UNESCO

UNI TWIN

GENIe

Global-problematique Education Network Initiative

CWRU GENIe

GENIe European Office

Published by:

Generalitat de Catalunya
Departament de Medi Ambient

UNIVERSITAT POLITÈCNICA DE CATALUNYA

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Contents

Chapter 1

Presentation

1. Presentation

"The challenge in bridging the gap between science and decision-making is in blending reasoning with vision".
FEDERICO MAYOR ZARAGOZA at the
International Meeting of Science Editors

The symbiotic relationship of education, science and culture –the very foundation of the UNESCO mandate– has become increasingly important at the threshold of the new millennium. The formulations of development policies which will satisfy basic human needs on the one hand and sustainability on the other in the context of globalization of the economy, resources allocation, environmental change, etc., mandates that an unprecedented number of scientific facts be taken explicitly into account when considering development policies. At the same time, legitimate aspirations and visions rooted in respective cultures play pivotal role. Hence, it is imperative that science and culture (objective and subjective aspects of reality) be blended together in responsible development policies. Education in the broadest sense is needed to equip the present and future stakeholders for that task in the new era of the complex, global society of the 21st century:

a) Decision-makers have to acquire skills to take into account explicitly what the sciences are providing at the time.
b) Scientists have to learn how to identify scientific priorities more directly responsive to policy needs.
c) The public-at-large has to understand the reality of globalization.
d) Perhaps most importantly, education is needed to prepare youth for careers and lifestyles in the 21st century.

The UNITWIN-UNESCO CHAIRS PROGRAMME was launched in 1991. Its key features are the rapid transfer of knowledge and assistance within the institutional development of higher education with a special focus on developing countries. These goals are achieved primarily through the establishment of inter-regional networks that link higher education institutions throughout the world. The program aims to give fresh impetus to the teaching scope of member institutions, bringing an end to isolation through links provided by modern communication technology, and enhancing the dynamic partnerships of academia with its social environment.

In response to these concerns, UNESCO launched **the Global-Problematique Education Network Initiative, otherwise known as GENIe**, under the leadership of Mihajlo Mesarovic, Professor of Systems Engineering and Mathematics at Case Western Reserve University in Cleveland (Ohio, USA), and Global Issues Science Advisor to UNESCO. The GENIe Program is co-directed by Narasingarao Sreenath, Associate Professor of Systems and Control Engineering at Case Western Reserve University, CWRU.

GENIe is a broad-based educational initiative primarily aimed at the following audience:

a) Decision-makers and Scientists
b) Undergraduate, Graduate College and PhD Students
c) Secondary School Students

Twelve universities from around the world were the founding members of the network in its 1st workshop held at CWRU, Cleveland, Ohio, USA in June 1996. The first and main project of the Network was and continues to be the development of a virtual, distance-learning classroom on global issues and sustainable development. All members of the network share the same teaching materials, computerized data bases, models, etc., for lecturing on global issues. A key aspect of the classroom activities is to link students from various member institutions around the world via the Internet in order to jointly develop scenarios for the global future based on knowledge assumptions and perspectives from their respective regions and then to assess these scenarios in a multi-cultural dialogue. The members of GENIe will become centers for the development of regional networks for the diffusion of globally oriented education.

The 2nd workshop of GENIe took place on 9th-13th December 1996 at the Technical University of Catalonia (Terrassa-Barcelona, Spain) and was followed by the 3rd workshop, held in Cleveland, USA (20th-24th April 1998). The most recent workshop of GENIe was once more held at the Technical University of Catalonia, in December 1998, and was organized by **GENIe's European Office**, i.e., the UNESCO Chair at UPC on Technology, Sustainable Development, Imbalances and Global Change, with the support of the Ministry of the Environment of the Government of Catalonia. Together with Mihajlo D. Mesarovic, Professor Josep Xercavins, Co-ordinator Professor of this UNESCO Chair, is the co-director of the GENIe European Office.

The GENIe European Office has also organized a wide range of activities, including the coordination of the 1st African Workshop held in Nairobi, Kenya (2nd-5th April 1999) and the 1st Latin American Workshop, which took place in Santiago del Estero, Argentina (15th-19th February 2000) with the special collaboration of CENEPP (Association for the Promotion of Rural Development). The following UPC professors also participated in these activities: Xavier Álvarez, Miquel Barceló and Juan Martínez.

Furthermore, a series of workshops entitled “Bridging the Gap between Science and Decision-Making”, is being organized. The first two workshops (Venice, Italy, 1993, and Santiago de Chile, 1995) were followed with one on the Nile River Basin (Cairo, Egypt, 1997) and one on “Climate Change: past, present and future of the Kyoto Conference” (Terrassa-Barcelona, Catalonia, Spain, 1998).

At present, as we begin 2000, the most active GENIe members have been the Professors from the following Universities around the world: David McGinnis, Iowa University (USA); Silvia Simonit, Rosario University (Argentina); Lekan Oyebande, Lagos University (Nigeria); Aston C. Chipanshi, Botswana University (Botswana); Boris Polozhintsev, Saint Petersburg State Technical University (Russia) and Chen Bocheng, Tsinghua University (China). Ali Vali and Gundo Susiarjo, PhD Students at CWRU are also key members of GENIe.

First GENIe Conference / Workshop, Case Western Reserve University Cleveland, OHIO, USA, June 24-28, 1996

Picture in front of the Adelbert Hall, CWRU

Names from left to right, rows from bottom to top.

First Row: Kyungtae Song (Japan), Andrew Cowling (United Kingdom), Juliann Mitchell (USA), Rafael Fernandez (Mexico), Mariana Fernandez (Mexico), Christina von Furstenberg (UNESCO), Lekan Oyebande (Nigeria), Bernd Hamm (Germany).

Second Row: Wei-Min Zheng (China), Ali Vali (India).

Third Row: Michael Miller (Canada), 'Sree' N. Sreenath (USA-Co-Director GENIe), Mihajlo D. Mesarovic (USA-Co-Director GENIe), Shouju Ren (China).

Fourth Row: Boris I. Polozhintsev (Russia), Josep Xercavins i Valls (Spain), G.V. Singh (India).

Last Row: Manuel de Melo Pinto Ribeiro (Portugal), Orhan Guvenen (Turkey).

Founding Members of the GENIe Network*

Candido Mendes, Candido Mendes University, Brazil
Wei-Min Zheng, Tsinghua University, China
Bernd Hamm, Universitat Trier, Germany
G.V. Singh, Jawaharlal Nehru University, India
Yasuhiko Takahara, Chiba Institute of Technology, Japan
Rafael Fernandez, National Autonomous University, Mexico
Abdellah Laouina, University Mohammed V, Morocco
Lekan Oyebande, University of Lagos, Nigeria
Manuel Pinto Ribeiro, European University, Portugal
Boris Polozhintsev, St. Petersburg State Technical University, Russia
Josep Xercavins i Valls, Polytechnical University of Catalonia, Spain
Orhan Guvenen, Bilkent University, Turkey
Narasingarao Sreenath, Case Western Reserve University, USA*

*CWRU hosts the GENIe Coordinating Center.
Drs. Mihajlo Mesarovic and Narasingarao Sreenath are Co-Directors of GENIe.

Organizers of the GENIe Secondary School Network

Art Grady, Gilmour Academy, Gates Mills, OH, USA
Michael Miller, Upper Canada College, Toronto, Ontario, Canada
Maria do Rosario Empis, St. Dominic's International School, Lisbon, Portugal

Chapter 2

"Methodology: Towards Integrated Assessments with Reasoning Support Tools"

2. "Methodology: Towards Integrated Assessments with Reasoning Support Tools"

Mihajlo D. Mesarovic, Narasingarao Sreenath,
David McGinnis, Josep Xercavins

2.1. Characteristics of Global Earth/Human Issues Systems: Uncertainty and the Goal-Seeking (or Decision-Making) Paradigm

The global earth/human issues and systems are characterized by both complexity and uncertainty. Often these characteristics are confused with one another. For instance, a simple system defined by a single equation could be highly uncertain. On the other hand, a complex system could be completely certain.

These issues and systems are full of uncertainties and risks, they are transnational in nature; they have long range impacts covering multiple generations; they concern many people on our planet; they are related to human behavior (consumption, mobility, technology, demography, etc.) but they have also its indigenous development; they are connected with almost all economic activities, etc. Clearly a number of fundamental characteristics of this issues and systems lies in the organization and function of society itself, so that a thorough analysis of decision-making mechanisms is a sine qua non. In this framework, sufficient attention to decision risks, in connection with basic uncertainties inherent in social research, related with environmental problematique is necessary.

In fact, the main characteristic of theses issues and systems is customarily described in terms of the so-called human dimension, human factor, which focuses on two sets of indicators: the impact of anthropogenic activities on the environment, e.g., the increase in greenhouse gases and resulting changes in the atmosphere and climate, etc.; and the impact of environmental change on humans, e.g., change in agricultural productivity under assumed change in the atmosphere, etc.

And so the key question is: how these two categories of indicators are related or how these two sets of indicators are connected, i.e., how the human system functions in time? This requires: a proper representation of the process of interaction between humankind as a system and the natural system; and explicit recognition of the specific and unique character of human functioning as a system.

