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The Need for Industrial Transformation

Anna J. Wieczorek
Executive Officer of the IHDP IT project

Pier Vellinga
Chair of the IHDP IT project

1. Introduction

Until the 1960's the post war economic growth was considered a great achievement of modern societies, as it was able to assure stability and welfare. The end of 1960s, however, brought criticisms of economic growth for what was seen as its darker side. The 1972 Report to the Club of Rome was a warning to the world about fatal effects of continuous exponential economic growth and its consequences: increasing pollution, overexploitation of renewable resources, exhaustion of non-renewable resources (Meadows 1972). A heated debate over economic growth and the environment was started between the supporters, who considered economic growth good for the environment and the antagonists, according to whom economic growth was the root cause of the environmental degradation and for that reason should be reduced or even reversed. As a result, in the late 1980s theoretical investigation of the relationship between economic growth and environment was started, many computer models and future forecasting were developed, but the debate could not be put to rest due to a lack of environmental data as well as differing opinions and values about what is a sustainable future. The first empirical studies were carried out only in 1990 and they revealed the existence of an inverted U curve relating use of energy and materials with income, the so-called Environmental Kuznets Curve (EKC) (Panayotou 1997). The curve was consistent with the observation that in some of the developed countries environmental pressure has been reduced while economic growth has continued. In 1992 the World Bank published a report (World Bank 1992) suggesting the possibility of delinking economic growth from its environmental burden (de Bruijn, 1999). 1992 was also a year of the Rio Earth Summit, during which the countries of the OECD committed themselves to sustainable development and since May 2001 the decoupling of environmental pressures from economic growth became one of the main objectives of the OECD Environmental Strategy for the First Decade of the 21st century (OECD, 2002).

Since the first environmental movements of the 1960s the OECD countries have been successful in using regulatory instruments to reduce pollution and overexploitation of natural resources. Technology advances made it possible to increase life expectancy, improve resource use, reduce pollution and better understand how life support systems operate at a global level. All OECD countries have developed a portfolio of environmental policies and many socio-economic imbalances have been addressed especially in more environmentally aware countries. The report by Azar (Azar et al., 2002) on the past trends and prospects for the future decoupling indicates that there has been *some* decoupling of *some* emissions in *some* developed countries. Part of the explanation being the shift of some industries from developed to developing countries. However, according to Johnson (Johnson 2002, 26) "…despite all the elegant rhetoric that surrounds discussions about sustainable development, we are far from heaving made significant progress toward that goal". One would wonder why.

This chapter analyses the complexity of global environmental problems (section 2) and the difficulties with solving them in a traditional way (section 3). In section 4 we propose a transformation of production and consumption systems as a way to approach global environmental problems and we present foundations of the Industrial Transformation project of the International Human Dimensions Programme. The name of the project is clarified in section 5. Section 6 presents a short overview of the current knowledge on societal transformations and in section 7 we look into different messages that Industrial Transformation carries around the world. We close the chapter with a concluding section 8.

2. Complexity of global environmental problems

Figure 1: Local Average Income Levels and Environmental Quality.

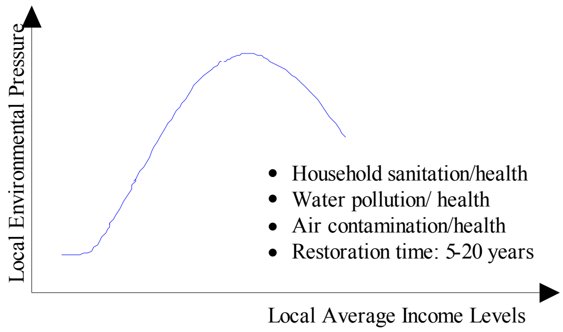
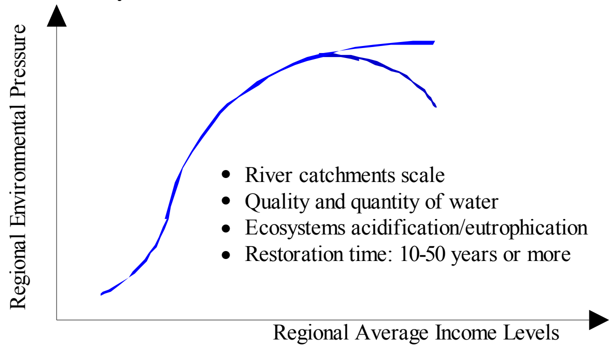


