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Industrial Transformation: Research Gaps and Possible Research Topics for IIASA

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Abstract

Industrial transformation has been identified as a priority research topic within the International Human Dimensions Programme on Global Environmental Change (IHDP). This paper looks at the research gaps in the area of Industrial Transformation identified within the framework of IHDP. Furthermore, the paper explores possible research topics for IIASA and discusses possible research questions for the topics of "Technology" and "Consumption".

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1. IHDP

1.1 Introduction

Concern about the effects of human behavior on the environment increased enormously in recent decades, though worries about environmental degradation have existed as long as economic activities have been conducted. But as the scale and severity of the present-day damages to the environment seems to be larger than ever, there is reason to state that environmental degradation is one of the main problems humankind now has to deal with. Publications like the report for the Club of Rome (Meadows et al., 1972) and Our Common Future (Brundtland, 1987) increased awareness among society that human activities play an important role in driving global environmental change and that the consequences for mankind of these changes could be large.

In this report Global Environmental Change (GEC) is defined as alterations in the natural (e.g. physical or biological) systems whose impacts are not and cannot be localized (National Research Council, 1992: 25). GEC refers to both global environmental problems, and to local and regional environmental changes occurring at a global scale.

1.2 The Human Dimensions on Global Environmental Change

In the scientific research community most attention was given to the physical/ chemical and biological aspects of global environmental change, e.g. deforestation, acidification and the loss of biodiversity. Therefore, research on GEC was mainly done by natural scientists. Though this research was important, and still is, the notion that human aspects were intertwined with GEC has been growing. It was recognized that GEC is driven by trends in global production and consumption (National Research Council, 1992: 21). The awareness of the importance of the human factors that drive global environmental change and the effects of these changes on humankind, is now spreading throughout the scientific

community in general and the social science[1] *community in particular.*

The *recognition of the human dimensions of* GEC *does not imply that they have to be studied in isolation of the physical and biological dimensions, or that they are more important than the latter.* **O***n the contrary, "to understand global environmental change, it is necessary to focus on the interactions of environmental systems, including the atmosphere, the biosphere, the geosphere, and the hydrosphere, and human systems, including, economic, political, cultural, and sociotechnical systems*" (**N***ational* **R***esearch Council*, **199**2: **1**)**.**

S*tudying the human dimensions of* GEC *deals with these interactions between human and environmental systems* (*see* **F***ig.***1.1**)**. I***t includes therefore not only the way people and societies contribute to global change, but also the way global environmental change affects people and societies and the ways and means for people and societies to mitigate and adapt to global environmental change.* Q*uestions with respect to the human causes of* GEC f*ocus on the social driving forces of human behavior influencing* GEC**. F***ive main driving forces can be considered* (**N***ational* **R***esearch Council*, **199**2): **P***opulation Growth,* E*conomic Growth, Technological Change,* **P***olitical-Economic* **I***nstitutions,* **A***ttitudes and* **B***eliefs.* Q*uestions concerning the consequences of* GEC f*or people and societies are dealing with responses to actual or anticipated* GEC**.**

[1] **F***ollowing the* **N***ational* **R***esearch Council* (**199**2) '**S***ocial* **S***cience' is here defined as to cover a broad range of research activities usually associated with disciplines such as economics, sociology, political science, psychology, anthropology, geography, and history and interdisciplinary field such as policy science, human ecology and management.*

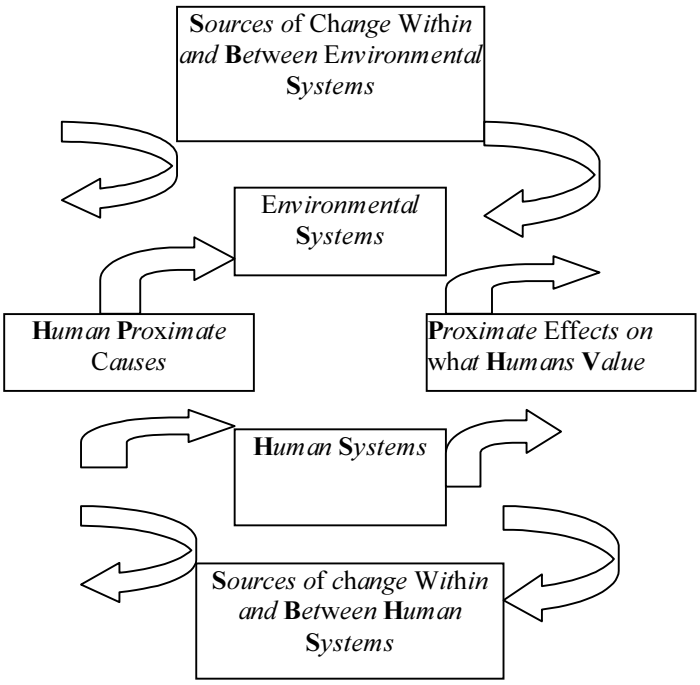


Fig. 1.1. Interactions between human and environmental systems. Source: National Research Council (1992: 34)

Global environmental change affects people and societies not only through effects on the physical and biological environment of their activities but also by changing social and economic organization and human values. People respond to GEC, *among others, by means of national or international policies, individual perception and action, and markets.*

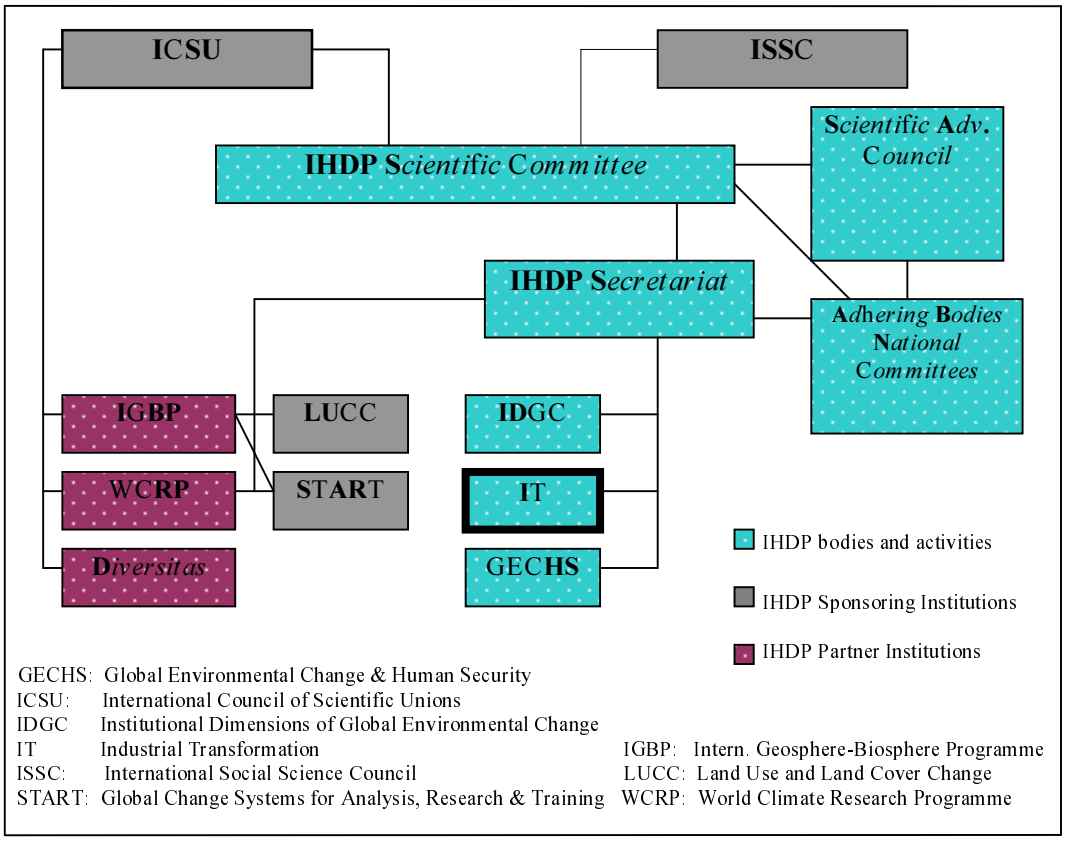
The above-described dimensions of GEC *imply, inter alia, that single-factor explanations and one-dimensional policies are not adequate. It also supports the notion that* GEC *requires stronger links between social and natural sciences, both to understand* GEC *and to support policies. By its nature* GEC *has to be approached in an interdisciplinary and international way by the scientific community. To sum up,* "*research on the Human Dimensions of* GEC *strives to understand the interactions between human systems and environmental systems, particularly global environmental systems, and to understand the aspects of human systems that affect those interactions*" (*National Research Council*, 1992:33).