The first aspect (the relationship of humankind with nature) is best understood in terms of the reflexivity concept (see **Figure 2.1**). Simply put, humanity is changing the environment while simultaneously being changed by it. It is a continuous feedback relationship. Humans are not outside observers of environmental change but rather are on the inside of the system being changed. This imposes a fundamental uncertainty (a limit to complete, objective knowledge or predictability). The human impact and the impact on humans cannot be considered separately but as clearly related (connected) in real-time. Understanding this reflexive, feedback configuration of the global earth/human systems is central to understanding the human role in global environmental change.

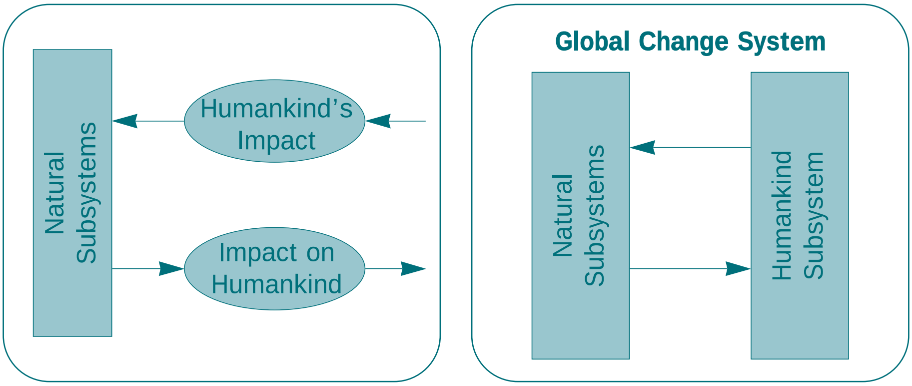

Figure 2.1: Reflexive relationship between humankind and nature

The second aspect (proper representation of the specific character of humankind and the role it plays in global environmental change) needs a paradigm different than the input/output or state transition paradigm used thus far in the study of global change. In the state transition paradigm the system is assumed to be fully describable in terms of the state of the system at a given time and the system transformation (mapping, transfer functions) of that state to another state as well as the input between two instances in time. This paradigm originated in physical sciences. To convey the true nature of such a paradigm we refer to it as the "Newtonian mechanics" paradigm. It assumes that only lack of data and knowledge prevents us from being able to fully predict the future; there is no room for uncertainty or indeterminism. The state transition (input/output, stimuli/response) view can be useful under limited circumstances in the representation of humankind as a subsystem but erroneous if overextended. Using this paradigm, models (economic, energy, integrated, etc.) are developed in terms of differential (or difference) equations with or without equilibrium processes. It has been observed that the problem with such models is not that their predictions are wrong, but that they are right most of the time except when the predictions are really needed. If the time horizon is short and "business as usual" prevails, the prediction using input/output paradigms does not go wide from the mark. It is when the change is sufficiently large and the consequences are felt over a sufficiently long period of time that the input/output paradigm breaks down.

An alternative to state transition is the goal-seeking (or decision-making) paradigm. It has its origin in biology and the study of human behavior rather than physical phenomena. More concisely, the functioning of the system in the goal-seeking paradigm is represented by two items: goal(s) of the system; and the processes which the system possesses to pursue these goals and to respond to the influences from the environment. The goal-seeking paradigm requires more items. The following are needed for representation of the system in the most general case:

- A range of alternative actions (decisions), available to the system in response to what is happening or is expected to happen in the system's environment.

- A range of uncertainties, which the system envisions as possibly affecting the success of the selected decision. The uncertainties can be due to two sources: uncertainty as to what might happen in the environment, i.e., the external input from a range of anticipated inputs; and uncertainty due to an incomplete or inaccurate view (representation, image) of what the outcome of the decision will be even if the external input is correctly anticipated. This represents the bias on the part of the goal-seeker as to how the overall system functions. For example, if the first kind of uncertainty is resolved in the sense that the environmental input is exactly as expected, the outcome can still be uncertain due to the lack of knowledge on the part of the decision system as to how the environment is going to react to the decision.

- A range of consequences (outputs) following implementation of the system's decision.

- An evaluation set ("performance scale"), used by the system to compare the results of alternative actions; i.e., given the outcomes of the two decisions, which of the two is preferable.

- The decision system's view of the environment; i.e., what is the system's understanding of the environment. In other words, what output (consequence) the system expects after a decision is implemented and the environmental influence is correctly anticipated. In reality, it is seldom, if ever, a complete and accurate reflection of the reality.

- An evaluation mapping, used to compare the outcomes of the decisions using the preference scale, and taking into account the "extent or cost of the effort".

- The tolerance function (relation) which indicates the degree of satisfaction with the outcome if a given uncertainty comes to pass. For example, if the conditions are of full certainty, the best (i.e., optimal decision) can be identified. If, however, there are several events which are anticipated the performance of the system can be allowed to deteriorate for some uncertainty, but it must stay within a tolerance limit which will ensure "survival of the system".

This paradigm accommodates concepts of "satisfactory human behavior" as opposed to the "optimization" view commonly used in economic theory, explicitly accounts for uncertainty -both true uncertainty and uncertainty under risk (usually accounted using probability theory), and tolerance (acceptability, survival, etc.).

An important role in this formulation is explicit recognition of uncertainty and the concept of tolerance (acceptability, survival). The performance can deteriorate for extreme occurrences in the environment but it can still be acceptable or satisfactory (the outcome being within tolerance limits) if "survival" of the system is assured regardless of what occurs within the range of anticipated occurrences.

Several remarks are helpful in clarifying the contrast between the two paradigms:

- The input/output paradigm is far easier to model and should be legitimately used whenever it does not result in a large distortion of reality. However, if the behavior of the system is truly purposive, i.e., goal-seeking, this might not be possible. An illustration of this can be found in the computer programs for theorem proving, chess playing and the likes. These programs are not developed in terms of state transitions but rather in terms of the so-called end-means, i.e., in terms of goals (ends) and processes (means) to pursue these goals.
- The need for a new, human-based paradigm is recognized even in well-established fields such as economics. Kenneth Arrow has recently observed "*...the very notion of what constitutes an economic theory may well change. Some economists have maintained that biological evolution is a more appropriate paradigm for economics than equilibrium models analogous to mechanics.*"

- Formalization of the goal-seeking paradigm briefly outlined above provides a basis for a deeper theory of the "human dimension" of global environmental change, as well as for other phenomena where recognition that humans are not inert physical objects (machines) is essential.

- Input/output representation appears to be simpler in the sense that it requires fewer items to be described. This, however, can be misleading. If the system is truly goal-seeking, the input/output representation depends on the range of environmental influences (inputs). Under different circumstances (different category of inputs) the input/output representation becomes different. The system appears to "switch" from one mode of behavior to another (e.g., in the so-called self-organizing systems). If the environmental change is extensive, a large number of alternative representations are needed with the system appearing to switch, in time, from one mode of behavior to another. On the other hand, if the goal-seeking representation is achievable, it remains invariant over a large range of environmental inputs.

- Goal-seeking representation requires a deeper understanding of the system and is often difficult, if not prohibitive. However, even if the input/output description(s) has to be used, the results of the analysis should be interpreted in reference to the true paradigm of the system.

Accepting the need for a reflexive and goal-seeking representation of humankind in global change, the question is how this can be realized.

One approach is to develop computer algorithms which represent the processes which the goal-seeking system uses to pursue its goal. This is within the domain of so-called artificial intelligence.

Another approach being considered at present consists of **putting the human inside the model**. Rather than simulating goal-seeking behavior by computer algorithms, the human (user) is put in the position of being an integral part of the model (a component, subsystem) representing goal-seeking (decision-making) behavior. The human is in a reflexive relationship with the computer models of the natural systems. One way to look at this is to view the human as being in a "game" type, interactive relationship with the computer algorithm parts of the model. The human/computer inter-linkage is "tight" in the sense that the computer model cannot evolve in time unless the user "simulates" the functioning of the humankind system. The architecture is that of a blended simulation/gaming process. It is not pure simulation because the computer components of the total model cannot proceed to the next step without the human's actions and it is not pure gaming in the sense that the human action is deeply imbedded in the structure of the overall system (model) –it merely represents the subjective view of humans as to how humankind responds to changes in the environment. A brief description of such an interaction in reference to time evolution is given in **Figures 2.2** and **2.3**.

In order to blend subjective (humanistic, non-numerical) aspects of the future and to avoid projection of the past into the future in a "mechanistic" fashion governed exclusively by a model, symbiotic interactive processes of scenario formulation and assessment is used in these studies. In traditional scenario analysis (**Figure 2.2**) the assumptions and policy options are selected at the beginning of the model run and the future is determined from the initial time until the end of the entire policy time horizon solely by the fixed structure of the computer model and parameters estimated from the past data trends.