Figure 2: Regional Average Income Levels and Environmental Quality

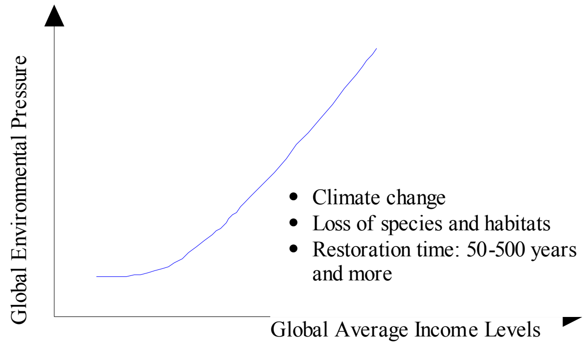


When we take a closer look at the Environmental Kuznets Curve as presented by the World Bank we discover that indeed it is true but only for local environmental problems such as air contamination or water pollution in the cities (Vellinga 2002). The empirical evidence (Azar et all 2002) confirms that indeed growing income levels can be combined with improvement of local environmental quality (Figure 1). This is probably for two reasons: firstly, because people take action based on health impact observations and secondly: because costs and benefits play out at the same (local/national) level and within one generation. Therefore as income levels go up and as local environmental/health problems become manifest, there is a driver and there are financial means to introduce technologies and regulations (incentives and institutions) that reduce pollution and protect the health of the population. Many cities and many countries in the industrialized part of the world have gone through this curve. However many cities in developing countries are still in the upward part of the curve and they suffer from multiple problems, not only environmental.

When we talk about environmental problems that are manifest at a regional level, such as acidification and water quantity/quality issues at the scale of river catchments, there is less evidence that people successfully address these problems as income levels go up. One reason is that upstream and upwind industrial and agricultural activities benefit from the ability to pollute and overuse environmental resources such as water and air, while downstream and downwind, people and nations experience the negative impacts. Another reason for continued environmental degradation as income levels go up, is the time delay between the act of polluting and the effect of pollution downstream. There are some examples of regions and environmental problems where the curve has been pulled downward but this is not a general empirical finding. For most regions of the world the jury is still out.

Similar curves drawn for global environmental problems such as climate change and loss of species and habitats do not resemble Environmental Kuznets Curves at all. Empirical data illustrate that there is no income related levelling off point when we look at the relation between income and emissions of greenhouse gasses (given the predominant use of fossil fuels). The OECD list of red lights (problems that have worsened in the past, or are expected to do so in the future), next to the greenhouse gas emissions, also includes: decline in tropical forest coverage, overfishing and loss of biodiversity (Environmental Outlook, 2001). Environmental problems at this level are challenging because income levels correlate with energy use and present day energy use is coupled with CO_2 emissions. Similarly, the space and resources we use for our activities (housing, transport, food and also recreation) grows linearly with income projections going up; this is at the expense of natural habitats. There is also no direct correlation with human health impacts so the sense of urgency to address these issues is generally low. Finally those who could take first actions – the developed and richer countries - are the least vulnerable to the effects of global environmental change and they do not feel immediate urgency to take any action. Indeed, a critical feature of global environmental change is the time scale of biophysical response: climate responds to changes in the concentration of greenhouse gasses at a time scale in the order of decades to centuries and more.

Figure 3: Global Average Income Levels and Environmental Quality.