1.3 IHDP

I*n order to complement t*he *physical and* b*iological researc*h *on glo*b*al environmental c*h*ange*, *t*he **H***uman* **D***imensions o*f G*lob*a*l* E*nvironmental* Ch*ange* **P***rogramme* (**HDP**) w*as* f*ounded in* **199**0 b*y t*he **I***nternational* **S***ocial* **S***cience* C*ouncil* (**ISS**C)**. I***t* w*as considered to* b*e t*he *social science parallel to t*he **I***nternational* G*eosphere-***B***iosphere* **P***rogramme* (**IGBP**) *and t*he W*orld Climate* **R***esearc*h **P***rogramme* (WC**RP**)**. I***n* **1996 HDP** w*as renewed and c*h*anged in t*he **I***nternational* **H***uman* **D***imensions o*f G*lob*a*l* E*nvironmental* Ch*ange* **P***rogramme* (**IHDP**), *in particular t*hrou*g*h *t*he *co-sponsorsh*i*p* b*y t*he **I***nternational* C*ouncil o*f **S***cientific* **U***nions* (**ICSU**)**. IHDP** *reflects t*he *growing international recognition o*f *t*he *importance o*f *t*he h*uman dimensions o*f *glo*b*al environmental c*h*ange and t*he *glo*b*al scope o*f *interest and researc*h *o*f *social scientists from around t*he w*orld* (**IHDP**, **199**7)**.**

IHDP *is an international*, *interdisciplinary*, *social science program to promote and co-ordinate researc*h *aimed at descri*b*ing*, *analyzing and understanding t*he h*uman dimensions o*f GEC**.** Th*oug*h **IHDP** *is a social science program*, *its concern is* wi*t*h *t*he f*ull range o*f *social and natural sciences disciplines necessary to analyze and understand t*he h*uman's role as* b*ot*h *t*he *possi*b*le cause and target o*f GEC**.**

A*t present*, **IHDP** *is developing a researc*h f*ramewor*k *that emp*h*asizes t*he *dynamics o*f *t*he h*uman driving* f*orces o*f c*hange and socio-cultural and institutional influences on t*h*ese* f*orces***.** Th*is international program is c*h*aracterized* b*y* "*an emp*h*asis on t*h*ose processes t*h*at are universal and cumulative*, *or t*h*at transcend regional or national* b*oundaries and see*k*s to integrate and stimulate co-operation among international and interdisciplinary scientists* b*y esta*b*lis*h*ing* b*o*th *a net*wo*r*k *and a pla*t*form* f*or communication and discussion*" (**V***ellinga et al***.**, **1997**: **1**)**. IHDP** *stimulates concrete researc*h *activities* b*y means o*f *sponsoring researc*h *and esta*b*lis*h*ing ne*w *researc*h *pro*j*ects***.**



The **IHDP** *Programme Elements*, *Sponsoring Institutions and Partner Institutions*

Source: **IHDP** *Update nr*. **1**, **1997**

2. Industrial Transformation

2.1 What is Industrial Transformation?[2]

Industrial Transformation has been identified as one of the three priority research topics within **IHDP.** The *Industrial Transformation Research Agenda is about "understanding the human drives and mechanisms that could enable a transformation of the industrial system towards sustainability, and in physical terms to decouple industrial activities from their environmental impacts"* (**Vellinga et al., 1996**: 4)**.** *It includes research efforts describing the patterns (over space and time), organization and technology of production and consumption of manufactured goods and services, their natural and energy transformations and associated environmental impacts and the consequences of these*

impacts for the quality of life (**V***ellinga et al.*, **1997**: 4)**. A***ccording to these definitions, it would actually be better to substitute the term "industrial transformation" by "economic transformation"***. B***ut due to the established use of the term "industrial transformation" in recent years, we will continue to use "***I****ndustrial* T*ransformation*" (**IT**)**.**

The **IHDP** *approach to* **I**T *focuses on industrial or economic activities***.** Th*at is*, **I**T *looks at the industrial or economic activities in terms of their connections to* GEC**. I***ndustrial activity is one of the main contributors to global environmental change***. I***ndustrial activity refers to all processes for the production of goods and services that are either consumed directly or are required as inputs to other industrial activities***. I***ndustrial activities are not a collection of isolated processes or phenomena***. R***ather, industrial activities draw upon nature, impact upon nature*[3]*, and are shaped by economic, social and technological factors***.**

I*ndustrial activities can be regarded as a system constituted in ways that vary through time and over space, and which have impacts on the natural environment that are also spatially and temporally variable***. A***s a consequence, the impact of industrial activities on the global environment is multidimensional***. A***t the same time, there is a growing recognition that environmental problems may become important constraints to industrial activities***.** GEC *refers to both global environmental problems, and to local and regional environmental changes occurring at a global scale***.** G*lobal environmental problems that relate to industrial activities include the depletion of stratospheric ozone; the enhanced greenhouse effect (climate change); loss of biodiversity; land degradation; pollution of international waters; and the depletion of natural resources***.** Ex*amples of local and regional environmental problems include the accumulation of organic micro pollutants and other pollutants, and the accumulation of heavy metal and other materials or substances and consequent contamination of drinking water, agricultural area or silt; acidification; storage of hazardous wastes; air pollution (smog); and nuclear accidents***. I***ndustrial activities relate directly or indirectly to such environmental problems***.**

A *growing demand for industrial products and a rapidly increasing world population exert pressure on industrialization processes throughout the world***. A***s a result, humanity faces*

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[2] Th*is section is based on* **V***ellinga et al.*, **1996.**

[3] Cf. *the concepts of industrial metabolism and industrial ecology***. I***ndustrial* **M***etabolsim refers to the physical-chemical processes transforming resources into end-use products and waste***. I***ndustrial* E*cology refers to the interaction of industrial activities with the natural environment***. S***ee* **A***yres and*

a tension b*etween a liva*ble *environment on t*he *one* h*and*, *and t*he '*need*' f*or material* w*elfare on t*he *o*ther h*and*. **I**f h*istorical patterns o*f *industrial development* with *its environmental impacts are extrapolated into t*he f*uture*, b*o*th c*hances to o*b*tain* eq*ual* w*elfare* f*or a growing* w*orld population*, *and a liva*ble *environment are at sta*ke**.** **D***iffe**rences* b*etween so-called developed and developing countries imply an extra challenge to t*he *interrelations*h*ip* b*etween industrial development and environmental degradation*. **I***n t*he *developing countries s*hi*fts are ta*k*ing place* f*rom agricultural to industrializ*ed *societies and more or less strai*gh*t on to an in*f*ormation society*. **I***n developed countries* we *notice a s*hi*ft* f*rom an industrialized via services to an in*f*ormation society*. The *causes and conse*q*uences o*f *these large s*hi*fts are* high*ly comple*x *and* b*eset* wi*t*h *uncertainty*.

