 6a of today increases to 11.8 a in 2050, i.e. almost

doubles instead of disappearing which is in accordance with our footprint analysis below as well as with the 14:7 dematerialisation pattern.

a = Rio average level

2050	Number of people	Factor	Total emission	Allowed	Gap
High level	3 billion	5 a	15 a	6 a	11,8 a
Low level	7 billion	2/5 a	2,8 a		
Σ	10 billion	7/4 a	17,8		

Table 14: CO₂ emissions in 2050

Getting along with the CO₂ gap is one of the greatest challenges ahead and will require a complete reorganisation of the world energy system. In this process, **alternative forms of energy** [34] and **efficiency gains** [58, 72] will have to play a major role. Changes should occur fast to allow for **rebuilding the infrastructures needed according to their amortisation cycle**. The role of **nuclear energy** in the process is a complicated issue in itself [48] see also Chapter V.

4. Total photosynthetical product: A global ecological footprint perspective

The following approach to a gap analysis is maybe the most far-reaching one, as it takes **many human activities into account simultaneously**.

The human economy uses natural capital to satisfy the needs of humankind. The natural capital is supplied by the earth. The amount of natural capital is one Earth or ca. 11361 billion global hectares in 1999 according to [70], and, within the TERRA project, to work by M. Mesarovic and his co-workers [64]. Here the natural capital is counted in **biophysical units** (see also [13]). To get to that point, Wackernagel et al. [70] distinguish six human activities that require **biologically productive space**. Those are:

1. Growing crops for food, animal feed, fiber, oil and rubber.
2. Grazing animals for meat, hides, wool and milk.
3. Harvesting timber for wood, fiber, and fuel
4. Marine and freshwater fishing
5. Accommodating infrastructure for housing, transportation, industrial production, and hydro-electric power
6. Burning fossil fuel

Note again, the fossil energy is translated in this approach into an equivalent biomass production requiring land to an extreme degree. Proceeding this way completely avoids the **greenhouse issue**, so critical today. **Hydro-electrical power** is dealt with explicitly, while consideration of **wind energy, solar converters** as well as **photovoltaic cells** are missing. Actually such solutions constitute only a very tiny part of energy production today and their increased use in the future might fall under the concept of dematerialisation.

Nuclear energy production is totally skipped from the picture. To what extent this is realistic will depend on the future. Some major new incidents in nuclear energy facilities could lead to such a situation. Otherwise, also this might be dealt with under the aspect of dematerialisation.

Note that in Chapters II and III, we followed clear ideas about the total dematerialisation of the future societies considered. E. g. in the double factor-10 case, we expect a dematerialisation year by year in synchronisation with GNP growth. The reference point for our approach chosen **could be an aggregated value for the natural capital used, such as the total photosynthetical product**. In this context, a double factor 10 means that , while GNP grows ten times, the total photosynthetical product used by humans does not change, because the amount of that product needed for a unit of GNP produced will shrink completely synchronous to GNP growth.

Now going deeper into the issue of describing the total photosynthetical product, a major issue is **aggregation**. If we want to aggregate these different impacts we have to adjust the land and sea areas according to their bioproductivities, multiplying each land use category by an “equivalence” factor. The human impacts can be described in “**global hectares**” and can be merged into one number. The biologic productivity is given by the equation:

$$A = \sum P_i \cdot E_i$$

where P_i is given the actual, physical hectares of land or sea type i and E_i is the equivalence factor for the area type i , A is then the area demand expressed in global hectares, as shown in the following table.

Area	Equivalence Factor [gha/ha]	Yield Factor [-]
Cropland	2,11	1,00
Primary Cropland	2,17	1,00
Marginal Cropland	1,76	1,00
Forest	1,34	1,00
Forest AWS	1,34	1,00
Forest NAWS	1,34	1,00
Pasture	0,59	1,00
Permanent Pasture	0,47	1,00
Unharvested cropland	2,17	1,00
Fishing Grounds	0,35	1,00
Marine	0,35	1,00
Inland Water	0,35	1,00
Built	2,17	1,00
Hydro Area	1,00	1,00
Energy	1,34	1,00