Scenario Generation Using the Traditional Computer Modeling Approach

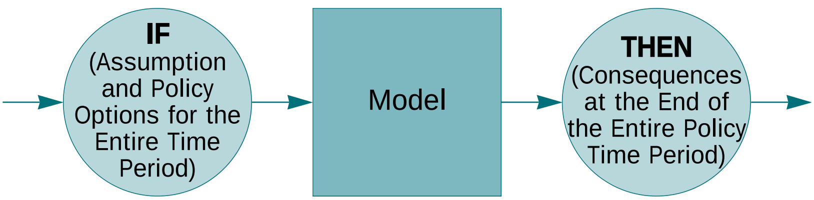

FIGURE 2.2

In the interactive process used in the policy analysis (**Figure 2.3**) the future course is outlined in time increments; the human is but a sub-model on par with the computer algorithms. The process starts with the implementation of present policies and assumptions about uncertainties over a relatively short time increment (although the long-term view is taken into account as needed in making the incremental assumptions). The computer program portion of the model generates feasible consequences of the policies and assumptions at the end of the first increment. The human then makes new policy choices and assumptions for the second time increment on the basis of the newly arrived at state of the system at the end of the first time increment. In response, the computer generates the state of the system at the end of the second time increment providing a basis for policy consideration by the human for the next time increment. The process proceeds iteratively until the end of the entire policy time horizon. Computer algorithms (models) do not predict the future in such a process but rather have the role of consistency checks to make the vision and goals of the human consistent with the facts (reality).

Implementation of such human/computer modeling goes beyond the time interactive process. The challenge of developing such symbiotic, human/computer models consists fundamentally of carefully distinguishing where human intuition and common sense, vision, views on uncertainty, etc., (subjective aspects) are needed from where the logic, numbers, and facts (objective aspects) are used for deeper computer analyses. Symbiotic human/computer modeling provides a framework to take into account non-numerical (non-measurable) aspects of reality. The omission of non-measurable aspects can lead to a major distortion of the representation.

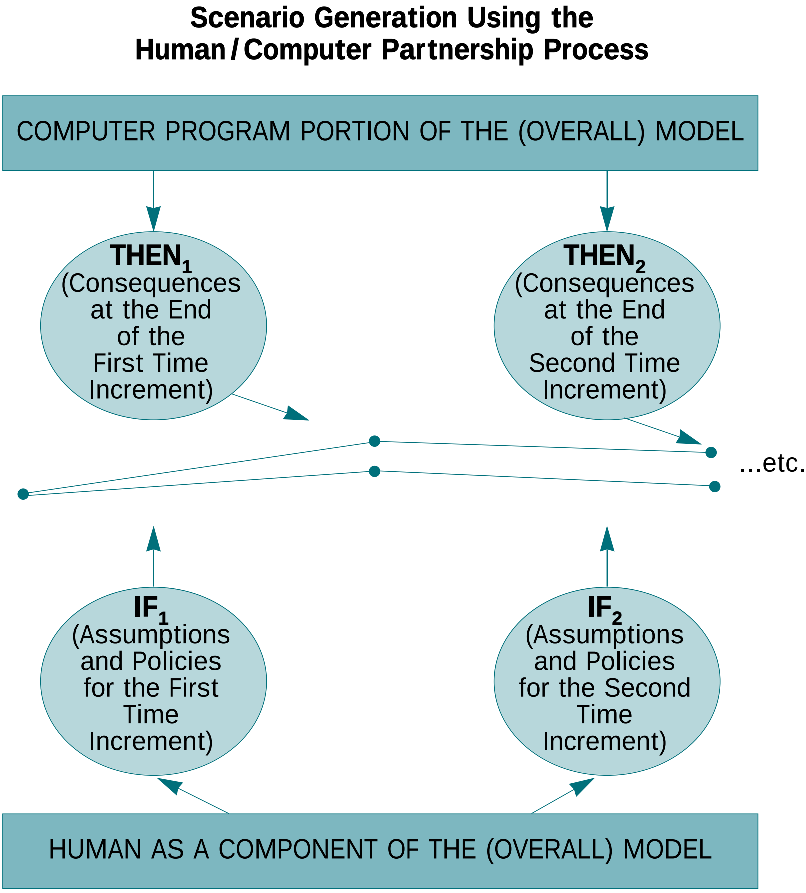

FIGURE 2.3

2.2. Characteristics of Global Earth/Human Issues and Systems: Complexity and Multilevel Hierarchy Modeling

Uncertainty and complexity are two different obstacles to understanding which should not to be confused; instead they should be addressed in different ways. Making representation of a real system more complex does not diminish the underlying uncertainty; rather it merely obscures the source of the lack of understanding.

Actually, in a number of instances a simple projection of trends is not much different than the results obtained by large input/output models. The size of the model does not improve its being true to the reality. Increasing the size of the model could be counter-productive by reducing the transparency of representation (i.e., obscuring what is really happening). This is particularly true when analysis is to result in real-life policies.

Complexity is a concept (or term) which does not have a meaning in itself but acquires its meaning only in a broader context. There is a dynamic, burgeoning, exciting new field of "complexitology" which attempts to come to grips with a general theory. The research has been criticized as accommodating too many distinct, even contradictory, views. This is a bit unfair because complexity is a derived rather than a primary concept. It can legitimately be defined in different ways within different contexts.

Global environmental change is most certainly a complex phenomenon. Understanding global environmental change requires the notion of a complex system. In this regard, the notion of a complex system in the mathematical theory of general systems is relevant. The starting point is the notion of a system as a relation among items or objects. A complex system is then defined as a relation among the systems. Items which form a complex system through interaction (i.e., subsystems) have their own recognizable boundary and existence while their behavior (functioning) is conditioned by their being integrated in the overall system. The human body is an obvious example; its parts (i.e., organs) are recognizable as such but their functioning (and even existence) is conditioned as being part of the total system, i.e., body. In our view, it is futile to argue whether this concept is a valid representation of the complexity. What is important is whether the concept can help us in addressing the challenges such as global environmental change. We argue that the concept of a complex system can be useful in that respect in two ways: in presenting a more truthful and credible representation of the global change environmental phenomenon; and in providing a framework for representation of the decision-making processes in the global environmental change.

Several additional remarks on complexity as reflected in the above notion of complex systems can help clarify the concept:

- Complexity should not be confused with unpredictability or indeterminacy ("surprising behavior"). A simple system in the sense of being faithfully described by a small set of equations can be chaotic (i.e., indeterminate) or self-organizing (i.e., have several modes of behavior) exhibiting surprising (unexpected) behavior without being complex.

- The concept of a complex system has an intimate relationship with the concept of hierarchy (another concept which can have alternative legitimate interpretations!). The behavior of a complex system, by definition, can be considered on at least two levels: the level of subsystems; and the level of the overall system. Conversely, a hierarchical system which has two or more levels can be legitimately considered as complex.

The distinction between complex and "complicated" systems is suggestive in this context. A single level, large, integrated model is "complicated". For example, some computer-based policy models takes hours, if not days, for a single run. Such models are not practical for policy analysis where uncertainty prevails and transparency is a prerequisite.

In its crudest form a complex system is viewed as having a large number of variables (items) and being characterized by the phrase, "everything depends on everything else." However, complex systems do function in nature in an orderly fashion and have functioned as so throughout human history. The Roman Empire provides an example of a system that was truly complex in view of the available means for communication and management. Yet the system functioned successfully for centuries. The statement "everything depends on everything else" indicates the breakdown state of the complex system which otherwise functions by its own internal management rules. Under normal conditions, a complex system possesses internal rules of management or behavior which allocate the responsibilities to subsystems commensurate to their information processing and decision-making capacities.

Multilevel modeling also provides a basis for time effective management and credible policy development in complex situations. Such a hierarchy for the problem of global coordination of national greenhouse gases mitigation policies is shown in **Figure 2.4**.

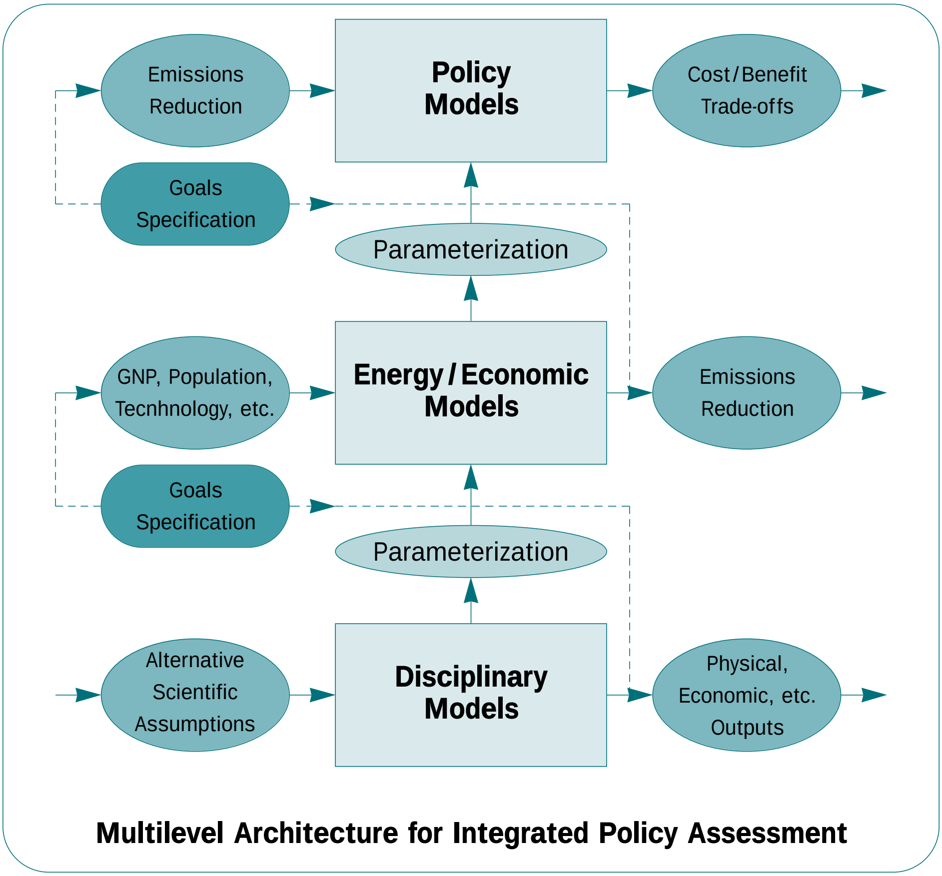

FIGURE 2.4

On the policy level, national emission targets are determined for an assumed coordination mechanism (trade in carbon rights, mitigation fund, etc.) using aggregated indicators (e.g., per unit cost of emission reduction as a function of time and volume). The emission targets are then used on a more detailed level (referred to as the system level) to identify feasible conditions to meet trade-offs on the policy level. For example, a degree of reduction of energy intensity (conservation, change in energy mix from fossil fuels to other sources, etc.). On the disciplinary models level the feasibility of these changes are evaluated. Models on higher levels are parameterized by the information from the more detailed, lower level models.