S*ustaina*b*le development re*q*uires a trans*f*ormation o*f *current tra*j*ectories o*f *industrial development*. "T*ransformation*" *refers to* q*uantitative and* q*ualitative c*h*anges in t*he *con*f*iguration o*f *economic and social systems*. **I***ndustrial* T*rans*f*ormation involves*: *c*h*anging structures o*f *production*; c*h*anging modes o*f *regulation o*f *production* (*social*, *economic*, *and tec*h*nological*); *and c*h*anging material and energy trans*f*ormations*. The*se c*h*anges are re*f*lected in t*h*eir impact on t*he *environment*. **I***ndustrial* T*rans*f*ormation re*q*uires e*f*forts in addition to t*he *traditional patterns o*f *industrial development su*ch *tha**t dissipative losses are restricted to levels t*h*at do not e*x*ceed carrying capacities*, *or to levels compati*ble wi*t*h *societies' capa*b*ility to adapt to any resulting environmental c*h*ange*. Th*is re*q*uires an understanding o*f *t*he h*uman dimensions*, *i.e*. h*uman drives and social me*ch*anisms*, *that could ena*ble *a trans*f*ormation o*f *industrial systems to*w*ards sustaina*b*ility*[4]**.**

2.2 Research Agenda on Industrial Transformation

S*ince t*he *development o*f *a* **S***coping* **R***eport* (**V***ellinga et al*., **1996**) *and an* **I***nventory o*f **R***esear*ch *document* (**V***ellinga et al*., **199**7) *on* **I***ndustrial* T*rans*f*ormation*, whi*c*h *provide an de*f*inition o*f *t*he *resear*ch f*ield* **I**T *as* w*ell as an overvie*w *o*f *ongoing resear*ch *relevant* f*or* **IHDP-I**T, *there is a clearer vision o*f *t*he *resear*ch f*ield*. The *idea o*f *t*he **IHDP** *resear*ch *pro*j*ect* **I***ndustrial* T*rans*f*ormation is t*h*at it* w*ill serve as a* '*scienti*f*ic ve*hi*cle*' *to catalyze resear*ch *about understanding t*he h*uman drives and me*ch*anisms t*h*at could ena*ble *a*

S*imonis* (**199**4), *and* **S***ocolo*w *et al*. (**199**4)**.**

[4] **S***ee f*or f*urt*h*er general in*f*ormation on* **I**T *t*he **IHDP-I**T **H***omepage*: h*ttp*://*ibm*.*rhrz*.*uni-bonn*.*de*:80/**IHDP**/**.**

transformation of the industrial system towards sustainability. In other words, **IHDP-IT** *can be seen as an umbrella under which existing research efforts as well as new research directions could be brought together in order to enhance this understanding.* The *aim is that the* **IHDP** *research community, in consultation with governments, corporations and* **NGOs**, *will develop and implement a* **R***esearch* **A***genda on* **I***ndustrial Transformation.* **O***ther goals of this research project are selecting a (small) number of research themes to be developed and carried out under the aegis of* **IHDP**, *providing a consultative network for ongoing research and strengthening the international cooperation including* **O**ECD, CEEC's *and* **D***eveloping Countries.* **A***n overview of activities within the framework* **IHDP-I**T *which have been developed since last year is given in* **A***ppendix* **1.**

The *present ideas regarding the set up of the research agenda are as follows.* Th*ree related fields of research are to be considered (see Table* **1**)[5]**.**

1) **S***ystem-***A***nalytical perspectives, such as the* E*nvironmental* K*uznets* C*urve,* **I***nternational* **M***ass* **B***alance* **R***esearch,* E*co-restructuring and* **D***eveloped-***D***eveloping country interactions.*
2) **I***ndustrial* E*cology including* **I***ndustrial* **N***etworks,* E*co-efficiency,* **L***ife* C*ycle* **A***nalysis,* G*reening of* **I***ndustry and* **O***rganizational* **I***ssues.*
3) C*onsumers, including* C*onsumer* Ch*oice issues and the* **R***ole of* C*onsumers in* **D***ecision-***M***aking.*

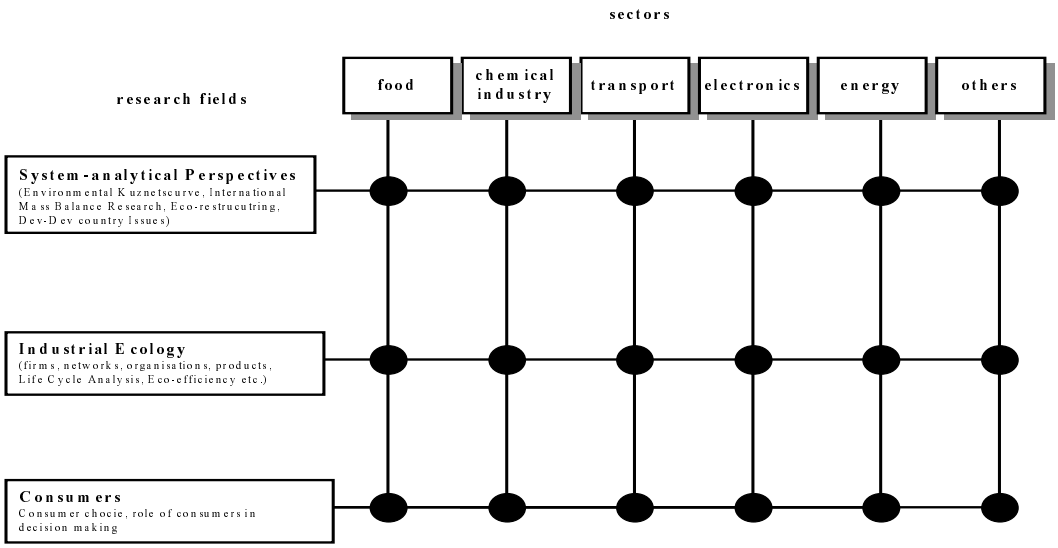

Table **1.** *Tentative set-up of the* **R***esearch* **A***genda*

To ensure that the research agenda will reflect real world issues it is proposed to focus on specific sectors, e.g. the food sector, chemical and/or steel industry, transport, the electronics and/or other sectors. Moreover, the need for information is evolving from state-of-the-environment issues to production and consumption patterns and state-of-the-sector-issues. Focusing on specific sectors also has the advantage that industry representatives will find it easier to participate in the development of, and to contribute to the research activities. Presently leading scientists are being approached to participate in the Research Planning Committee. The terms of reference for the Research Planning Committee will be finalized and presented to the IHDP-Steering Committee for approval in September 1997. It is to be expected that the Research Agenda will be finalized by mid-1998.

At present the tentative set-up of the research agenda can serve as a tool to identify research gaps in the field IT. The Research Planning Committee, provided with input on research questions from Regional Workshops[6], will consider existing research gaps and formulate research directions. However, during the discussions held at IT -Workshops this year, several research gaps have already been identified and some research questions named. An overview of this and additional research questions based on literature, is given in the next section.

3. Research Gaps on IT

3.1 introduction

In this section several research needs are presented, based on the Inventory of Research (Vellinga et al., 1997), the tentative set-up of the Research Agenda (see Table 1) and the results of several IHDP-IT workshops. In accordance with the tentative set-up of the research agenda, three fields are distinguished: The System-Analytical perspective, the Industrial Ecology or Business perspective and the Consumer level of analysis. This classification follows an important and powerful boundary in established research fields that have relevance for IT, namely the difference between so-called 'top-down' and 'bottom-up' approaches. Top-down approaches tend to view society as a whole with little differentiation towards various actors and a relatively poor understanding of behavioral or micro aspects (see Vellinga et al., 1997: 4). These approaches are more or less captured

[5] For an elaboration and explanation of this classification see introduction to section 3.
[6] See Appendix 1 for information on Regional IHDP-IT Workshops.

under the h*eading of* **S***ystem-***A***nalytical* **P***erspectives*, *system-analytic in* the *sense* th*at* the h*uman aspects of* the *studied* ph*enomena are supposed to* be *captured ade*q*uately* by *the system in* whi*c*h h*umans operate* (**D***e* **B***ruyn and* **A***nder*b*erg*, **199**7: 2)**. O***n* the *contrary*, *the* b*ottom-up approac*h *is* c*haracterized* by *starting* the *analysis* f*rom individual* (*groups of*) *actors* (**V***ellinga et al***.**, **199**7: 4)**. A***nalyzing* the *trans*f*ormation of society towards sustainability from* the *consumption point of vie*w, *implies more or less* this b*ottom-up approac*h**.** (**M***ore detailed discussion of* th*is* b*oundary is provided in* c*hapter* 4**.**)

A*s is* the *case* wi*th* the *set-up of* the **R***esear*ch **A***genda*, *this classification is* q*uite ar*bi*trary***. I***t* h*as to* be *emphasized that* the *main reason* f*or distinguish**ing several levels of research is to give a clear overvie*w *of relevant research and is not meant to establis*h *dividing lines* b*etween these levels***. O***n* the *contrary*, *the research on* **IHDP-I**T h*as to overcome traditional dividing lines or* b*oundaries***.** Wh*at is more*, *the fact that strong* b*oundaries*, *like the di*ff*erence* b*etween* '*top-down*' *and* 'b*ottom-up*' *approac*hes, *exist is one particular* j*ustification* f*or the development of* the *researc*h f*ield* **IHDP-I**T**.** T*o give an* ex*ample*, *as* this *researc*h f*ield deals* wi*th* the h*uman drives and me*ch*anisms of industrial activities it cannot* k*eep up a* b*oundary* b*etween* p*hysical* f*lows of economic activities on* the *one* h*and and consumer* beh*avior on* the *o*ther h*and***.**