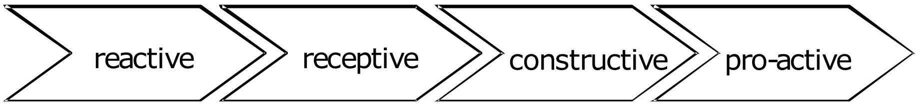


Global environmental change is thus so very difficult to approach in the traditional way in which environmental problems have been addressed so far because the activities that cause these problems (energy use, food production, mobility) are deeply embedded in our cultures. The global environmental problems often originate from different sources, are characterised by a great number of stakeholders and their interests and are marked by large uncertainties. They are also urgent and require action before the effects actually become visible.

3. How have we solved environmental problems so far?

Let's analyse trends in societal response to environmental problems over the last 50 years. Figure 4 presents a number of stages in societal response to environmental problems. In most of the OECD countries environmental policies were initiated in the period between 1960 and 1970. The first set of policies can be characterized as predominantly reactive: policies driven by visible negative effects such as massive fish killing in polluted rivers and health problems related to air pollution and chemical waste. The response can be characterized as "end of pipe", implemented by technical specialists. An important philosophy was keeping the cost down. In response to the oil crises in the 1970s, these policies were complemented with ideas about efficiency gains in the production process. This required the involvement of managers. Optimisation of resource use became the major driving philosophy.

Figure 4: Development stages in corporate and societal response (adapted from Winsemius and Guntram 1992 and Vellinga and Herb, 1999)

A) 

B)	End-of-pipe	Process	Product	System
C)	Specialists	Managers	Sector	Society
D)	Minimisation	Optimisation	Acceleration	Vision

A) response phase C) main actors

B) focus of attention D) driving philosophy

From, say 1990 onward, new approaches can be recognized where environmental concerns are transformed into opportunities for developing and selling new products. The driving philosophy for such strategies is acceleration: developing new markets based on environmental performance and green image. A major question is: will the approach focused on green products be powerful enough to limit global environmental change to acceptable proportions. The answer is: probably not. Green products are only marketable when they fit in the larger physical and institutional framework. A hydrogen car needs an infrastructure with hydrogen service stations, and renewable energies can only compete in a market where the price of fossil fuel use reflects all environmental cost. There are plenty of technologies available or within reach for clean production, such as zero emission power plants and zero emission cars and ecological and/or low input farming systems. Still they do not easily enter the market for two reasons: one - they may not fit in the present energy, transport, food production and consumption systems, which are "locked-in" with status quo interests including education, research, infrastructure and not in the least commercial interests; and two - the incentive structure through its historical development favours the present system of sharing private and public costs (in any fiscal, property, international trade and liability system of rules and regulations some cost are internalised in the price of production and consumption while other cost are born by the public, e.g. health cost, or future generations, e.g. climate change or other species e.g. loss of biodiversity).

4. Transformation – a panaceum?

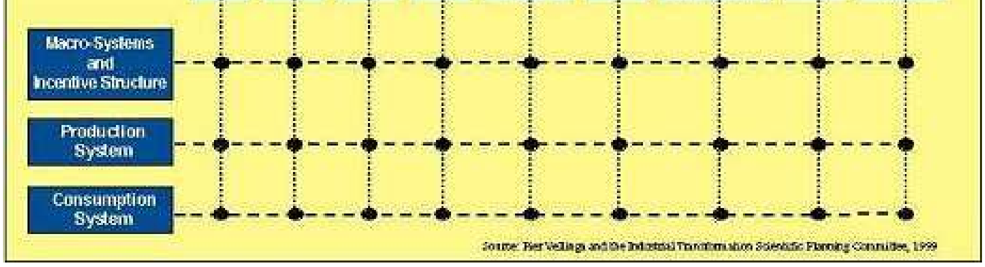
Global environmental change will test, in an unprecedented way, the capacity of the human species to manage their activities in a pro-active manner, especially when we want to combine growing income levels with a significant reduction in the impact of human activities on global life support systems. Such an approach will have to focus on systems and systems change. A system being defined as a chain of production, distribution, consumption and disposal activities including the incentives that shape the system (i.e. property, liability and fiscal laws and regulations). Given the complexity of such chains and given the need for a pro-active approach such system changes will require the involvement of society as a whole and they will require an inspiring vision to mobilize all participants (see Figure 4). It is clear that such visions are likely to compete with one another, which can slow down the change, but this is not necessarily counter productive as competition is a driving force in itself. Furthermore, a change to more sustainable systems is only partially a matter of technology. Economic, socio-cultural and institutional change plays an equally important role. In fact, transformation can only be successful when the technological change is inherently coupled with a societal change.