The analysis using the hierarchy of models can also be conducted from the bottom-up. Changes are assumed on the lower levels and the impact on trade-offs is evaluated on the policy level.

- The hierarchy multilevel approach to complexity should be contrasted with single discipline models. In the latter, phenomena from other disciplines are considered as externalities by translating the concepts (variables) from other disciplines in terms of the concepts of the main discipline. Systems dynamics which restrict attention to time changes is another example of "flattening" real-life hierarchy.

- The scale at which the policy makers function is different than the level of policy analysis using integrated models. The development using the hierarchical architecture of the ensemble of models helps in facing this dilemma.

2.3. Characteristics of Global Earth/Human Issues and Systems: Multidisciplinary and Multilevel versus Integrated Modeling

The need to represent phenomena from different scientific disciplines in the modeling of global earth/human issues leads to the concept of integrated modeling in which all relevant disciplines are taken into account. Early integrated models (more than twenty years ago) addressed resource/population issues while, more recently, the emphasis has been on climate change. A straightforward ("brute force") approach to integrated modeling consists of developing models in the respective disciplines and then linking them together without due regard as to how much is known about the linkages. There are serious shortcomings to such an approach which can greatly diminish the faithfulness of the constructed model. Views have been expressed that an integrated model is as good as its component sub-models. The problem of the validity of such an integrated model goes much beyond that. The key problem is in the linkage which integrates the sub-models into the overall integrated model. While the phenomena within disciplines could be modeled with a degree of confidence, linking disciplinary models is highly conjectural. The interdependence of the phenomena between different disciplines can be viewed as one of the "ultimate" challenges to science. Creating an integrated model possesses the danger of misrepresentation due to: burying the lack of knowledge deep within the model structure making it more difficult to understand what contributes to the overall (integrated) model behavior; conveying the impression of certainty where it does not exist; and resulting in fundamentally different behavior of the integrated model than the behavior of the real system in spite of the faithfulness of the sub-models. Even the simple links between well-defined, fully determinate models can lead to fundamentally different behavior.

When the sub-models are themselves complex it is not possible with any degree of certainty to know whether the resulting integrated model produces a fundamentally different behavior than observed in real life. Even a simple and weak linkage can fully destroy the faithfulness of the overall model in spite of sub-models being consistent with reality.

The important question in integrated modeling is how plausible it is that the representation will not be distorted by the linkages. This question needs careful scrutiny even in modeling of physical systems, such as in linking atmosphere and ocean models, not to mention models involving humans.

Other shortcomings of integrated climate change-focused models is that they do not provide the possibility to account for the human goal-seeking behavior. A set of numbers and fixed mapping functions are used throughout the model to represent the results of complex and uncertain individual and societal processes. A simple example is the use of elasticity's in economic modeling to represent the outcome of exceedingly complex decision processes. A small set of numbers (values of elasticity's) stand for the reaction of individuals and societies to change (e.g., energy consumption relative to prices). Although the elasticity relationships are empirically established from the past data, their validity over future time horizons depends on human decisions (individual and societal) yet to be made. Justification for relying on elasticity's to encapsulate human behavior depends on the time horizon, magnitude, rate and character of change.

An alternative to integrated modeling by the "hard wired" linking of computer programs is the multilevel integrated modeling approach which consists of four steps:

- Development of a multilevel, conceptual framework which will indicate the relative position (role) of the disciplines and indicate the linkages needed.
- Construction of the models within the disciplines represented.
- Linkage of the disciplinary models using either coded links where the available knowledge is justified or via the user where the links are conjectural or have to be carefully monitored.
- Development of a goal-seeking framework to incorporate the human inside the model.

A multilevel framework currently being used to research cybernetics of global change is shown in **Figure 2.5**. The highest level represents the individual's perspective (needs, values, etc.) The next, so-called societal (or group) level represents formal and informal organizations in reference to the problem domain for which the model is built. The central level encompasses economics and demography (an "accounting" view). Underneath this level is the representation in physical terms, i.e., in terms of mass transfer and energy flows (metabolism). At the very bottom, there is the level of natural, ecological/environmental processes.

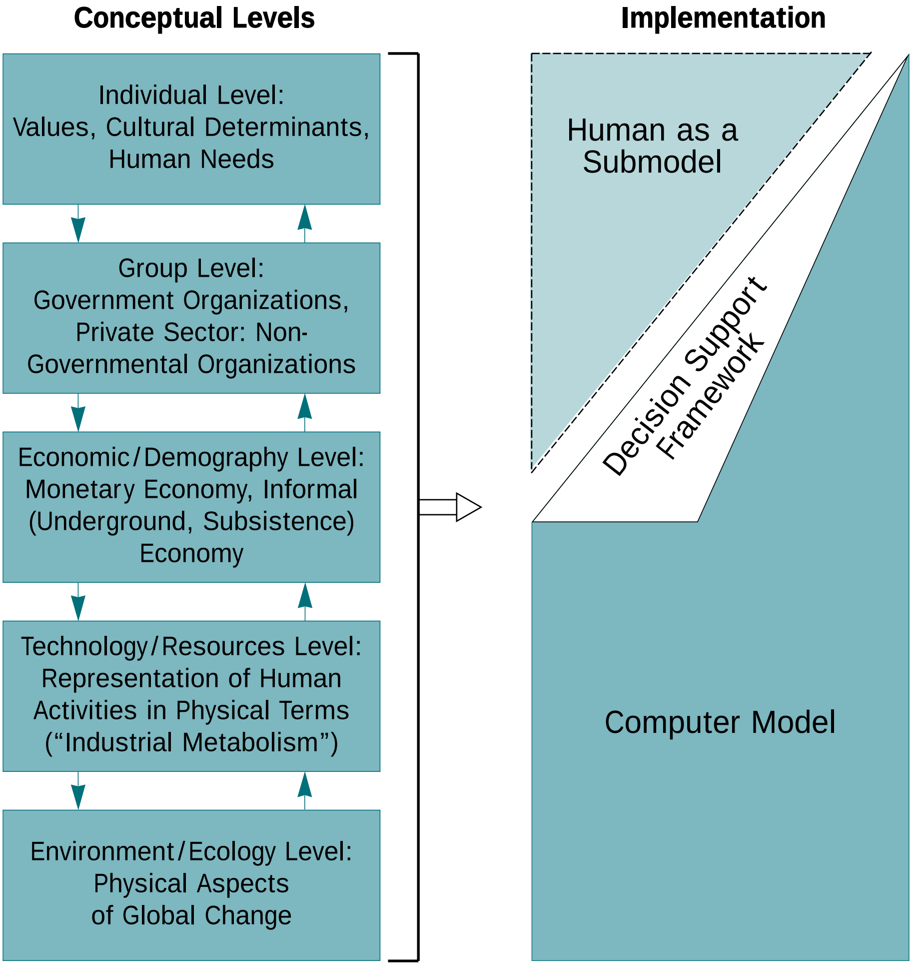

FIGURE 2.5

After these two last sections several remarks should be made in reference to the multilevel framework:

- The architecture shown in the last figure is only one of several possible alternatives. Important to the approach is not whether the structure shown in Figure 2.5 is the right one, but rather that a multilevel structure should be constructed as the first step in integrated modeling of complex systems.

- The multilevel architecture provides the basis for including the human inside the model. First, the linkages between and within levels which are uncertain are controlled by the human who can experiment with alternatives to establish the most plausible relationships under the circumstances. Second, the human represents (simulates) the appropriate functions on the levels where the goal-seeking paradigm is called for. In particular, functioning on the higher levels is not amenable to state transition modeling and the human takes on the role of a sub-model.

- Using the multilevel approach helps avoid the misdirected efforts to model various phenomena which do not fit the state transition paradigm. The best examples, perhaps, were the attempts to model political processes which lead to the most implausible conclusions. Actually, only phenomena which are modelable by state transition should be modeled as such. All uncertain phenomena or processes which cannot be modeled numerically should not be included in the state transition type of models.