The f*ollowing overvie*w *does not pretend to* b*uild up a complete list of* wh*at can* be *done in the researc*h f*ield* **IHDP-I**T b*ut provides some researc*h *gaps* whi*c*h *can* be *included in ne*w *researc*h *pro*j*ects***.**

3.2 General Research Gaps

3.2.**1** S*ystem-***A***nalytical* **P***erspectives*

I*dentification of transformation processes*

The *modern industrial or economic system is* c*haracterized* by *many inter-lin*k*ages* b*etween and interdependencies of actors***. P***roducers*, *consumers*, *policym*a*kers*, **NGO***s*, *etc***.** *do not act in an isolated* w*ay***. O***n* the *contrary*, *their activities are* '*locked in*' *in a* whole *range of activities on* whi*c*h *they* h*ave only limited in*fluence**.** T*ransformation of* the *industrial system towards sustainability re*q*uires* k*nowledge of* th*ese interdependencies in order to ma*k*e interventions* f*easible and e*ffi*cient***. F***or* ex*ample*, *the car industry is em*b*edded in a structure* whi*c*h *includes*, *among other things*, *the oil industry*, *the transportation in*frastructure, *consumer* beh*avior and ur*b*an planning***. D***ecisions made in one of* th*ese* '*fields*' *can* h*ave*

significant and long lasting influences on the environment (car mobility,) while many of these decisions do not take these effects in account (e.g. the building of the interstate highway system in the US.). Just raising fuel taxes in order to slow down the growth in mobility could therefore have little or no impact. To get a better understanding of transformation processes two types of research are required:

Theoretical research

Theoretical research on the identification of transformation processes can be characterized by system-analytical research on the relationships and interdependencies important for decoupling economic activities from their environmental impact. This research will deal for example with questions like how to satisfy needs (for example mobility) in society in a different (i.e. more sustainable) way? Can we identify the path to substitute fossil by sustainable energy sources? An important part of this kind of research will be studying the connection between innovation, technology adoption and environmental policy, because technological change is an important driving force in the economic system. Another subject is Integrated Assessment. Research on the identification of transformation processes can contribute to Integrated Assessment efforts by more explicitly specifying the interactions between various groups in the society in combination with production and consumption.

Case studies

Case studies are an important way to identify how transformation processes do take place. Studying success stories of (small) transformations, like the substitution of fuel with lead by fuel without lead, can help to increase the understanding of how to incite changes in production and consumption processes. Relevant questions are: which actors were involved and how did they interact? Who came up with the initiative, which factors where critical for the success? How to manage such transformation processes? Can we extrapolate these successes? What are the possibilities of self-transformation (analog to self-organization)?

Technology

Technology plays a crucial role in the economic system and with respect to the environmental impact of economic activities. Nevertheless, processes of technological change in general are still not well understood in social science. An important research gap on the use of technology with respect to making economic activities more '*environmentally* friendly' has to do with the market introduction of '*green*' technologies. It seems that many available techniques are not implemented in production processes.

Why *is that*, what *are the* barriers? **A***re they mainly of a technical nature*, *is it* b*ecause of competitive deliberations*, *or* has *it to do more* with *psychological reasons*, *or...*? **A** *main question with respect to the role of technology in pursuing sustainability*, *is* whether *certain goals*, for *example* 'factor **1**0' *or* 'factor 4'[7] *are* feasible with *current technologies*? **I**f *not*, which k*inds of technologies are needed to achieve these goals*? **S**uch *research deals with long term technological changes***.**

Ex*tending* **M***ass* **B***alance* **R***esearch*

A *lot of* work *on* **M***ass* **B***alance* **R***esearch* - b*ased on the concept of industrial metabolism* – h*as been done over the last decade and much research is still going on***.** **M***aterial* **F**low **A***nalysis* (**MFA**) *and* **S**u*bstance* **F***low* **A***nalysis* (**SFA**) *increased the understanding of material and substance flows through the economy significantly***.** Th*anks to* **L***ife Cycle* **A***nalysis* (**LCA**), *more is* known *about the life cycle of products and their impact on the environment in several stages of the life cycle***.** The *results of this research increased the possibilities of intervention in production processes in order to reduce the physical throughput* (**D***aly*, **199**2) *through the economy***.**

N*evertheless*, wh*at still lacks with respect to research concerning the physical flows in the economic system is a thorough integration of these results with socio-economic structures in society***.** **M***aterial and substance flows are driven by socio-economic forces and depend for a great part on economic* (*power*) *relationships and consumer preferences***.** **S***uccessful intervention in order to reduce the physical throughput requires an understanding of these* (*concealed*) *driving forces***.** Therefore, *research has to be done on linking* **MFA**, **SFA** *and* **LCA** *with societal*, *economic and spatial aspects***.** W*ays of doing this are*, *inter alia*, *integrating* **SFA** *and macro-economic modeling and integrating* **SFA** *and energy-modeling/scenarios*[8]**.** **I***n addition*, *cross-country comparisons of mass balance flows can gain insight in international differences*, for *example* between Western- *and* Eastern Europe**.** **S***uch comparisons can generate for this reason information to harmonize international policies and/or strengthening of international collaboration in managing and reducing the physical flows in the economy***.**

[7] **F***actor* **1**0 *means a reduction of the material intensity of the economic system by a factor* **1**0**.**
[8] **S***ee for example* Gerlagh *et al***. (1996).**

The Environmental Kuznets Curve and Beyond

The Environmental Kuznets curve refers to empirical research on the linkage between economic activities and environmental impacts. Following the original Kuznets curve, an inverted U-curve relationship between inequality of income and growing GNP, the Environmental or Green Kuznets curve (Selden and Song, 1994) describes an inverted U-relation between environmental pressure - in terms of material inputs and pollution levels - on the one hand, and growing GNP on the other hand. Thus, the curve sketches first rising environmental pressure per unit of income but after a certain level of income, falling levels of environmental pressure per unit of income, and later in absolute terms. Evidence for such patterns has been found on a case-study basis for several materials and pollutants, as well as for energy in a cross section of countries (De Bruyn and Anderberg, 1997: 12). Several reasons are given for these patterns: relocation of dirty industries, structural changes in the economy, technological improvements, environmental policy and materials and energy substitution. However, the likelihood of the 'inverted U-curve' has been discussed, among other things, because of growing evidence that the relationship between environmental pressure and growing GNP may be in the longer term N-shaped more than inverted U-shaped. In other words, there might be 'relinking' instead of 'delinking' (De Bruyn and Opschoor, 1997).

Facing growing GNP in most countries (developed and developing countries), a better understanding of the relation between growing levels of income and environmental pressure is of great importance. Additional empirical research on the Kuznets curve is required to increase this understanding. However, the latter should not be a goal in itself but serve as a starting point for a better understanding of the causes of the found patterns. Therefore research that goes beyond the Kuznets curve is required to provide necessary information in order to decouple economic activities from their environmental pressure.

Research questions here deal, for example, with structural changes of the economy: which sectors can grow, which should shrink from an environmental point of view? What is the impact of this on national levels of welfare, employment rates and international spatial distribution of economic activities. There might be reason for revitalising the concept 'selective growth' In order to analyze the consequences of changes in the economic structure, and the incentives to reach a desired change, an important part of research on this topic will consist of scenario-building. Obviously there is here a link with research investigating transformation processes.

Policy-making

Transforming the economic system towards sustainability requires an adequate incentive structure. The idea is raised that the present-day 'tools' are not appropriate enough to stimulate such a transformation. Research is needed on rethinking used tools (for example, the possibilities and limits of market instruments), design of new ones and a better use/mix of available tools. Research in this area can be affiliated to existing and past research on public policy and the environment. In general, most research gaps described in this section imply research on policy issues because of the many direct or indirect links between the studied topics and policy.

3.2.2 Industrial Ecology

Behavior of Enterprises

The behavior of firms with respect to the environment has been identified as an area in which still a lot of research can be done. A central, abstract question here is: why do businesses do the things they do? This question is an important one when talking about a transformation of the industrial systems towards sustainability, because it is at the basis of the impact of industrial activities on the environment. There are factors determining actual behavior of enterprises. What are these factors or driving forces? Apparently, enterprises fulfill some needs. What are these needs of the society? Thereupon: are there ways of influencing these driving forces, and other ways of satisfying these needs (cf. Identification Transformation processes)?