These considerations and a wide international, multidisciplinary consultation provided foundations for the creation of the Industrial Transformation project (IT) of the International Human Dimensions Programme on Global Environmental Change (IHDP). The overarching goal of the IT research is threefold:

- To understand complex society-environment interactions;
- To identify driving forces for change;
- To explore development trajectories that have significantly smaller burden on the environment.

The IHDP-IT programme is based on the assumption that important changes in production and consumption systems will be required in order to meet the needs and aspirations of a growing world population while using environmental resources in a sustainable manner. This type of research has to be of a multi-disciplinary character. Industrial Transformation therefore builds on the foundations of a range of social science disciplines including economics, sociology, psychology, human ecology, anthropology, political science, geography, and history, as well as on the foundations of natural sciences such as physics, chemistry, biology, and technological sciences. To provide a framework for the co-operation required between various disciplines, a matrix was developed (Figure 5). The rows reflect the disciplinary research fields that each has a certain tradition (outlined in Vellinga 1999a), while the columns describe a set of human activities aimed at meeting specific human needs. Through this multidisciplinary approach, the Industrial Transformation Project strives to build on existing pillars of research and draw from expert communities while developing new research topics and radical approaches.

Figure 5: Tentative Framework for Industrial Transformation Research with research fields/disciplinary approaches in the rows and human needs/activities in the columns (Vellinga 1999b)



5. Why *Industrial* Transformation?

The word *Industrial* in the name of the project was selected to describe and indicate the need for a transformation of ALL human activities defined as a chain of interrelated economic activities aimed at providing a specific need for a society. Industrial Transformation was defined analogously to Industrial Metabolism and hence refers to all processes reflecting economic activity instead of those of the industrial sector alone. Industrial Transformation could also be called *Societal* Transformation but this word is confusing as it emphasizes changing norms, values and attitudes instead of transforming inputs into outputs (de Bruijn 1999). Looking at the history of how societies moved from agricultural to an industrial mode of subsistence, one could argue that many countries are past the industrialization process and therefore Industrial Transformation is over, *but* this is not what IT refers to. Current societies including the so-called post-industrial world are strongly based on the production of goods and services in ways that have a massive effect on environment (e.g. the energy and food sector as well as tourism and the health care sector). Industrial Transformation is therefore about transforming production and consumption based societies towards sustainability.

6. From chaos to convergence

Since launching of the IT Science Plan in the early 2000, a number of relevant research initiatives have been developed worldwide, many of which were supported by the IHDP IT programme. The aim of these activities has been firstly to better understand the complex society – environment interaction and the process of socio-technological transformations; secondly to use this understanding to inform policies and strategies to realize purposive transitions; and thirdly to better understand the different messages that Industrial Transformation carries throughout the world.

For example, the research group focussing on innovation theories based at Twente and Maastricht (The Netherlands) developed a "multilevel perspective on transitions" to help us understand dynamics of transformations. They distinguish three levels: niche, regime and landscape (Geels 2002):

- *Niche*: denoting a space where individuals, based on existing knowledge and capabilities develop new technologies or concepts that are geared towards problems of existing regimes. Niches provide space for learning processes and development of social networks, which support innovations. Innovations generated at this level are usually radical.
- *Socio-technical regime*: accounting for stability of existing technological development. Regimes refer to rules that enable and constrain activities within communities. If innovations are generated at the regime level- they are mainly incremental.
- *Socio-technical landscape*: encompassing the wider context of a regime in the form of socio-cultural and normative values, economic and broad political processes. The context of landscape is very difficult to change and if it does change, it takes much longer than in the case of regimes. (Geels, 2002).