So we can conclude that the multilevel approach helps in the management of multidisciplinariety. Integrated modeling leads to ever more complex models for two reasons: first, by linking already large disciplinary models; and, secondly, in order to resolve uncertainty an increasing number of details are introduced in the models.

2.3.1. Deconstruction of a System and Hierarchical Representation

An example of hierarchical representation of a multidisciplinary complex system that can be deconstructed into sub-systems is given in Figure 2.6. Starting at the top left hand corner and proceeding anti-clockwise, a gradual deconstruction process is given. A simple representation of the globe in the top left hand corner divides it into living (biosphere) and non-living sphere. Below this is the representation wherein the biosphere is further divided into non-human species sphere and non-living sphere. Together this is called Nature sphere. In the final representation in the right hand portion of **Figure 2.6**, the human sphere is further deconstructed into representation with hierarchies. In general the subsystems at the top in a hierarchical representation provide constraints through the downward directed arrows, whereas the upward arrows from the subsystems at the lower levels provide performance specification to their upper level. Other examples of such hierarchical stratification is given in **Figure 2.7**.

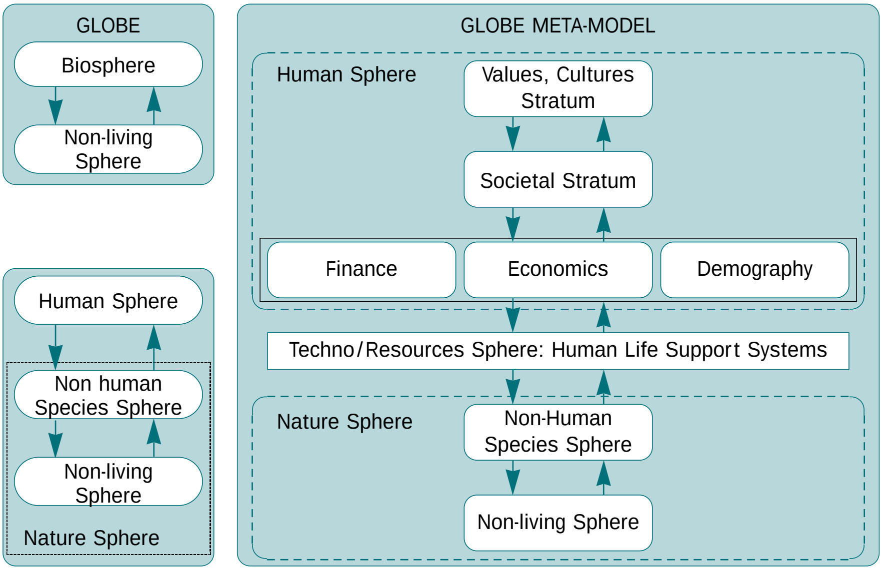

FIGURE 2.6: DECONSTRUCTION OF THE GLOBAL SYSTEM

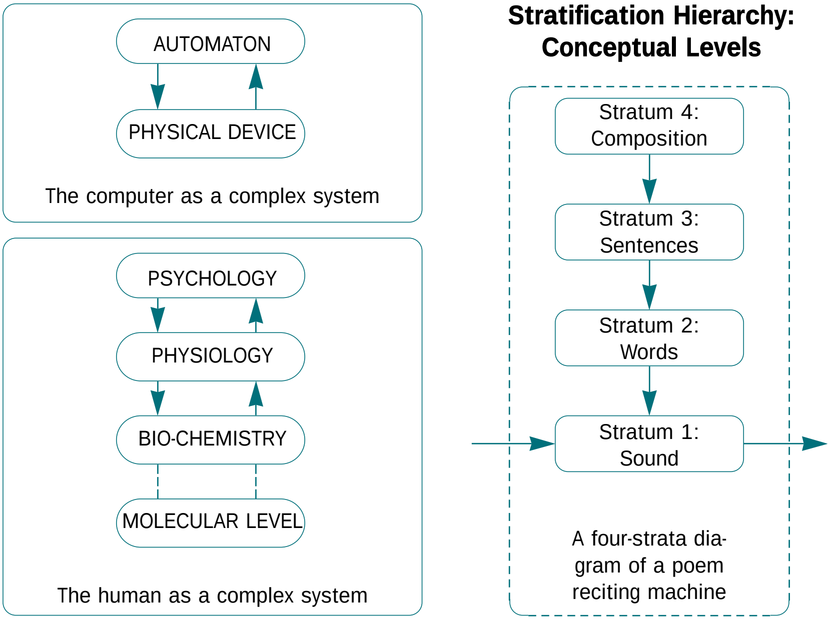

FIGURE 2.7: OTHER EXAMPLES OF HIERARCHICAL REPRESENTATION

2.4. Integrated Assessment as a Process

The concept of integrated assessment is then introduced in recognition of the less than reliable forecast capabilities of integrating modeling. Although, in general, integrated assessment is not identified with integrated modeling, in practice, integrated assessment very often turns out to be the development of an integrated model followed by sensitivity analysis.

From the cybernetic viewpoint, integrated assessment is a human-based process of reasoning about the future in which all available tools and information are used in contrast to the computer-based approach, such as in integrated modeling plus sensitivity analysis. The process is akin to the decision support approach used in management science and practice.

2.5. GLOBESIGHT: a Reasoning Support Tool

To research integrated assessment as a process, a prototype of an integrated assessment support system, named GLOBESIGHT –from GLOBal forESIGHT– has been developed and used in several alternative circumstances around the GENIe (Global-problematique Education Network Initiative), and under the leadership of Professor Mihajlo D. Mesarovic. In the process that begin in understanding the past, evaluating the present and looking into different feasible futures, GLOBESIGHT, playing a role of a “consultant”, requires the human to represent the subjective and qualitative aspects of the issue at hand whereas known data, procedures, models are inherent in it. Historical data (time series), other kinds of information (i.e., textual), and a family of models (both integrated and partial) are used in the reasoning process.

The architecture of GLOBESIGHT is shown in **Figure 2.9.** GLOBESIGHT reasoning support software has been available on SUN hardware as well as PC hardware for a number of years. SUN Solaris and LINUX version are available. Currently only Microsoft Windows 95/98 and Windows NT are supported. The front end is based on Visual C++/Visual Basic with the back end in MS Access.

Using a time interactive, "reflexive", feedback configuration of the human and the computer, the human and the computer "walk hand in hand", step by step, along alternative, feasible, future paths. The time horizon is broken into shorter time intervals and at the end of each time interval the human reconsiders assumptions (regarding policies, as well as scientific uncertainties) and makes the necessary changes for the next time interval. The scenario which emerges in such a process is not known beforehand (i.e., at the beginning of the model run). It is the result of a symbiotic relationship between the human and the computer in which objective (numerical) and subjective (human visions) sides of the future evolution are blended. (Remember the detailed discussion of section 2.1.).

So with this reasoning tool we are able to, as a summary:

- **Blending Science with Vision:**

  To quote Federico Mayor, Director General of UNESCO, in 1995: "*The challenge in bridging the gap between science and decision-making is in blending reasoning with vision*". In other words, we want to blend objective with subjective, quantitative with qualitative, numerical with non-numerical. This means that one needs to account for scientific as well as political, sociological, and behavioral –the so called soft aspects– explicitly when considering modeling policy formulation and analysis.

- **Reasoning About the Future:**

  Foresight and insight rather than forecast (numerical prediction), is at the heart of our approach (see **Figure 2.8**). Developing foresight involves considering all possible (not probable) contingencies and developing a feel for potential futures. As one saying goes –the future is not yet determined completely since decision about the future are yet to be made. Thus, we rule out forecast as a goal. True uncertainty in parameters would not allow us to forecast. Insight, on the other hand, relates to the approach of determining or finding dominant relationships that helps in understanding and explaining away the system behavior based on experimentation of the model.

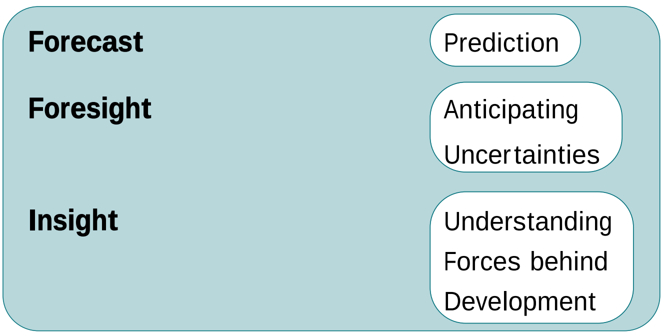

FIGURE 2.8: DIFFERENCE BETWEEN FORECAST, FORESIGHT, AND INSIGHT

The GLOBESIGHT analysis support system consists of the following modules (see again **Figure 2.9**):

- The **Information Base** contains quantitative, and verbal (or qualitative), data and information that is useful to the user for consulting during the exploration of an issue at hand. This information and data of a country/region/world takes the form of description of the geography, culture, socio-economic data and so on. The qualitative data will be helpful to the user to get a general idea about the conditions when researching specific issues in a region. The quantitative data in the form of numerical time series gives us the past and present trends in demography, economy resources, etc.