Table 15: Equivalence factors for computing 'global hectares' from ecological footprint by region [13]

WORLD FOOTPRINT AND BIOCAPACITY (bill gha)				
	Footprint [bill gha]	Area [bill ha]	Biocapacity [bill gha]	Ecological Deficit [bill gha]
Cropland	2,59	1,24	2,59	0,00
Unharvested cropland	0,57	0,26	0,57	
Forest AWS	1,44	3,88	5,21	3,46
Wood Fuel	0,31			
Permanent Pasture	0,60	3,46	1,63	1,61
Fishing Grounds	0,84	2,30	0,81	-0,03
Built	0,60	0,28	0,60	0,00
Hydro Area	0,02	0,02	0,02	0,00
Fossil Fuels	6,47	0,00	0,00	-6,47
Nuclear Power	0,47	0,00	0,00	-0,47
TOTAL	13,9	11,44	11,44	-1,91

Table 16: World Footprint and capacity, see also [13]

Because land use is transformed over time and because there occur technological changes with impact on land use, the amount of biologically productive space on the earth constantly changes. But the annual growth rates are very small. From 1960 to 1999 the biocapacity grew from 11 billion global hectares to 11.4 billion global hectares. That is equal to a linear annual growth rate of 0,09 %. Assuming a linear growth rate until 2050, the total amount of biocapacity will then be 11.9 billion global hectares.

If we consider the global demand by regions, we can detect that the distribution is not equal. The North American people need over 6.3 times more biocapacity per person than Africans. All factors of this type are given next.

Ecological Footprint by 7 regions 1999						
Region	Population In billion	Global hectares per capita	Global hectares per region in billion	Available Global hectares in billion	Gap	in %
North America	311	9,5	2955	11361	2587	123%
Western Europe	387	5	1935			
East Europe	350	3,7	1295			
Latin America and Caribbean	503	2	1006			
Middle East and Central Asia	323	2	646			
Asia and Pacific	3300	1,5	4950			
Africa	774	1,5	1161			
World	5948	2,3	13948			

Table 17: Demand of biocapacity by region, cf. [11]

Now we aggregate the 7 regions into a **high-level consumers´ region** (which includes North America, Western Europe and East Europe) and the **low-level consumers** which include the rest of the world. The situation for 1999 is given in the following table. In this situation we have a gap of 2487,5 billion global hectares or 22%, in other words, about a 20% overshoot. Such an overshoot practically means that it would require **1.2 earths**, or one earth for 1.2 years, to regenerate what humanity used in 1999. Note again that this is only true, if energy would essentially be produced via biomass.

Ecological Footprint by 2 Regions 1999						
Region	Population In billion	Global hectars per capita	Global hectars per region in billion	Available Hectars in billion	Gap	in %
High level	1000	6,2	6185	11460	2487,5	122%
Low Level	5000	1,5	7763			
World	6000	2,3	13948			

Table 18: Ecological Footprint Gap by two regions in 2000

Global Ecological Footprint 2050

We now try to estimate the Global Ecological Footprint 2050. According to the estimates of the International Institute for Applied Systems Analysis (IIASA) from 1998, the future energy demand until 2050 will rise to about 215 %. Simultaneously, we assume that the energy demand per capita in the high level countries will decrease about a third, because of new technologies, high energy taxes and a larger environmental awareness. These developments will **save a lot of energy**. Additionally, we assume the number of people to grow from 6 billion 10 billion in accordance with Scenarios AB, year-2050 case. Also, we assume that 2 billion more people (including a compensation group as used above for the topics of nutrition and energy) will change from low-level to highlevel consumers, since developing countries such as China, India etc. will pick up to some degree to the developed countries under Scenario A and B. This is compatible with the situation in Tables 5.1-5.3 and 8.1-8.3.

The energy demand per capita in the rest of the developing countries will about double because also there, the living standard will be essentially higher than today. That concerns topics such as more mobility, radios, TVs and the use of electric kitchen stoves, refrigerators etc. The other human impacts are assumed as constant until 2050.