A niche-based approach to sustainable development – the Strategic Niche Management that has been developed in conjunction with the multilevel perspective on system innovation advocates a deliberate stimulation and protection of the novel socio-technical niches to seed a transformation of the technological niches towards sustainability (Kemp, Schot, Hoogma 1998).

These findings gave foundations to a new approach – transition management which has been defined as an anticipatory form of multi-level governance that uses collective, normative visions as starting point for formulating long-term, collective innovation strategies (Rotmans et al 2003). This managerial approach advocates an evolutionary way of steering instead of command-and-control governance. It suggests that a transition takes place through a sequence of the following stages: a pre-development phase where there is very little visible change at the systems-level but a great deal of experimentation at the individual level; a take-off phase where the process of change starts to build up and the state of the system begins to shift because of different reinforcing innovations or surprises; an acceleration phase in which structural changes occur in a visible way through an accumulation and implementation of socio-cultural, economic, ecological and institutional changes; and a stabilization phase where the speed of societal change decreases and a new dynamic equilibrium is reached.

Critics of the approaches and taxonomy described above indicate that indeed traditional innovation may be explained in the terms niche innovation. However, changes required to reverse the trend of growing global environmental pressures are likely to be triggered only by institutional changes at the level of "regimes" or "landscapes". It is claimed that addressing energy, food and transportation systems and their effects on the global environment requires changes in the existing international incentive structure for these activities. Such changes should include some kind of internalisation of external cost of environmental resource use e.g. through taxes and/or through the allocation of resource use quota systems and the introduction of tradable resource use rights. The critics argue, however, that niche innovation can only come about after relevant changes have been made in the international "level playing field" (in evolutionary economics this is called the "selection environment"). In terms of transformation management: stimulation of niche innovation is only worthwhile when incentives at global scale are adjusted simultaneously (assuming the systems addressed are embedded in global markets).

Berkhout and Smith (2004) propose a taxonomy listing four different types of transitions: path dependent, reorientation of trajectories, emergent transitions and purposive transitions, each with its own pace and features. Berkhout argues that the normatively driven purposive transformations (such as those triggered by the desire to avoid irreversible damage to life support systems like climate, biodiversity and the water cycle) do not fit the typical model as described by Geels (Geels 2002) and the others mentioned above.

Historical analysis of technological innovations leads also to the conclusion that most innovation tends to be of an incremental nature but broad transitions do occur (Elzen 2003). Taking into account the fact that these transitions have not been planned and that there was no consensual vision about where the societies could transform to (either in more or less sustainable directions) the main challenge for research remains in gaining a better understanding of the dynamics of transitions so as to be able to suggest possibilities for inducing and stimulating the occurrence of transitions. It seems likely, however, that purposive transitions, taking place on mainly environmental grounds, will have different characteristics, may be more costly and therefore more difficult to implement (van de Kerkhof & Wieczorek 2003).

The road towards sustainability through the decoupling of economic development from its environmental burden proves to pose many challenges. There are many areas of human needs that need to be addressed such as food, fresh water, health, shelter, mobility and energy, to name only a few. There are also many dimensions in which sustainability needs to be achieved, including e.g., technical, socio-economic, cultural or spatial aspects. Achieving sustainability in the broad sense therefore appears to require a multitude of changes that have been referred to by analysts from different disciplinary backgrounds using a variety of concepts. *System innovation*, *regime transformation*, *industrial transformation*, *technological transition*, *socio-economic paradigm shift* are some of the best known (Elzen 2003).