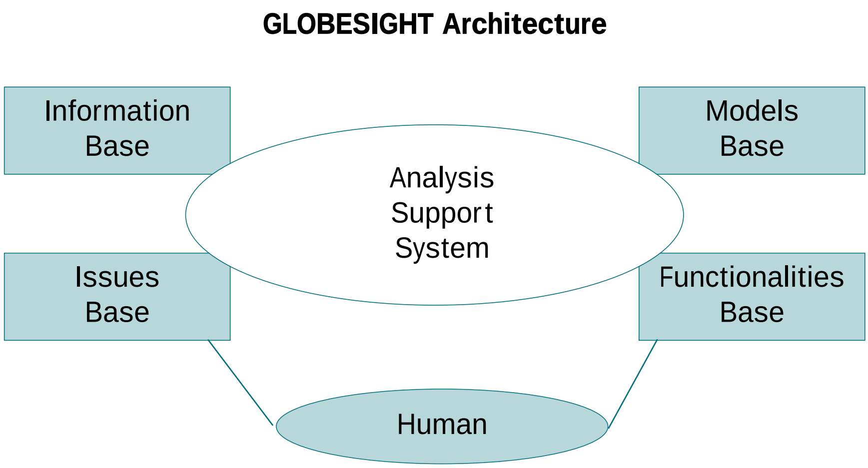

FIGURE 2.9

- The **Issues Base** is a depository of the analyses (results, as well as assumptions) already conducted for future reference, comparative evaluation and extension of analyses.

- The **Funcionalities Base** contains interactive procedures which allows the user to actively participate in the process. It deals with three tools basically (input, output, and process). Broadly input consists of data import and model management utilities. Utility exists to transfer data into and out of the database. Output formats include multi-axis graphs with an easy to use interface to change different type of plots (line, bar, stacked bar, pie, etc.). In addition a geographical information system (GIS) interface is available. Features such as rivers could be overlaid on the graphs. Standard geography views are included. Interpolation routine to shape key inputs such as rate of economic growth, etc. using multiple interpolation methods are available.

2.6. The Models Base in GLOBESIGHT

First of all we try with our models to combing scientific integrity and transparency of models:

- We model only those parts of the system where scientific data and scientific knowledge is available. This essentially means "Do not model what is not modelable." Adhering to this principle is easier said than done. Modeling is an art. Knowing what aspects of the system to model and to what depth/level is primarily driven by the requirements of the analysis and the availability of data to parameterize the system. Ability to recognize this comes with experience. The models that we use are borrowed from the literature in specific disciplines, or have basis in them. Our models can be a simple representation but have a scientific basis. Its parameters values are computed based on more complicated model runs (for example more complicated models running on supercomputer), data available through detailed analysis by credible research, and further made available in literature. In keeping with this principle we do not model the political process, expectations of the people, any behavioral aspects, values, attitudes, cultural norms, the impact of basic human physical and other needs, on society, and economy, etc. These subjective aspects accounted for by the approach labeled as "putting the human inside the model" largely explained before.

Models that we use will be reduced form models. This approach is one of the latest new trend in complex system modeling particularly for policy analysis (the "goal" in our study). Reduced form models also reflect the final audience for our approach who are from decision-making, education and the public domain. Rather than building complex models dominant relationships (sometimes key identities, e.g., kaya identity, PAT identity) having a strong interaction between variables are identified with the parameters; complexity is traded for uncertainty in parameter changes. By reduced form models we also mean models that are easier to understand and explain to decision-making staff, decision-makers or the public. This will assure that while the models are scientifically credible, the results of the models would be easy to explain. These "small" but "approximate" models are parameterized from the results of the supercomputer models. Often during rigorous scientific representation the model transparency is lost and one would require the model builder or an expert to be present to operate or use the model. This principle helps us to overcome this limitation.

Then, consequently with all the aspects seen in this chapter, we try to address these considerations, as well as the need to deal with complexity and uncertainty in a proper, differentiated manner using a multilevel hierarchical architecture and an integrated assessment approach. In the simplest terms, models for determining, for example, population evolution are developed on three levels. On the higher, policy, level assessment is made by aggregate considerations. On that level only the key factors are represented, while detailed mechanisms of how these factors evolve over time is either assumed or delegated to separate, more specific studies. On the lower level, such detailed considerations are conducted either on an integrated or sectorial basis. The result is a two-layer hierarchical structure illustrated for the global warming issue in **Figure 2.4**. The model on the higher level is parameterized by the analysis on the lower level while the results of the policy analysis on the higher level represent constraints for the assessment on the model level.

Taking population issue like another example, and the first part of the policy analysis of this study, the population model first level consists of a simple first order growth rate equation

$$pop_t = pop_{t-1} * [1 + rpop_{t-1}/100]$$

where

pop_t - population of the region in the year 't',

and

rpop - rate of population growth in percentage

In words the equation above simply states that population next year is the population this year plus change in the population represented by the growth rate times the population this year. Such a representation is not inaccurate but could be highly uncertain with all the uncertainty embodied in the growth rate.

A second level population model resolves the uncertainty somewhat by representing the births and deaths separately but statistically through the use of crude birth (crbrt) and crude death (crdth) rate –usually given in the units of per thousands of population–. Thus the second level model is represented by:

$$pop_t = pop_{t-1} + pop_{t-1} * [crbrt_{t-1} - crdth_{t-1}]$$

and the rate of population growth is computed now as

$$rpop_{t-1} = [crbrt_{t-1} - crdth_{t-1}]/10$$

The third level model tracks individual cohorts from age 1 through age 85 and age 85+, and uses fertility and mortality information.

It is very important to insist and to realize that the very simple model on the higher level is not inaccurate. Rather, it is uncertain since the change in the growth rate depends on a number of uncertain factors. However, given a growth rate profile, the model correctly outlines the population evolution. In other words, it is the uncertainty of the input rather than inaccuracy of the model structure, which is reflected on the top level. On the lower level the relationship between uncertainty and complexity changes. While complexity is increased, uncertainty still remains but it is within a reduced range. Even if the dynamics of the population on the lower level is properly represented in terms of age cohorts, the question of attitudes towards family planning and the impact of education, religion and other factors, still remain uncertain. In other words, uncertainty goes deeper and deeper and still remains there. Uncertainty cannot be removed by increasing complexity. What is achieved, however, is that the range of uncertainty is reduced and the assessment could lead to more feasible, realistic results. For example, on the higher level one can assume a dramatic population growth rate change, i.e., dropping to zero in say 10-15 years. But the analysis on the deeper level would indicate, however, the impossibility of such an assumption in view of the dynamics of the age cohort nature of the population. If the age distribution pyramid is broad-based (i.e., percentage of population of young people is much higher than that of older people), then the population growth will continue for a period of time even if family size is transformed overnight to the replacement level. This is obviously due to the fact that the number of girls at an early age range is much higher than the number of women in the reproductive age range and since these girls will move into the reproductive age cohort, the number of children will still be as high if not higher than before even if family size is reduced. This is a well-known phenomenon which has to be taken into account when making assumptions on the policy level.

The approach then is the following: using the population model on the lower level, a number of alternative scenarios regarding attitudes towards family planning are analyzed and the family of population growth rate time profiles is used as an alternative inputs to the population model on the top level. This prevents unreasonable and unsubstantiated assumptions from the higher level while still leaving enough room for uncertainty considerations. The approach taken is to focus on the policy level with additional assessment on the lower level for the assumptions that need to be better justified. Essentially, analysis has been conducted in terms of the growth rates of the relevant factors with the justification of growth rates changes provided by the analysis on the lower level.

2.6.1. About the more general Equations in our GLOBESIGHT Models

Let us return again to our "familiar" population equation.

$$popt=pop_{t-1} * [1+ rpop_{t-1}/100]$$

which in general could be formulate in the following

$$popt=pop_{t-1} * [1+rpopm_{t-1} * rpop_{t-1}/100].$$

This equation looks simple (and indeed it is) and can be grasp intuitively and easily understandable. But often we underestimated the underlying concept.

From the mathematical point of view it is an integrated equation that represents the dynamic variation on time of the variable popt. But, why is it this? Because the evolution of this variable on time depends of the initial value –the initial quantity– of this variable and then, mathematically speaking, the universal form of the description of this dynamic evolution (for all kind of phenomenaís in which the evolution on time of the variable depends on the quantity of the variable that we have initially) is an exponential law, which integrated form is the form that we are using here and in general in our models (of course if the variables that we would like to represent follow this kind of evolution).

We will use the multipliers, i.e. parameters, i.e. $rpopm_{t-1}$, in order to take into account the possible or normal variation in time of the time constant ("the rate") that define the intensity of the variation.

2.7. Scenario Analysis

Scenario analysis should accommodate a multitude of factors –conceptual (verbal), relational (models) and numerical (data)– that can be interrelated in a coherent manner. It integrates two complementary components of a comprehensive scenario analysis (the yin and the yang –see **Figure 2.10**): verbal vision scenarios (VVS –also called narrative scenarios) along with the use of models for numerical assessment (sometimes referred to as quantitative analysis). Lack of one or the other renders a scenario analysis incomplete.