Less abstract research questions concern, among other things: Where do environmental investments take place? Which are the factors determining the implementation of eco-efficiency? It seems to be that 'green' investment is intertwined with other innovations, but how? A better understanding of the decisions, or even better: the driving forces, behind current change in industry that affect environment, is needed for influencing or extending transformation processes. To support (long-term) policy with respect to the latter, it could be valuable to develop decision-making models that incorporate and distinguish the many criteria upon which decisions carrying environmental impacts, are made. Research is also needed on developing tools for priority setting and environmental impact evaluation and on comparing different national styles of environmental management. Needless to say that not only manufacturing firms, but also services and small firms should be studied.

Network**s** *o*f **F***irms*

I*n line* wi*t*h *t*he f*orme*r, *a more specific researc*h *gap* wi*t*h *respect to* b*usiness and t*he *environment concerns t*he *net*wor*king o*f f*irms***. S***everal* k*inds o*f *net*work*s can* be *distinguis*he*d* (**RMNO**, **199**7: 34): **I***ntra-organizational net*work*s* (*relations*hi*ps* wi*th*i*n t*he *organization*), *trans-organizational net*work*s* (*relations*hi*ps* b*etwee*n *organizations in t*he *supply c*ha*in*) *and supra-organizational net*work*s* (*relations*hi*ps* wi*t*h *other organizations*)**.** **U***nderstanding t*he *motivations and dynamics o*f *lin*k*ages in and* b*etween organizations is important* b*ecause decreasing t*he *environmental impacts o*f *industrial activities re*q*uire* k*nowledge trans*fe*rs*, *learning*, *resource s*ha*ring and* h*arnessing o*f *innovative capacity***.** **A** *lot o*f wo*r*k *can* be *done on understanding t*hese *motivations and dynamics and on integrating t*heo*ries o*f *organization* wi*t*h *t*he k*nowledge a*b*out* how *organizations a*ffe*ct and are a*ffe*cted* b*y t*he*ir p*hy*sical surroundings***. I***n addition*, *more applied* q*uestions are o*f *importance*, f*or ex*a*mple*: **H**ow *to organize sustaina*ble c*hains*, *t*ha*t is* how *to integrate economic motives* - whi*c*h *are t*he *main reason* f*or firms to cooperate* - wi*t*h *environmental considerations*?

3.2.3 C*onsumption*

F*rom t*he *t*hr*ee distinguis*he*d researc*h f*ield* wi*t*hi*n* **IHDP-I**T (*see* **F***ig***. 1.1.**), *t*he **S***ystem-***A***nalytical* **P***erspectives on t*he *interaction* b*etween economy and environment*, *t*he **I***ndustrial* E*cology researc*h *and* C*onsumption*, *t*he *latter is t*he *least explored topic***.** G*iven t*hi*s* f*act and t*he *importance o*f *consumption in t*he *area* **IHDP-I**T - *consumption* ha*s signi*fi*cant direct e*ffe*cts on t*he *environment and is*, *as part o*f *t*he *economic system*, *inter*twi*ned* wi*t*h (*or mirroring*) *production* -, *consumption* ha*s* b*een identified as t*he *l*a*rgest researc*h *gap* wi*t*hi*n* **IHDP-I**T**.** T*o* b*e more precise*, *t*he *researc*h *needed to* b*e done concerns environmental consumption***.** E*nvironmental consumption can* be *de*fi*ned* f*ollowing t*he (*preliminary*) *de*fi*nition* b*y* **S***tern* (**N***ational* **R***esearc*h C*ouncil*, **199**7: 20):

> C*onsumption consists o*f h*uman and* h*uman-induced trans*fo*rmations o*f *materials and energy***.** C*onsumption is environmentally important to t*he e*xtent t*ha*t it ma*kes *materials or energy less availa*ble f*or f*uture use*, *moves a* b*iophysical system toward a di*ffe*rent state or*, *t*hrou*gh its e*ffe*cts on t*hose *systems*, *t*hr*eatens* h*uman* he*alt*h, w*elfare*, *or o*the*r t*hi*ngs people value*[9]**.**

[9] **O***ne o*f *t*he b*enefits o*f *t*hi*s de*fi*nition is t*ha*t it spea*ks o*f ‘*t*he *environmental impact o*f h*uman c*hoi*ces*’ *ra*the*r t*han ‘*environmental impacts o*f *consumption*’**.** T*he latter seems to* b*e a redundancy*, *narrowing*

Most disciplines have their own theories and views on consumption and tend to emphasize (or reduce the topic to) a particular aspect of it. Consequently, social science, in general, still lacks a well-established general theory of consumption. **A**n interdisciplinary approach to consumption could bring the understanding of the role consumption plays in changing economic activities towards sustainability, a step further. Work that has been done on the relation between environment and consumption so far concerns, for example the effects of prices and other economic signals, dematerialization and decarbonization, shifting from linear to cyclic patterns of wastes (industrial ecology/metabolism) and the development of indicators.

What has to be done is empirical research to identify which economic activities are most disruptive from an environmental point of view, the responsible key actors, and what the trends in consumption patterns have been. **I**n addition there is research required on the possibilities of influencing consumption patterns. **U**nderstanding the ways of how to steer consumption patterns towards a more sustainable direction requires not only research on (political and economic) instruments, and technological and economic solutions. The challenge is to go beyond this by taking behavioral forces and linkages between culture and environmental consumption into account. **A** lot of work can be done on the role of values, ethics and collective activities with respect to change consumption patterns, and the formation and evolution of lifestyles and needs / preferences in both consumers' decisions and policy.

A better view on the determinants of consumer behavior is also desirable given the importance of predicting future global demand for consumer goods, energy, water, food and other resources. **I**n particular there is still every reason to think that consumption will increase as income rises. The research questions concern, inter alia, the facts that the precise relationship between income and consumption is not clear (cf. the Environmental Kuznets curve), the development of consumer culture in developing countries is following a different trajectory from the historical path of the developed countries, and that it cannot yet be predicted how extra income will be apportioned to various goods and sectors. **M**oreover, it might be that the beneficial effect of efficiency gains acquired by environmental policy will be partially or fully compensated by their rebound effects[10] on

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the broad scope of this field.

[10] **R**ebound effects are counter productive effects on the macro, meso and micro level due to adaptive behavior on the demand side when new resource saving technologies and/or behavioral options are introduced (**H**interberger et al., **1997**).

consumer's income and behavior**.**

B*ecause consumption is an integrated part of the economic system, changing consumer* behavior *depends on many factors, and shifts in consumption patterns will have* (*unforeseen*) *consequences at all levels in the economic system.* **I***t is important to obtain an increased understanding of the structures environmentally significant consumption is embedded in.* **O**b*viously there exists a strong link between research on the understanding of these structures/ relationships and the research described under the heading identification of transformation processes* (*see section* 3.2.**1**)**.**

4. IIASA and IHDP-IT

4.1 Relevance of IHDP-IT for IIASA (general)

The *goal of* **IHDP** - *to understand the interactions between human systems and environmental systems, particularly global environmental systems, and to understand the aspects of human systems that affect those interactions - fits perfectly with the goal of* **IIASA. I***n the* **A***genda for the Third* **D***ecade* **IIASA***'s goal is described as "to conduct international and interdisciplinary scientific studies to provide timely and relevant information and options, addressing critical issues of global environmental, economic, and social change, for the benefit of the public, the scientific community, and national and international institutions*" (**IIASA**, **1991**: *i*)**.** T*o these ends,* **IIASA** *will focus on three central research themes*:

- G*lobal* E*nvironmental* Ch*ange*
- G*lobal* E*conomic and* Te*chnological* T*ransitions*
- **S***ystems* **M***ethods for* **A***nalysis of* G*lobal issues*

R*esearch on* **IHDP-I**T *is about "understanding the human drives and mechanisms that could enable a transformation of the industrial system towards sustainability, and in physical terms to decouple industrial activities from their environmental impacts*" (**V***ellinga et al.*, **1996**)**.** T*herefore, this research addresses a critical problem humankind now has to deal with, namely the global environmental degradation due to economic activities.* **F***or this reason* **IIASA** *is very appropriate to conduct research within the framework* **IHDP-I**T *since "***IIASA***'s broad range of current activities provides a strong base for addressing the critical problems of global change and the associated problems of*

human development" (**IIASA**, **1991**: 3). **M**oreover, research on **I**ndustrial Transformation has inherently a policy relevant character. **A** primary goal of **IIASA** has been "to develop insightful, policy-oriented studies and analysis relevant to critical societal issues. This methodological orientation has been successful and will be a continuing characteristic of **IIASA**'s research program" (**IIASA**, **1991**: **1**).