Thus we assume that the global hectares needed per capita decrease from 6,2 to 4,5 at the high consumer level and rise from 1.6 to 2.5 at the low consumer level. Also we assume that the other impacts stay constant. This makes sense, since the absolute amount of energy exceeds the amount of the other human impacts into the ecological footprint by far, anyhow.

Ecological Footprint by 2 Regions 2050						
Region	Population in billion	Global hectares per capita	Global hectares per region in billion	Available hectares in billion	Gap	in %
High level	3000	4,5	13500	11460	19540	270%
Low level	7000	2,5	17500			
World	10000	3,1	31000			

Table 19: Ecological Footprint Gap in 2050

The scenario indicates a gap of 19460 billion hectares or 270 %. In other words, there would be a 270 % overshoot. That means that it would require 2.7 earths, or one earth for 2.7 years, to regenerate what humanity will use in 2050. Note that this includes, once again, the production of energy essentially via an equivalent biomass input. More or less, we see an over-

all doubling of environmental stress, as also indicated by the (14.7) pattern of world GNP and resource efficiency gains assumed for Scenarios A and B, today's overshoot is about 1.2 and a 14:7 pattern means roughly a doubling of environmental stress, these numbers are consistent with each other.

V. First inputs into a cross impact analysis for the considered futures

In this chapter, we look into major developments or incidents that could happen and would have, maybe in some **chaotic** ways, an influence on which of the considered futures would materialize or not. This could in the end lead to a **cross impact analysis** between the scenarios. Actually, the second author was looking into these issues more profoundly. His decades-too-early death means that he could not finish this work. Others will have to get on with this task. As a start, the following chapter looks into a number of major issues of the type mentioned.

We discuss in the following major incidents that could have an influence on which of the considered futures the world will end up with.

General orientation

As described at the end of Chapter II, the authors subjectively expect with probability of 85 % that **the world will react at some point to the physical limitations** concerning resource use and environmental burdens ahead, such as pointed out in the gap analysis in Chapter IV. That means, that humankind would not allow its own environment to be definitely destroyed. The reason is that the top of the global property pyramid usually gets “mad” if their claims come into danger and use whatever instruments available, up to war, to prevent that from happening. The world will thus find a way out of business as usual **WTO and WTO plus security kind of scenarios**, as we have them today, because there is no chance to survive that, see again the gap analysis in Chapter IV. The major question then is whether the route chosen will be the **eco-social** or the **resource-dictatorship one**. Here we gave rough personal estimates of probabilities by the authors of 35 % and 50 % for these two cases, see Table 1. The following list tries for a number of possible events to indicate, whether they will shift things more in this or that direction.

V.1. Security issues

Assume there are **more major terror strikes in the US, but not in Europe and Japan**. That would certainly lead to a stronger emphasis on security, but might still stay within the eco-social model. If there is major terror acts as well in Europe or Japan or in Europe, Japan and the US at the same time, it will probably lead to even stronger security emphasis under a clear resource-dictatorship regime. Concerning the renewed Iraq war, the authors made the following statement at the 2002 TERRA review. If there is a US attack against Iraq without

UN backing, the question is whether Europe says yes or no, which will be a tipping point. If Europe says no, may be Russia says no then, because Europe stands up against the US, this may help the eco-social case. As soon as Europe let the **US go with an unilateral attitude** towards war making on Iraq, it means a strong support for the resource-dictatorial case. In fact, this Iraq war took place without UN backing. Europe was and is in a split, an axis with Russia has been built up. The situation for the futures seems to stay yet open as before (no change in present probability estimates) also because **it is by far not clear how things in Iraq will develop further.**

Another important point is the Middle East. If we will witness stronger terror against Israel, we will again come to a bifurcation. The question is whether Israel will finally accept that there is no comfortable solution with resource-dictatorship and that the Palestines have to get a reasonable state. This could help an eco-social peace. However, if **Israel counteracts even stronger** and wants land, land, land, the question will be whether the US tolerates that or not and whether the Europeans will act openly against it. If there is agreement on this kind of Israeli policy, it indicates a route to the **resource-dictator case worldwide.** Otherwise it offers support for the eco-social case. If Israel uses nuclear weapons against “enemies”, or India against Pakistan, the question is of the same caliber. Would the US and/or Europe tolerate this kind of policy or not? If there is strong resistance, this could help the eco-social case. If such action by e.g. India is accepted, it's a clear case for a route towards resource-dictatorship-type solutions.