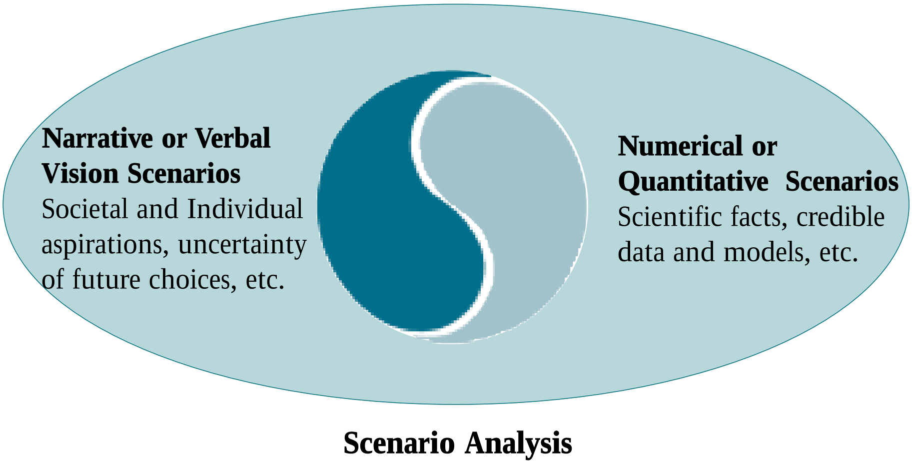

FIGURE 2.10: RELATIONSHIP BETWEEN VERBAL AND QUANTITATIVE SCENARIOS

Unless the alternative futures presented are documented as feasible (not forecasted and perhaps not necessarily even highly probable) and solidly taken into account based on scientific knowledge they will lack the required credibility. On the other hand, if they are based solely on aspects of reality which can be presented in numerical form, they will not address important –indeed, crucial– factors of society, political and individual aspirations, uncertainty of societal and individual choices that are yet to be made, future events, etc., as outlined in world vision scenarios. What is needed is an approach which is broad (general) enough, yet logically consistent indicating the "causality flows" –what depends on what, how the future evolves in time, represent feedbacks and other interdependencies, etc.

Chapter 3

UNESCO-UNITWIN GENIe

CHARTER FOR THE FOUNDATION OF THE UNESCO-UNITWIN Global-problematique Education Network Initiative: GENIe

At the workshop at Case Western Reserve University, CWRU, in Cleveland, Ohio, USA, on 24-28/06/96, **Global-Problematique Education Network Initiative, GENIe** (henceforth called the network), has been launched involving universities and other educational institutions, in agreement with the following points:

1. General Objectives

1.1. To provide students and instructors from different cultures with an opportunity to share their understanding of, and, expectations for the evolving global, interdependent, society in the 21st century.

1.2. To prepare students for professional careers and lifestyle in a global society.

1.3. To provide students and instructors with a sense of belonging in the global society and a sense of optimism and responsibility about the world of tomorrow.

2. Pedagogical Principles

2.1. A holistic view of global issues based on interdisciplinary foundations and defined as the Global Problematique.

2.2. The blending of scientific and humanistic perspectives and approaches (scientific facts and knowledge with humanistic goals and visions).

2.3. Active and cooperative learning which involves students and instructors in joint participatory exercises of critical thinking and problem-solving, both within and between universities.

2.4. The use of advances in informatics (databases, models, reasoning-support procedures, etc.) to help in our understanding of the complex phenomena of global change and exploring alternative futures.

2.5. Use of the Internet to link participants from different world regions in order to enter into a dialog, share experiences and conduct joint analyses of the conditions for sustainable development and the ways in which they can 'create a desirable future'.

3. Concrete Objectives for the Short- and Medium-Term

3.1. To organize, at each institution and in each academic year, a course, seminar or substantive part of another university course, on the subject of Global Problematique, in accordance with the general objectives and pedagogical principles of the network (henceforth referred to as GENIe course).

3.2. To use the software GLOBESIGHT (from GLOBal forESIGHT), as a common language and/or tool of the members of the network. In the GENIe course to use GLOBESIGHT as, at least, one of its 'tools and/or languages'. The course will be approximately equivalent to 3 credits (30 hours) of class and corresponding hours for practice and students work. All institutions of the network will work on at least one common issue, as a cooperative case study of the network each year, on the subject of the Global Problematique.

3.3. To communicate dynamically and actively the results of the work in the agreed upon cooperative case study of the network, in quantity and quality, to all the members of the network. INTERNET will be used as the habitual tool of the network.

4. About the Common Course: Issues, Manuals and Tutorials

4.1. Issues

The following is a list of suggested examples of issues that might be studied in the GENIe course:

- Humankind on the move
- Shift and crisis in centers of gravity
- Porosity of borders
- Sustainable development; resources; ecocapacity; biodiversity; etc. Population and demographic transition
- Climate change
- Institutions and governance in the global society.

4.2. Teachers' notes

Teachers' notes will be developed for use in the GENIe course on the Global Problematique at all GENIe participant institutions (henceforth referred to as GPIs). The notes will include:

a) The state of understanding of global issues, their causes and feasible future evolution.

b) Instructions on the use of joint information which will contain data on key global, regional, national and sub-national indicators, as well as textual information on culture, geography, societal organization, individual values and preferences, etc. Manuals describing scenario development as developed and used by the global issues assessment teaching tool (GLOBESIGHT). A tutorial which includes case studies presented in sufficient detail for easy classroom use.

c) Procedures for use of the Internet for interactive communication.

5. Long-Term Objectives

5.1. In the context of universities, education and research are two sides of the same coin. Thus in the long-term, the network must have common research objectives in the Global Problematique. GENIe will contribute positively through research capacity building in the GPIs, especially in developing countries.

5.2. Endogenize the working methods for international comparability, transparency and responsibility in dealing with global issues.

5.3. In recognizing the potential of GENIe we expect that GPIs in future will take a regional leadership role in developing GENIe sub-networks.

5.4. GENIe will actively support and encourage appropriate course development for students in education institutions prior to their enrollment at an university.

6. Organisation of the UNESCO-UNITWIN Network

6.1. The Advisory Committee will be made up of representatives selected by the Network's members.

6.2. According to the Foundation Workshop of GENIe, Mihajlo D. Mesarovic, Global Change Advisor to the Director General of UNESCO and Cady Staley Professor of Case Western Reserve University, Cleveland, Ohio, USA, is the co-ordinator of GENIe, and is authorized to sign this charter in the name of GENIe with the UNESCO.

6.3. The Network's headquarters will be located at the CWRU, Case Western Reserve University (Ohio, USA) –GENIe Co-ordination Center–, and at the UNESCO Chair on Technology, Sustainable Development, Imbalances and Global Change of UPC, Polythecnic University of Catalonia (SPAIN) –GENIe European Office–.

Annex to Chapter 3

Recognition of GENIe as UNESCO-UNITWIN Network

Excmo. Sr. D. Jaume Pagès
Rector
Universitat Politècnica de Catalunya

Re.: PROJECT

13 July 1999

Appreciate Rector and friend,

I am pleased to inform you that after the meeting held in March with Mr. Mesarovic and Mr. Xercavins, and after having carefully analysed all the activities carried out by the UNESCO Chair of Technology, Sustainable Development, Imbalances and Global Change, I have decided that the GENIe Network (Global Problematique Education Network Initiative), of which this UNESCO Chair is an integral part, will be converted into a UNITWIN Network.

I should also like to inform you that I agree with your proposals regarding:

1. That the representative of the net will be its President, Mr. Mihajlo Mesarovic.
2. That the Office of the net will be shared by the Case Western Reserve University (Cleveland, Ohio, USA) and the Technical University of Catalonia, this last one through the UNESCO Chair on Technology, Sustainable Development, Imbalances and Global Change.
3. That the European Office of GENIe, which has the support of the Ministry of the Environment of the Government of Catalonia, will have its site at the Technical University of Catalonia.

Could you please give my congratulations to Mr. Mesarovic, Mr. Xercavins and all their team for the excellent quality of the work they have done, which coincides fully with the priorities of UNESCO.

Please accept my best wishes.

Federico Mayor Zaragoza
Director General of UNESCO

Chapter 4

Collaboration Agreement for the Creation of the GENIe European Office with the Support of the Ministry of the Environment of the Government of Catalonia

COLLABORATION AGREEMENT BETWEEN THE MINISTRY OF THE ENVIRONMENT OF THE GOVERNMENT OF CATALONIA AND THE TECHNICAL UNIVERSITY OF CATALONIA FOR THE CREATION OF THE EUROPEAN OFFICE OF THE GLOBAL-PROBLEMATIQUE EDUCATION NETWORK INITIATIVE (GENIe)

Joan Ignasi Puigdollers i Nobolm, Minister of the Environment of the Government of Catalonia, acting ex officio on behalf of the Ministry of the Environment of the Government of Catalonia (hereinafter Ministry of the Environment)

AND

Jaume Pagès Fita, Rector of the Technical University of Catalonia, acting ex officio on behalf of the Technical University of Catalonia (hereinafter UPC)

HEREBY STATE

1. That the Global-Problematique Education Network Initiative (hereinafter GENIe) was set up under the auspices of the UNESCO in 1996 for the purpose of promoting knowledge and education regarding the human difficulties encountered in the emerging global society of the 21st century. This education is channeled on the one hand towards students and on the other towards both scientists and those entrusted with finding a way to bridge the gap between the two groups and enable them to work in collaboration.
2. That the Ministry of the Environment has been a member organization of GENIe since April 1997 and is interested in ensuring a greater presence for its initiatives within Europe.
3. That Case Western Reserve University (Cleveland, Ohio, USA) is the international headquarters of GENIe, but that in the light of recent developments a need is felt for a European office collaborating with the US office in general organizational tasks and in particular focusing more specifically on its European and African members.