IIASA can benefit from the **IHDP-I**T network, since it will serve as a vehicle to generate new research activities, among other things, by means of generating possibilities for funding. **A**n **I**T project at **IIASA** could be related to the **IHDP-I**T agenda in the same way that the **IIASA** project on **L**and-**U**se and **L**and-Cover Change links to the **IGBP-IHDP** core project on **L**and **U**se Change.

4.2 Research Gaps and IIASA

In chapter 3 several research gaps in the field **IHDP-I**T were addressed and briefly described. The research questions were mainly classified in three fields: The **S**ystem **A**nalytical **P**erspective, the **I**ndustrial Ecology or **B**usiness **P**erspective and the Consumer **P**erspective.

Although **IIASA** has experience in the second field of analysis, the **I**ndustrial Ecology or **B**usiness level of analysis[11], this field is with respect to a potential contribution of **IIASA** to **IHDP-I**T the least interesting of the three. The reason is that the main research gaps in this area concern 'networking of firms' and the 'behavioral aspects of firms'. **S**ince **IIASA** has not much experience with this kind of research it is likely that it can not meet the quality level of research done by institutes and individuals who have a standing tradition in this field, for example the research conducted within the Greening of **I**ndustry network (see Groenewegen et al., **1996**).

What **IIASA** does have is an outstanding expertise on research which can be captured by the term '**S**ystem-**A**nalytical **P**erspectives' (see chapter 3). **S**ince its foundation in **19**72, **IIASA**'s research program is characterized by international, interdisciplinary research with an emphasis on this systems or top-down approach. **F**or this reason, it is argued that it is preferable that a potential role of **IIASA** in the research field **IHDP-I**T will stand in

[11] **M**ainly in the projects '**R**egional **M**aterial **B**alance **A**pproaches to **L**ong-Term **E**nvironmental **P**olicy **P**lanning' (**IND**) and '**F**uture **E**nvironments for Europe: **S**ome **I**mplications of **A**lternative **D**evelopment **P**aths'. **S**ee for the latter for example **N**orberg-**B**ohm et al. (**19**88).

line with this tradition.

But, *following the argument given in section* 3, *that the existence of strong boundaries or dividing lines is a particular justification for the development of the research field* **IHDP-IT**, *new research in this area has to overcome the traditional dividing lines.* Therefore *new system-analytical research ought to broaden the scope in the sense of integrating top-down and bottom-up approaches.*

Although *most of the research gaps at the system-analytical level of analysis are appropriate to be conducted by* **IIASA**, *an exception has to be made for the research gap with respect to* **Mass Balance Research.** The *main challenge in this research area consists of linking the* **SFA** *and* **MFA** *with societal and spatial aspects, for example by means of integrating macro-economic modeling with substance flow modeling.* **However**, *there is not a real challenge for* **IIASA** *on this topic because a lot of work is being and will be done by other institutes like the Wuppertal* **Institute** *and the* **SENSE Research School**[12]**.** **As** *argued in section* 3, *the consumer side of transforming the economic system towards sustainability is relatively unexplored.* **Also** *in this area new research in this field has to overcome the traditional dividing lines, though research on (sustainable) consumption used to start with individuals in society, for example by conducting case studies.* The *challenge here would be to link analysis of micro behavior with aggregate patterns of consumption.*

Having *said all this, still a choice has to be made on the research* **IIASA** *could focus on within framework* **IHDP-IT**, *for the next few years.* **In** *line with the above it can be argued that the emphasis should be on a system approach, that is, to analyze more aggregate patterns of production and consumption and simultaneously considering the challenge of overcoming the boundary between top-down and bottom-up approaches.* Two *fields of research are proposed here, based on the research gaps identified in section* 3:

1. T*echnology*
2. C*onsumption*

[12] **I***n particular the* **I***nstitute for* E*nvironmental* **S***tudies* (**IVM**) *of the* **V***rije* **U***niversiteit* **A***msterdam and the* C*enter of* E*nvironmental* **S***cience* (C**ML**) *of the* **L***eiden* **U***niversity.*

These research topics could form the basis for **IIASA** research on **IHDP-IT** in the future. They should not be seen as two separate activities, but as a preliminary way to organize new research activities. **A** motivation for these two topics is given below.

Technology is both an important cause of the environmentally disruptive character of the present-day economic system and a tool to contribute to move the same economic system towards sustainability. **U**nfortunately, processes of technological change in general are not well understood in social science. **I**n economics for example, technological change has been treated for a long time as '*manna* from heaven' and in many macro-economic modeling exercises nowadays, technological change is still treated as a black-box concept, though there is a growing attention to the micro aspects of technological change. **U**nderstanding transformation processes requires an understanding of processes of technological change, as this is one of the main driving forces of economic development.

Understanding processes of technological change requires an interdisciplinary approach, both theoretical (*system-analytic*) and empirical research, and an extending of existing ways of modeling in social science. **F**or these reasons '*technology*' is an interesting topic to be studied at **IIASA. M**oreover, **IIASA** has experience with research on technological development[13].

Consumption is a relatively less explored area with respect to the environmental impacts of economic activities. **I**n the research field **IHDP-IT** environmental consumption has been identified as the topic on which the most research can be done.

Consumption is an interesting topic for **IIASA** because of the experience of **IIASA** in dealing with complex and large issues, the link between this topic and the system analytical identification of transformation processes, the opportunities to overcome micro-macro boundaries in this field and the relevance for policy of this research.

In line with the set-up of the **IHDP-IT** research agenda there could be a focus on several sectors. **A**t this stage the sectors transport and energy are chosen for several reasons:

- transport and energy are interrelated,
- policy is important in both fields,

[13] **F**or example within the ECS and TED projects. **S**ee also **F**oray and Grübler (**1997**) for a general overview on Technology and the Environment.

- both have been studied at **IIASA** in the ECS project,
- environmental or sustainable consumption is strongly related to consumption of energy and mobility/transport is a current and exemplary problem of 'lock-in' effects,
- both sectors are important with respect to the identification of transformation processes, and therefore important in understanding the transformation of society towards sustainability.

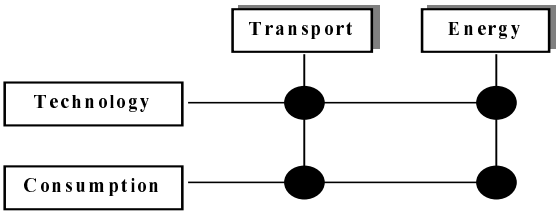

Fig 4.1. **P**reliminary proposal for **IIASA** research on **IHDP-I**T

4.3 Technology

As said above, processes of technological change in general are not well understood in social science. **I**t was argued that this is also the case in economics though since the **19**70s more attention is given to micro aspects of technological change[14]. **A**n exception however in this generalized view on how economic science deals with technology, is the evolutionary tradition in economics, in which much research on processes of technological change has been conducted[15].

It is valuable to extend the evolutionary approach, in which phenomena like innovation, imitation and diffusion of technology are analyzed, to 'green' technology. **S**o far, only limited but promising work has been done on the latter (cf. the work of **R**enee Kemp **M**E**RI**T/**M**aastricht **U**niversity). This area of research is promising because it can deal with questions about the emergence and distribution of cleaner technologies in society, which is obviously highly relevant in order to decouple industrial activities from their environmental impact. **A**n important feature of the evolutionary tradition, that points to the importance of this tradition for the research field **IHDP-I**T, is that it has been able to overcome the distinction between micro-behavior on innovation, imitation and

[14] **S**ince the pioneering work of **F**reeman.