V.2. Economic issues

More shocks on the financial and the capital markets, more irregularities in great companies, in particular in the US, would help eventually the eco-social case, because people would understand even better that open markets are not everything, e. g. that **frameworks count, which is the eco-social position.** Also, if there is a clear and increasing open protectionism in the US against the rest of the world, in particular also against emerging countries with respect to agriculture, it could help Europe to build a position different from and opposed to the US position, hopefully including a **global Marshall Plan** proposal coupled with **WTO reforms** [10, 19, 21, 24, 48], and thereby promote the **eco-social case.** Similarly, if there would be major scandals in the US concerning a misuse of data, collected in the economic field to build profiles of all kinds, which would then be misused against the poor and the lower middle class, it could help the eco-social case. The same is true, if Europe soon starts work on a convincing alternative concerning architectures and software systems, that allow for high security and are efficient but avoid total data transparencies [49]. Most crucial could be consequences of a real **climate disaster** with flooded coastlines in South-East Asia and nu-

trition shortages in the US. Will the reaction be co-operative or pre-emptive, as discussed above? Does it involve a world criminal court that deals with the aggression issue or not? The involvement of the court or not could mean the decision between the eco-social and the resource-dictatorial case.

V.3. Social issues

If the world will witness further disastrous developments such as today in Latin America and Africa under present WTO and IMS regimes, that may help the eco-social case. Because we witness a “robbery” on a whole population and their wealth, particularly the lower middle class. Their wealth is channelled to a few people, belonging to those countries elite’s and their international partners/money borrowers. And if we will witness **more digital divides and other divides**, it could help make apparent the disastrous nature of a **full out deregulated capitalism** and help the eco-social case. This could particularly be true, if more terror, resistance, and migrations comes with it and the political question will be debated how to deal with these developments. Also, **massive starvation** along the gaps discussed in Chapter IV could help to promote the eco-social case, because it would become clear to most people that a new approach is needed.

V.4. Ecological and resource aspects

Within TERRA, we expect a **shock situation** on the oil markets around 2010/2015 (see Chapter IV). The world may not really have a way to deal with it. For instance, military power or money alone may decide, who gets the oil and who not. That will bring the world to a disastrous conflict with resistance from poorer or emerging countries and could lead us again to a bifurcation point with respect to an eco-social or an resource-dictatorship approach. Problematic will also be **extreme climate situations**. If there are heavy impacts of climate change in the North, such as at the moment with hurricanes and floods, this could help the eco-social case, but has also a potential for resource dictatorship. For instance, the US could argue that the increased emissions by countries such as India and China, leading to problems with harvest in the US, are an aggression because **they** change the status quo. The US could use military force against it, maybe pre-emptive. However, as the North is essentially doing all the CO₂ emissions, also the eco-social case has a strong logic. If disasters happen in the South, like a flooding of the Bangladesh coastline, everything is possible. Emphasis for the eco-social case might result from feeling guilty, on the other side also a temptation for a resource dictatorship-type solution may arise, because the North might want to blame others and show a way out of the troubles without having to pay a price, or because the North has to fight terror, coming from resistance to this kind of development. Whether an international

criminal court or the US alone will decide on such issues could turn out to be a most important issue for shaping the world's future, as was already discussed above.

In the field of environment and energy, aside to investing more into renewable energy [34], as was strongly advocated for by the EU representatives in the recent **Rio+10 summit** in South Africa (while, not surprisingly, any definite agreement was blocked by the US government) **nuclear power is a big issue**. As discussed in [48], even if there are good arguments to get out of this technology, a robust path into a sustainable future might still require a 50-100-year transition time, where, on the route, **nuclear power may even increase its share** in world energy production, before it eventually is phased out in accordance with the respective **amortisation cycles**. With this view in mind, a major nuclear incident in the North or South might have severe consequences. It could lead to even more pressures to stop nuclear power use, once and for all, particularly if accidents happen in the North. This has an **eco-social touch**, but might lead to dramatic energy shortages, more CO₂ emissions and trouble later, that could result in **resource-dictatorship**. This would also be true if the North tries to close down nuclear power facilities in the South because of security reasons or if the North would require extreme security installations there without proper compensation of resulting extra costs. The future might then be more control policy, security checks, enforcement etc. So overall, there could result a strong resource-dictatorship dimension.