The review of research carried out since the launching of the IT Science Plan in 2000 illustrates that transition research is still in its infancy with different schools of thought claiming the term (Vellinga & Wieczorek 2003a). This is mainly due to different disciplinary and interdisciplinary approaches to research and different attitudes regarding normative and non-normative aspects of research. Despite this variety of terms and the lack of well-established definition for a transformation, there is still convergence and a growing set of characteristic features of a transformation that scientists do agree about. They agree that:

- A Transformation is a major but gradual and long-term change in the way societal functions are fulfilled.
- Technological change is crucial in bringing about the change but its introduction is inherently coupled with high-level socio-cultural and institutional changes.
- Transformations involve a wide range of actors, including firms, consumers, NGOs, knowledge producers and governments.
- They are not caused by a change in a single factor but are the result of the interplay of many factors and actors that influence each other but they may also have their own trajectories of development.

The insights developed thus far also allow making policy suggestions that can inspire current attempts to define and implement various forms of transition policy. The challenge to realize transitions towards sustainability in a variety of domains can only be fruitfully tackled when near-future attempts to induce them are carried out in close interaction with work on furthering the understanding of the dynamic of transitions.

7. Understanding geographical differences

When studying historical transformations with the aim to fuel the policy process and envisage pathways towards sustainability, it is of utmost importance to take account of regional differences within the framework of global interconnectedness. This is not only due to various levels of economic development, but also because of different climatic conditions and topography and often very different cultural and socio-political patterns. For example, the challenge for the OECD countries is to continue economic development while reducing environmental burden (de-coupling of economic growth from its environmental burden). For the South Asian region a single challenge cannot be defined since differences among and within the countries in terms of production and consumption are too large to allow for such a simplification. The rapid change to natural gas busses in New Delhi or growth of kilowatts produced by decentralized renewable energy systems in India could serve as good examples of change for many OECD countries. But at the same time, the South Asian region is home to the largest number of poor and nearly half of the two billion people without access to energy (Wieczorek and Vellinga 2003b).

On the other hand, the industrializing East Asian mega-cities undergo a rapid transformation due to massive economic growth in the last few decades. This growth has been accompanied by increases in per capita income and significant declines in poverty and child mortality but also by tremendous increases in air and water pollution, resource degradation and escalating energy use. It has been widely recognized that this is due to policies failures and institutional weakness. On the other hand, evidence shows that incremental improvements in environmental regulatory policy were often overridden by the scale effects of increased production, consumption and resource use. Given this urban-industrial growth, the challenge for this region is therefore to shift to patterns of economic development that are significantly less energy, resource and pollution intensive (Angel 2000).

8. Conclusions

Global environmental change problems such as climate change, the loss of biodiversity and the overexploitation of water resources require major changes of the way energy, food, transport and water needs are met. In view of these global environmental problems and their irreversibility, there is an urgent need to explore development trajectories and implement strategies that have a significantly smaller burden on the global environment.

The activities causing global environmental change such as the production and consumption of (fossil fuels) energy, transport, food and water are deeply embedded in our societies. Therefore traditional command-and-control policy measures will not suffice in bringing about the required changes. System innovation offers a more promising approach. It advocates a reconsideration and innovation of the entire chain of production and consumption as well as the institutional and political structures that shape relations between the two.

The international community has developed a number of research concepts and tools to address the enormous challenge of global environmental change. There is a consensus that effective research approaches should include the analyses of technological, socio-economic and institutional change. Such multidisciplinary approaches are generally presented under the name of industrial transformation research.

Industrial Transformation research as described and promoted by the International Human Dimensions Programme (Vellinga and Herb 1999) brings the various research approaches together. This programme plays an important role in the generation and sharing of the knowledge required to initiate and guide international, regional, national and local efforts towards more sustainable production and consumption processes. The character of the most urgent global environmental problems legitimises the focus on the transformation of production and consumption of energy, transport, food and water and the technical, institutional and societal elements that shape these systems.

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