[15] **F**or an overview see **N**elson (**1996**).

implementation of new technologies and aggregate patterns of technological change
I*n addition an attempt could be made to integrate more sociological and psychological approaches with traditional research on technological change in this research, in order to deal with questions about, for example, barriers to the implementation of new technologies.*

A*nother approach in doing research on the relation between technological change and sustainability is so-called* 'back-*casting*'**.** T*his means that certain future goals are defined and from that scenarios on technological development paths are derived in order to identify ways to overcome the gap between the current and the desired situation.* **A***n advantage of this* 'back-*casting*' *is that it deals with long term technological change.* W*hereas the period in policy and business in general is not longer than say* **15** *years, and mostly is only* **5** *years, these long-term scenarios deal with* 20- **5**0 *years* (*cf.* **DTO**/J*ansen*)**.** **A***n important application of this* 'back-*casting*' *can be to identify if* 'f*actor* **1**0' *or* 'f*actor* 4' *is feasible with current technologies*? **I**f *not*, wh*at kinds of technologies are needed to achieve that goal*? **R***esearch on these questions is very relevant for the development of* (*long-term*) *technology policy.* **A***n additional challenge might be to focus not only on technology concerning the production/supply side but also on technology with direct influence on consumer/demand.*

P*ossible* **R***esearch questions*:

- **H**ow *do energy technologies emerge and evolve in society*?
- Wh*at are the processes of innovation, imitation and diffusion of* '*green*' *technologies in the energy sector*? Wh*at is the relation between investment in* **R&D** *in general,* **R&D** *on cleaner technologies, and the emergence of* '*green*' *technologies*?
- Wh*ich companies invest in* **R&D** *on cleaner technologies*, wh*at are the decision criteria*?
- **A***re there different patterns in decision processes concerning investment in* '*green*' *technologies, and if so*: wh*y is that*?
- T*o what extent can technology be used in policies to reduce* C**O**2 *emissions from the transport sector*?
- **I***s factor* **1**0 *or* 4 f*easible with current technologies and if not*, wh*at kinds of technologies are needed to achieve that goal*?

4.4 Consumption

I*n section* 3, *environmental consumption* w*as identified as t*he *largest researc*h *gap* wi*thin* **IHDP-IT. IIASA**-*researc*h *on t*his *topic could consist o*f *empirical analysis*, *investigation o*f *t*he *more* '*soft*' *side o*f *consumption and t*he *role o*f *environmental consumption in t*he *identification o*f *transformation processes***. A***ctual researc*h *can* f*ocus on one o*f *t*hese *t*hree *su*bj*ects or on an integration o*f *it***.**

E*mpirical analysis*

F*ollowing t*he **N***ational* **R***esearc*h C*ouncil* (**199**7), *empirical analysis can* be *done in* 4 *classes*:

- Wh*ic*h h*uman activities are t*he *signi*f*icant environmental disrupters*? **H**ow *environmentally signi*f*icant is eac*h *activity*, *and in* wh*at* w*ays is it destructive*? Wh*at* h*ave* b*een t*he *trends o*f *t*hese *activities over time*, *and* how *may tec*h*nological c*h*ange and o*t*her* f*orces a*ffe*ct t*h*ose trends in t*he f*uture*?
- Wh*o are t*he k*ey actors responsi*ble f*or *t*he *environmental disruptive activities*? Wh*ic*h *o*f *t*h*eir actions are t*he *important ones*?
- Wh*at* f*orces cause or explain environmentally disruptive actions*?
- **H**ow *can environmentally disruptive actions* be c*hanged*?

T*he empirical contri*b*utions in t*he f*ield o*f *integrated ecological economics are mostly presented in t*he f*orm o*f *case studies*, *patterns on individual pollutants*, *materials and energy***.** G*eneralizations on t*he *interrelations* b*etween t*he *ecological and t*he *economic systems are normally dra*w*n upon a num*b*er o*f *individual case studies*, *a practice* wh*ic*h *recently* h*as* b*een* f*ormalized in t*he f*orm o*f *meta-analysis***. M***eta-analysis can* b*e use*f*ul to gain insig*h*t in aggregate patterns o*f *consumption*, b*ased on availa*ble *case studies*[16]**.**

H*uman driving* f*orces o*f *consumption*

I*n order to e*ffe*ct positive c*h*ange in environmentally signi*f*icant consumption*, *it is re*q*uired to go* b*eyond analyzing tec*h*nological and economic* '*solutions*' b*y means o*f *considering* q*uestions* wi*th respect to* beh*avioral* f*orces driving* h*uman consumption* (**N***ational* **R***esearc*h C*ouncil*, **199**7: 37)**.** T*o capture t*he *latter*, *researc*h *needs to* b*e done on t*he h*uman* f*orces causing or explaining environmentally disruptive actions*, *lin*k*ages* b*etween culture*, *consumption and t*he *natural environment*, *and mere sociological and*/*or*

[16] T*he so-called* '**MAS**TE**RPOIN**T' *at t*he **F***ree* **U***niversity o*f **A***msterdam* w*ill in t*he f*uture serve as a central researc*h f*ramewor*k f*or meta-analysis***.**

psychological aspects of consumption.

A *promising research direction here is to integrate results of sociology and cognitive and social psychology in economics*[17]**.** **S***uch research is new*[18]*, interdisciplinary, steps outside established* '*schools*' *of research*[19]*, and promises to bring the understanding of the demand-side of the economic system further.* The *mentioned integration is to be reached, inter alia, by means of dealing with understanding the formation and evolution of lifestyles and needs/preferences and the social endogeneity of preferences: lifestyles, status etc*[20]**.** The *evolutionary tradition in economics seems to be very appropriate to deal with this kind of research*[21]**.**

S*ustainable Consumption and nature of transformation processes /interdependencies*
The *third topic for potential* **IIASA** *research on environmental consumption emphasizes environmental consumption in the presence of the identified complexities of transformation processes.* **R***esearch here could give attention, for example, to lock-in effects, interdependencies, multi-dimensionality of (policy) decisions and complex interactions in society.* **I***t will be important to establish the correct relationships between the meso-level of industrial sectors, the micro-level of individual consumers and the macro-level at which the beneficial effect of efficiency gains spurred by environmental policy may be partially compensated by their rebound effects on consumers income and behavior* (**H***interberger et al.*, **1997**:**17**)**.**

P*ossible* **R***esearch Questions*

- Wh*at is the precise relationship between increasing incomes and consumption*? **H**ow w*ill extra income be apportioned to various goods or sectors*? C*an we extrapolate existing trends*?
- **S***eeing consumption as an activity mirroring production*, wh*at is the interrelation of*

[17] **S***ee* **A***versi et al.* (**1997**) f*or an original and pioneering attempt.*
[18] Th*ough some of the ideas were already raised two decades ago, see* **S***citovsky*, **1976**/**1992.**
[19] **I***t criticizes the standard utility theory and the associated theory of decision making as the foundation of a descriptive theory of demand* (*see also* K*irman*, **1989**)**.**
[20] **I***n line with earlier work of, for example*, **P.** E*arl* (**1983**, **1986**)**.**
[21] **A***ctually, the pioneering work in this field stems from this tradition.* **I***n addition to the research on technological change they started recently with efforts to combine behavioral processes of choice and their social embeddedness* (*constructive microtheories in a* "**S***imonesque*" *or* "**V***eblenesque*" *spirit*) *with statistically approaches* (*abstract/generalized theories*; *cf.* **H***ildenbrand* (**1994**) f*or new statistically analysis of demand patterns*), *in order to generate stylized properties of aggregate demand profiles.* T*hey take for example routines, constructed preferences, bounded rationality at the consumer level,* "*preference learning*" *and innovation in presence of growing incomes, and path dependency of*

both- beyond mere price adaptation? That is what is the role of endogenous preferences, institutions, life-styles, marketing etc?

- What are the linkages between energy-use patterns and the patterned consumption of other goods and services?
- Research on the social patterning of transportation and gasoline consumption
- Investigating the ways work, employment, leisure activities and consumption are interrelated
- Whether increases in materials efficiency can keep pace with, or even triumph over, the forces driving increased consumption
- Research on the social endogeneity of preferences in order of investigating ways to influence consumption patterns. What can we say about the social embeddedness of consumption, the existence of routines and the ways preference evolve in society?

4.5 IHDP-IT and Existing Research at IIASA

The proposed research topics could form the basis for **IIASA**-research within the framework **IHDP-I**T for the next few years. The above described research outlines can be elaborated to one or two new research projects. **A** new research project might focus on technology or consumption or an integration of both.