VI. On the role of ICT in the considered futures

There is **no doubt on the extreme importance of ICT for the future**, be it good or bad. Actually, ICT is strongly interwoven with all the futures, discussed throughout this paper. To better understand what particular type of ICT systems will play a major role in what future, we distinguish in the following four major areas of ICT systems that will play a major role in any future, but with different emphasis in all futures considered. We will also indicate which systems have a pre-dominant importance for what future.

(1) Systems to massively promote consumption increases and business activities

Important features

- e-commerce “unlimited”, using clients’ profiles, etc.
- entertainment
- support of business activities

(2) Systems for massive security control and military control / not compatible with a European civil rights’ perspective (potentiation for Orwell’s nightmares)

Important features

- Everybody has to be coupled with a mobile phone all the time, checked via biometrical control. Every de-coupling of a human from his mobile phone gives an alarm
- All movements of people are followed via GPS, all payments, all phone calls are forced to be done using these devices; they also act as loudspeakers, so all verbal communication is stored, automatically digitalized and can be followed online from a central facility
- This is the only device to pay
- Mobile phones communicate with each other within 100 meters distances, so in a central computer it can be followed who is physically close to whom
- There are street side cameras and flying platforms (drones) to check all strange constellations and to act on the spot if needed.

(3) ICT systems to control standards

- Under an eco-social as well as resource-dictatorship design, strict standards have to be implemented concerning social, cultural, and ecological aspects. Co-financing flows are coupled to the implementation of such standards in the eco-social case, punishments in the resource-dictatorial scenario. While the ecological standards are similar under sce-

nario C and D, in the social and cultural field, they are quite different, but the need for control is the same.

- In the eco-social case, the main instrument is money flow in compensation for implementing (development-level dependent) standards. This concerns good governance, effective administration, rights and roles of women, reproduction rights, rights of workers and children, education levels, implementing cultural standards, implementing environmental standards.
- In the resource-dictatorship design, apart from the resource use and pollution issue, social and cultural concerns are as follows: Monitoring for saving rain forests, for protecting important biotopes, etc. against the day-to-day interests and needs of poor people, control and avoiding migrations, keeping societies within enforced or dictated CO₂ emission levels, etc. **Satellite information systems** and GIS systems will be of crucial importance here. This also means, that even the most **natural rights of the poorest to their habitat** could be sacrificed even more than today to implement standards set by the North [54].

(4) Systems for empowering and creating more equity

Important features concern:

- e-education,
- help in everyday situations (e-help)
- knowledge management,
- “soft” security,
- medical care (e-health)
- broad availability of political and scientific information (e-government), etc.

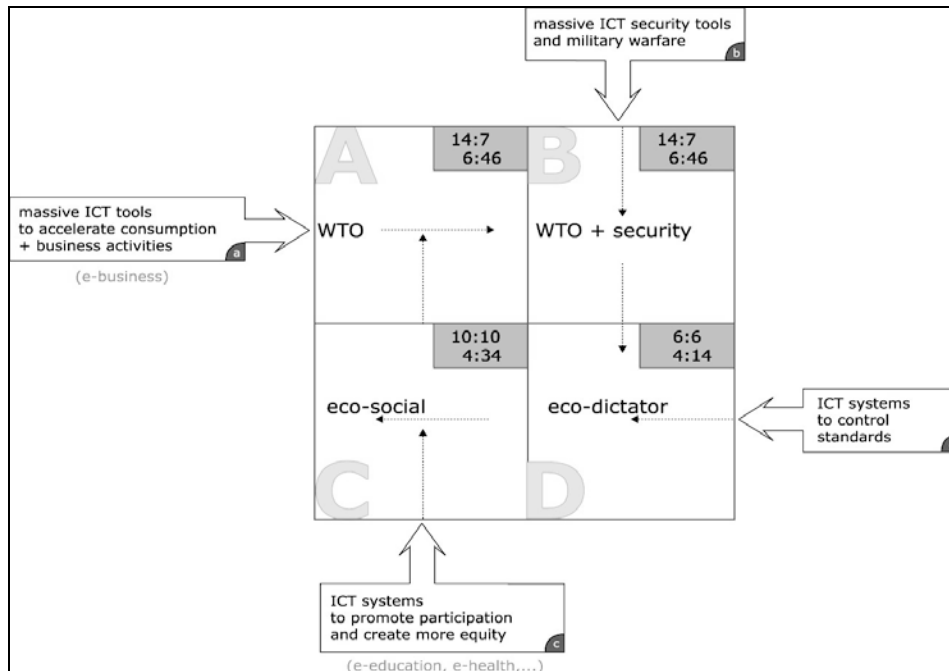


Fig. 6: ICT systems categories related to the futures considered

Note: All scenarios will implement elements of systems of all four categories (1-4). However, each scenario is characterized by using, to a huge extent, two of the ICT systems types described. This association is as follows:

Scenarios	ICT Systems World
A (WTO)	Business/Empowering
B (WTO + security)	Business/Security
C (eco-social)	Empowering/Control of standards
D (eco-dictated)	Security/Control of standards

Table 20: Emphasis in ICT deployment, depending on the futures considered

It is important to get an idea what a full employment of such systems will cost and how important ICT is to get to the respective aims, e.g.

- (a) How much money input may go into this kind of ICT systems?

- (b) Security and warfare can cost percentages of GNP; meaning in scenarios B and D a severe loss of quite some (public) funding for other concerns in order to fund such systems
- (c) Systems for empowerment are the crucial tool to combine development and more equity and environmental care. This issue has to be dealt with also under the aspect of **regionalization** of the issue as indicated under II, particularly in the case of scenario C. Note that in this case (scenario C), 1-2 % of world GNP would be available for co-funding of development, maybe as part of **global Marshall Plan**. Strategies have to be developed on how this money would be best spent on an **international scale** and on the **regional level**. How much of that huge budget for co-financing would go
- into clean water/nutrition
 - infrastructure building, in particular ICT infrastructures and systems
 - capacity building (for good governance)
 - education (partly IT-based)
 - health care (partly IT-based)
 - implementing reproductive rights
 - pension systems
 - funding of science and research (partly with IT-support)
 - paying for intellectual property rights
 - paying for experts

(Note: The **EU integration and extension processes** offer some insight of how to proceed. Also, there is some insight available from reports of the UN side of how much money would be needed today for some of those purposes (cf. [68]), e.g. in order to implement the so-called **Millennium aims** [6]. The proposal of the British treasurer Brown for a World Marshall Plan for the Rio + 10 in South Africa gives some other valuable hints as well [6]. Also, we refer again to Al Gore's proposal [21] some years ago on the same issue and on a recent NGO based initiative, pointing in this direction [24].

What do ICT systems for implementing standards of all kind cost? E.g. what does this mean for environmental monitoring and control, using satellite images. References to initiatives such as GEMS (**Global Environmental Monitoring and Safety**) on the EU/German level with reference to GALILEO would be helpful.

VII. Architectures and software design issues in the security field: A most crucial issue

The security situation has dramatically changed since September 11, 2001. Modern societies are in a very critical situation with their open infrastructures. What can be done for protection, even using most advanced technologies, is limited. On top, it is obvious that the **modern electronic opportunities create completely new risks for people**. One topic is a **total collapse of the network and computer infrastructure** which would have disastrous consequences for the people, particularly concerning arrangement of everyday life. This could turn out to be a life or death issue. Simultaneously, the danger is growing to **have less and less data protection**. Actually, consumer-related developments concerning the use of mobile phone, paying with credit cards, automatic road pricing etc. are already creating an always denser net of digital documentation of people's life. **The security situation now creates the risk of always more data transparency, concerning personal data**. Whenever there are attacks, conflict, terrorism, politics goes the easy way of more control, taking more data, combining more data, etc. There is a real danger now, that even democracies will go to that direction, not to think about what would happen if Scenario D, the resource-dictatorial approach comes about. That would mean we get soon into a strict regime with **massive security elements (Orwell's "1984", multiplied)**.