Another option is to integrate the proposed research outlines with existing **IIASA** research projects. The most obvious projects for including **IHDP-I**T research activities are EC**S** and TE**D. A**s indicated in section 3 and 4, much research within **IHDP-I**T is linked to current research activities conducted in these projects.

Taking an **I**T-perspective, within the EC**S** project complementing work might be done on energy consumption, energy technology, scenario-building and more specific questions concerning the sectors transportation and energy. The TE**D** project might deal with research on the innovation, imitation and diffusion of 'green' technologies, the integration of social and psychological approaches in economics (for example, evolution of preferences, the social embeddedeness of consumption patterns), and empirical research on processes of technological change.

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preferences in account.

5. Practical Issues for IHDP-IT research at IIASA

Conducting **IHDP-IT** *research at* **IIASA**, *implies in addition to the selection of the research questions the involvement of external persons and organizations.* Ch*aracteristic for* **IIASA** *research is the collaboration with outstanding researchers, some of them staying for a longer or shorter period at* **IIASA. N***ext to* **IHDP**, *several organizations are relevant with respect to* **IHDP-IT** *research at* **IIASA** *for their experience in a certain field.* **B***elow, some organizations and persons with which* **IIASA** *potentially can collaborate in* **IHDP-IT R***esearch are listed.* **M***ost of these persons and organizations are already involved in the preparing activities on* **IHDP-IT. N***eedless to say that the following gives only a preliminary indication and does not pretend to include or exclude persons and/or organizations.*

5.1 Organizations to Collaborate with

Center for the Integrated Study of the Human Dimensions of GEC	**USA** – *Carnegie Mellon*
SENSE *Research School*	The *Netherlands*
TATA *Energy Research Institute*	*India*
Wuppertal Institute	*Germany*
SPRU *Sussex*	*England*
Institute for Social Studies (**ISS**)	The *Netherlands*
Greening of Industry Network	**NL / USA**
OECD	*France*
Rensslaer Polytechnic Institute	**USA**

5.2 Persons to Collaborate with

Stefan Anderberg	*Institute of Geography Copenhagen*/ **IHDP**	**DEN**
Frans Berkhout	**SPRU** *University of Sussex*	UK
Cuttler Cleveland	*Boston University*	**USA**
Faye Duchin	*Rensslaer Polytechnic Institute*	**USA**
Paul Ekins	*Keele University*	UK
Sylvie Faucheux	*University Versailles*	**FRA**
Sukehiro Gotoh	*National Institute for Environmental Studies*	**JAP**
Fritz Hinterberger	*Wuppertal Institute*	GER
Marcella Ohira	*Inter American Institute for Global change Research* (**IAI**)	**BRASIL**
Hans Opschoor	*Institute of Social Studies* (**ISS**)/ **IHDP**	**NL**
Rajendra Pachauri	*Tata Energy Research Institute*	**INDIA**
Charles Perrings	*University of York*	UK
Nigel Roome	*Tilburg University*	**NL**
Juliette Schor	*Tilburg University*	**NL**
Robert Socolow	*Princeton University*	**USA**
Paul Stern	*George Mason University* / **IHDP**	**USA**
Mauricio Tolmasquin	*Inter American Institute for Global change Research* (**IAI**)	**BRASIL**
Arild Underdal	*University of Oslo*/ **IHDP**	SWE
Charles Vlek	*Groningen University*	**NL**
Ernst Worell	*Utrecht University*	**NL**

Annex I Overview of Activities IHDP-IT

The **IHDP**-*steering group* h*as requested in* **N***ovem*b*er* **1995** **P***ier* **V***ellinga*, **D***irector of t*he **I***nstitute* f*or* E*nvironmental* **S***tudies* (**IVM**) *of t*he **V***rije* **U***niversiteit* **A***msterdam and* **S***cientific* **D***irector of t*he **SENS**E **R***esearch* **S***chool*, *to initiate and coordinate t*he *preparations* f*or t*he *development of an international researc*h *agenda on* **I***ndustrial* T*ransformation***.** The **V***rije* **U***niversiteit*, *t*he **N***etherlands* **A***cademy of* **S***ciences*, *t*he **N***ational* C*ommittee on* E*nvironmental* **R***esearch and t*he **IHDP**-*steering committee* h*ave provided t*he f*unds to support t*hose *activities***.** The *activities started in* **1996** w*ith t*he *development of a* **S***coping* **R***eport* (**M***arch* **1996**)**.** Th*is* **S***coping* **R***eport* w*as* b*ased on t*wo w*orkshops* h*eld at* **IVM** *and descri*b*es in an a*bstract *and preliminary* w*ay t*he **R***esearch* **F***ield* **IT.**

Wh*en t*he **SR** w*as approved* b*y t*he **IHDP** **S***teering* C*ommittee in* **M***ay* **1996**, *a small group started at t*he **I***nternational* **I***nstitute of* **A***pplied* **S***ystems* **A***nalysis* (**IIASA**) *to* work *on a inventory of researc*h b*y summarizing main ac*hi*evements and researc*h *clusters t*hat w*ould* b*e relevant f*or **IT.** Th*is document* (**D***e* **B***ruyn et al.*, **199**7) *descri*b*es t*he *researc*h *activities in t*he f*ield of* **I**T *and summarizes several* b*ackground papers* (**H***ertwic*h (**199**7), W*elc*h (**199**7), **D***e* **B***ruyn and* **A***nderberg* (**199**7), **H***interberger et al.* (**199**7))**.** Th*is* **I***nventory of* **R***esearc*h *document* w*as discussed and endorsed at an international* w*orksh*o*p on* **I**T, h*osted* b*y t*he **V***rije* **U***niversiteit*/**IVM** *on* **F***eb*r*uary* 20*t*h **1997. R***ecently*, *a revised version of t*he **I***nventory of* **R***esearc*h (**V***ellinga et al.*, **199**7) w*as f*i*nished***. I***t* h*as* b*een m*o*dified and complemented on t*he b*asis of t*he *discussions during t*h*is* w*orksh*o*p***.**

D*uring t*he **IHDP** **O***pen* **S***cience* **M***eeting* h*eld at* **IIASA** (**12**-**1**4 J*une* **199**7) *t*he *set-up of t*he **R***esearc*h **A***genda on* **I**T w*as presented and discussed during a plenary and t*wo *small group m*e*etings***.** The **M***eeting provided support* f*or developing a* **R***esearc*h **A***genda***.** **M***oreover t*he *set-up of* **R***egional* W*orksh*o*ps on* **I**T, *to* b*e organized in* E*ast*-**A***sia*, **S***out*h **A***sia*, **S***out*h-**A***merica and* **M***eso*-**A***merica*, **A***frica*, E*astern* E*urope*, W*estern* E*urope and* **USA**, w*as discussed* wi*th researc*h*ers f*rom *t*h*ese regions***. I***t* w*as decided t*h*at t*h*ese* W*orksh*o*ps* w*ill* b*e organized* b*efore* **A***pril* **1998.** The *aim of t*he *regional* w*orksh*o*ps is*:

1. T*o discuss and consider t*he e*xisting researc*h *inventory and t*he *overall goal of t*he **IHDP** *researc*h *activities*
2**.** T*o develop ideas*, *set priorities and m*a*ke proposals* f*or a researc*h *agenda on* **IHDP**-**I**T, b*oth at t*he *glo*b*al level and t*he *regional level***.**
3**.** E*xplore contri*b*utions*, *including* f*unding* f*or t*he *implementation of t*he *prioritized researc*h *activities***.**

I*n* **S***eptem*b*er* **199**7 *a* **R***esearc*h **P***lanning* C*ommittee* w*ill* b*e esta*b*lis*h*ed*, wh*o* w*ill dra*w *up a* **R***esearc*h **A***genda***. I***t is envisaged t*h*at t*h*is* C*ommittee* w*ill consist expert representatives of t*h*ree di*ff*erent f*ields*, according to t*he *tentative set up of t*he **R***esearc*h **A***genda* (*see* T*able* **1**)**.** The *goal is t*h*at t*he w*or*k *of t*he **R***esearc*h **P***lanning* C*ommittee and t*he *results of t*he **R***egional* W*orksh*o*ps* w*ill result in a* **R***esearc*h **A***genda*, *to* b*e f*i*nalized* b*y mid* **1998. I***n* **199**8 *a glo*b*al* **IHDP**-**I**T C*onference* w*ill* b*e organized to discuss t*he *implementation of t*he **R***esearc*h **A***genda***.**

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