Still, this is one more area, where there is a **great difference between European and US positions**. Particularly, architectures and designs promoted via Microsoft products, easy-going and accepted by citizens, are a danger in this respect. The US are very much willing to promote this kind of systems, of course. Similar differences and dangers concern the question whether a **strong encryption of information of digital type should be allowed politically at all**. Another field of unease concerns the question of whether **individualised digital profiles**, for instance in e-commerce, are wanted or allowed or not.

In all these sensible areas, there are clear difference between US and European approaches. However, via the sheer power of Microsoft products, the logic and architecture behind its products lead us to situations, allowing more and more electronic control and always more trespassing.

What is missing today is a clearly articulated, long-term strong effort to get to **different security architectures and different software solutions**. This would be a costly and time con-

suming undertaking. But if that effort is not done now, then always under the short-term pressure of an actual terrorist attack, the tendency is to take what is there whatever the consequences.

Therefore, when looking into the issue of **what the European Union can do on its own now and how to care for a better future**, particularly in the software field, then, from the point of view of this document, the **field of security is of highest importance**. The Europeans should start immediately [49] to work for an alternative to present-day security architectures and systems. They should extend their great successes e.g. in defining a European standard in the area of mobile telephony, to do the same concerning a **conceptual frame and a software architecture frame, to deal with security issues** by taking the European view and staying within European lines of guaranteeing the individual data rights of citizens.

What then would be needed [49] is an **intelligent system design** that, while being **economically highly efficient**, allows to reach the following three aims simultaneously:

1. **High security,**
2. **high robustness and**
3. **guaranteeing civil rights concerning digital data.**

Behind this formulation is the thesis of the authors, backed by many publications of experts in this field, that, with an intelligent design, it is indeed possible to reach an **extreme quality in security** by the right design framework, **without losing significantly on the quality of data protection**. The key is an approach that takes care that, within in the bulk of electronic transactions, the **precise identity of the persons involved** needs not to be identified. This means e.g. using **alias names** with the particular aim **to make impossible a general automated integration and combination of data from different sources** to build profiles etc. An intelligent design with alias names in most cases can do the same for security as going down to the individual level. This has to and will allow (with great efforts, though) to go down to the level of the individual in criminal or terrorist activities, in terms of a reconstruction in part or totally of certain information flows. So, criminals and terrorists should not have any advantage concerning their activities in the digital age in comparison to the times before. But it is also the other way round. **The power of modern ICT solutions should not have as a consequence the loss of individual rights o citizens.**

Areas of application that have to be taken into account when working on the **architectural frame and design** described would concern issues such as e-government, e-learning, e-health, electronic marketplaces, logistics, security of information, of goods and people, the

issues of border control, security services, military etc. At the same time, there should be high investments into allowing for **fall-back positions** of an electronic and a non-electronic nature concerning the **robustness issue**, and this should be considered for the case of **peace** as well as **conflict**.

From a technical side, issues such as **intelligent software solutions, sensomotoric components, new chip generations, modern communication technology** including **satellite systems, usage of biometrical information** etc. have to be taken into account appropriately. Certainly, input from the side of the state, economy, science and the civil society should be involved from the first moment. This would help to get to a design that **fulfils all requirements concerning a European view on security, robustness and securing the informational rights of people**. We should via a good design, in particular, avoid principal resistance against software solutions from society as it happened in Germany with the first (and later modified) design of the ISDN services.

Solutions aimed at of course should be designed to become **world standard in the end**. At the same time, the whole approach should strongly promote the **market chances of companies in Europe** to develop services and technologies for the realisation of this intellectual design. This should, in particular, allow Europe a better stake in world markets, for instance in competition with Microsoft products, as part of an **intelligent double strategy** to deal with an insufficient global order [48, 52]. Of course, there should be involvement in **global standardisation processes** as well. Also, there could be an interesting coupling with the European project „Global Monitoring for Environment and Security (GMES)“ which is a joint initiative of the European Commission and the European Space Agency (ESA). Of course, also on the **ISO level**, we should and must build a counterbalance to the present activities of the US who want to fix standards in this area, particularly, in biometrical information, at that time. Here and in other places, the European position has to be brought forward with strong emphasis. **It really can make a difference in which direction the European Union operates and in which it doesn't.**

VIII. Where should Europe go in ICT development and use, to have ICT act as an enabler for the eco-social future?

Taking the considerations in this paper into account, a few recommendations for EU politics in the ICT field can be given, even **without doing a formal cross impact analysis**.

1. **Promote open information**, have all kind of information available for everybody around the globe on all kind of issues at the lowest price possible. Information in general helps for the better. It is one way to overcome the digital divide and **all other types of divides**.
2. Promote, in particular, **availability of public information** on all government levels, administrative levels, etc. This includes information on the European Union, UN statistics, tools for statistics to deal with information. All this should be free and available for the world civil society.
3. Help with considerable efforts to **overcome the digital divide**, in our countries and worldwide, among others by promoting **free software**. And **not allow to call the digital divide a digital opportunity**.
4. The EU should take a real effort to **empower world civil society** in all kind of aspects. This concerns empowering the EU civil society, but also the civil society worldwide.
5. The EU should **stronger advocate the eco-social model** in the policy agenda and name a global free market system without co-financing what it is, namely an unfair solution.
6. The EU should **work to make the internet a safe place**. That should be a place for which certain minimal standards are implemented, including enforcement standards. Here the EU should become more active.
7. We need **efficient robust security solutions and corresponding software according to Chapter VII**. This is a most crucial issue. Europe has to start fast and has to organize this issue with an European inspired philosophy of protecting the individual sphere. We should therefore have an alternative to US approaches and Europe should do everything to promote that approach and try to have agreements all around the globe for regulations in this spirit.
8. Europe should do whatever it can to **make content for education, empowerment of women, implementing reproductive rights etc. available via ICT**. Software for empowerment around the globe, multi-cultural-oriented, should be an explicit aim of European ICT policy. The same is true for **promoting free software**. We should create environments for free software, concentrated towards inexpensive and robust

computers, that can be used all around the globe, even in places with limited access to energy etc., among others to close the digital divide.

9. Europe should be active to promote all kind of software systems that **allow control and implementation of standards in the environmental field**, in resource use, but also in the social and cultural area. **Galileo** as an independent base for global positioning is a step in the right direction. We need more of such steps.
10. Europe should be more active in all kind of fields that allow an **intelligent ICT use in security and military issues** and make a double use from money being put to research in those fields.

Final Remarks

This paper gives a look into the future, distinguishing three/four futures we might be confronted with. The authors think that the Scenarios A and B, that is “business as usual” where human kind is destroying its ecological basis, is not the most probable one for the future and have a (joint) probability of may be 15%. We see the higher probability for the case, where humankind eventually succeeds in incorporating physical limitations into the economic system. However, the authors think it is more probable that the world will rather go the resource-dictatorial security regime type of route to this aim than to stay with the eco-social model, which would probably be our only and certainly our best and most future-oriented model for human kind to deal with the century ahead and to eventually achieve **sustainability**.

ICT in all that is the big enabler, but as often before in technological developments, **it enables for the good as well as for the bad**. We see **a strong responsibility resting on Europe**, among others, to help to find the right way into the future. The European split after the renewed Iraq war, does not make this task easier. Also, Europe has to come to the **right decisions concerning ICT development** that will certainly play a major role here. The special chances that lie in a **networked global civil society** were mentioned throughout this paper and should actually be promoted world-wide much more than today by EU politics. Also, the crucial importance of adequate architectures and software systems in the **field of security** were discussed in Chapter VIII. This is another field where the EU should act strongly. Some hints to where to put emphasis in general were given in Chapter VII. This concerns in particular all kind of software to **enable human development** and concerns software to monitor the status of the environment that should have a strong effect for going into the right directions. Let's do it.

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