4. That UPC currently has a UNESCO Chair of Technology, Sustainable Development, Imbalances and Global Change and that as a member of GENIe it is interested in housing the European GENIe headquarters.

In view of the above points, both parties agree to collaborate in a joint initiative as detailed in the following

CLAUSES

1. Object of the present agreement

The present agreement seeks collaboration between the Ministry of the Environment and UPC for the purpose of creating the European Office of GENIe and promoting various initiatives therein.

2. The European Office of GENIe

The European Office of GENIe (hereinafter the Office) will organize and co-ordinate a wide variety of activities towards a common goal: to ensure that the various persons, universities and institutions that make up the organization participate in the preparation and discussion of workshops and materials related to the issue of the gap between environmental policy and science.

To this end, the responsibilities of the Office will be:

- To organize a biennial general meeting for the members of GENIe.
- To coordinate activities for the European and African members and to call meetings and training sessions, prepare materials, etc.
- To work in conjunction with the Cleveland co-ordination office to identify schools eligible to be invited to join GENIe.
- To be actively involved in and support the development of a GENIe for secondary education centers.

3. Location of the Office

The Office will be located at UPC, at the UNESCO Chair of Technology, Sustainable Development, Imbalances and Global Change.

4. Directorship of the Office

Professor Mihajlo Mesarovic, Director of GENIe, and Professor Josep Xercavins, Co-ordinator of the UPC UNESCO Chair and co-founder member of GENIe, will be appointed joint Directors of the Office.

5. Annual activities of the Office

Each year, the Directors of the Office will reach an agreement with the Ministry of the Environment as to the activities of the Office.

6. Funding of Office activities

Depending on available funds and the agreements reached by the Directors of the Office with the Ministry of the Environment, an assessment will be made of the amount to be provided annually by the latter.

7. Promotion materials and other documents

In all written, graphic or audiovisual materials concerning the initiatives to be carried out according to Clause 5 above, it will be clearly stated that they were devised as part of the agreement between the Ministry of the Environment and UPC.

8. Validity

This agreement come into force on the day of its signing and has a duration of three years, implicitly extendible for periods of one year.

9. Resolution in advance

The present agreement may be resolved prior to the date of expiry in the event of the following:

1. Unfulfilment of any of the parts of any of the obligations established in this agreement.
2. Mutual accord thereto between both parties involved in the agreement.
3. Causes inherent in the current legal framework.

Both parties consent to this collaboration agreement and to this effect hereby sign the present document in triplicate in the place and on the date shown above.

Joan Ignasi Puigdollers i Noblom	**Jaume Pagès Fita**
Minister of the Environment Government of Catalonia	Rector of the Technical University of Catalonia

Chapter 5

Some GENIe Workshops “Bridging the Gap between Science and Decision-Making”

5. Some GENIe Workshops “Bridging the Gap between Science and Decision-Making”

5.1 “Integrated Assessment of Long-Term Development Prospects for River Basins” (Cairo, Egypt; 12-14 October 1998)

Objectives of the workshop

The workshop was initiated by UNESCO with the following complementary objectives:

- To assess application of the approach used in UNESCO GENIe project on bridging the gap between science and policy making for regional long-term water/population/development analysis

- To consider feasibility of developing vision scenarios of the Nile River Basin for the Water Vision Project of the World Water Commission under the auspices of the World Water Council.

The effort is envisioned to be a UNESCO GENIe and Egyptian team collaboration.

Background

About five years ago Prof. Federico Mayor, Director General of UNESCO asked Prof. Mihajlo Mesarovic to work with UNESCO to develop a program of activities aimed **at bridging the gap between science and decision-making** and more broadly to establish an educational effort for sustainable development. The following events took place:

- Prof. Mesarovic has been appointed as the Scientific Advisor on Global Change to Dr. Federico Mayor, Director General of UNESCO.

- Two workshops with participation of decision-making staff and scientists were conducted on the global climate change issue. The first workshop was in Venice (Italy) with a twelve-country participation with global coverage. The second was in Santiago (Chile) co-sponsored by the Inter-American Institute for Global Change (IAI), with 14 countries of IAI taking part.

- In 1996, Global-problematique Education Network Initiative (GENIe) was formed with Profs. Mesarovic and Sreenath as co-directors involving initially fourteen universities with global coverage. In 1998, the GENIe European Office was formed in Barcelona, Spain, sponsored by the Government of Catalonia and directed by Prof. Josep Xercavins. Global virtual classroom is one of the highlights of this effort involving students connected via Internet for multicultural, participatory scenario development and analysis.

- Prof. Sreenath has accepted to be a member of the Scenario Panel for the World Water Vision Commission formed under the auspices of the World Water Council. As part of this involvement the Mesarovic/Sreenath team has been asked to develop water vision scenario case studies as a contribution to the construction of the vision tool.

- Packard Foundation has given a two year grant to Case Western Reserve University for Profs. Mesarovic and Sreenath's effort on Population Growth, Water Scarcity and International Negotiations.

Approach

The approach used in UNESCO efforts stem from the research conducted for the second report for the Club of Rome “Mankind at the Turning Point”, published in 1974 and co-authored by Prof. Mesarovic and Eduardo Pestel. The basic approach and methodology has undergone a three generational evolution.

The basic principles of the approach are:

- Scientific Integrity
  Model only if scientific data and scientific knowledge is available. “Do not model what is not modelable.”

- Transparency
  Reduced from models for decision-making, education and the public domain.

- Focus on “Problematique”
  Holistic perspective of development.

- Participatory “Symbiotic” Reasoning Process
  Time Interactive Use of Scientific Information: “Putting human inside computer”.

A reasoning support system termed GLOBESIGHT –short for GLOBal forESIGHT– has been developed to implement the basic principles.

5.2 “Bridging the Gap between Science and Society in Decision-Making”: Climate Change; the Past, Present and Future of the Kyoto Conference (Terrassa, Spain; 18 December 1998)

Approach

The so-called greenhouse effect has come about as a result of excessive concentrations of gases in the atmosphere, mainly CO_2, originating from the burning of fossil fuels (coal, oil, gas) and resulting in an increase in the radiated energy which is reflected back from the atmosphere to the surface of the earth. Thus, the greenhouse effect leads to the global warming of the earth’s surface, giving rise to climate change and a number of related phenomena.

These effects are global in nature (for example, they are brought about wherever fossil fuels are burned, and we all suffer –or will suffer– the consequences). Finding solutions to these problems will involve decision-making on many different scales (state, nation, city, individual citizen) and science and technology also have an important contribution to make.

Organization

The main philosophical and practical aim of the UNESCO Global Problematique Education Network Initiative (GENIe) is to co-ordinate an international drive for training and education on a number of levels in the area of global issues (population, natural resources, water shortage, food, waste, climate change and others). Made up of basically of universities and a number of secondary schools from a wide range of countries (USA, Brazil, Argentina, Nigeria, Kenya, Portugal, Catalonia, Germany, Russia, China, India and Japan), GENIe also aims to bring the world of science and technology on one hand and society in general on the other closer together in the process of making the decisions which are so necessary if we are to deal with the challenges which will face us in the 21st century.

The Government of Catalonia has supported the initiative and has become its main promoter, creating the GENIe European Office, which is based at the Technical University of Catalonia (UPC) and is closely associated with the UPC UNESCO Chair on Technology, Sustainable Development, Imbalances and Global Change.

The organizers of the workshop are:

LLUÍS MIRET, JORDI HUGUET, MIQUEL RALLÓ, XAVIER RODÓ, JUAN MARTÍNEZ, JOSEP XERCAVINS
Collaborators and teachers of the UNESCO Chair on Technology, Sustainable Development, Imbalances and Global Change at UPC (Technical University of Catalonia)

ALI VALI, GUNDO SUSIARJO, NARASINGARAO SREENATH, MIHAJLO D. MESAROVIC
Collaborators and teachers of the Global Change Technology Group of Case Western Reserve University (CWRU), Cleveland, Ohio, USA

Programme

- Presentation of GENIe and the GENIe European Office
- Global Warming and Climate Change
- Can Global Atmospheric Conditions be Reversed to the Pre-industrial Revolution State?

- Kyoto (The Past, Present and Future of the Kyoto Conference) and Europe (before and after)

- Methodology for Outlining Future Scenarios of Global Warming and a Participative Exercise Involving All the Attendants

Chapter 6

First Encounter with GLOBESIGHT (GLOBal forESIGHT)

Ali M. Vali
Gundo Susiarjo
Mihajlo D. Mesarovic
Narasingarao Sreenath
Josep Xercavins

6. First Encounter with GLOBESIGHT (GLOBal forESIGHT)

Ali M. Vali, Gundo Susiarjo, Mihajlo D. Mesarovic, Narasingarao Sreenath, Josep Xercavins

From one tutorial of GLOBESIGHT, and as a preliminary "taste" of it, we are including in this publication one of the easiest examples of its uses.

6.1. Starting GLOBESIGHT

In this section you will learn how to start **GLOBESIGHT**.

Step 1: To start the population model we first load the **GLOBESIGHT**. Double click on the Globesight icon on the desktop. A Splash screen as in **Figure 6.1** will appear.

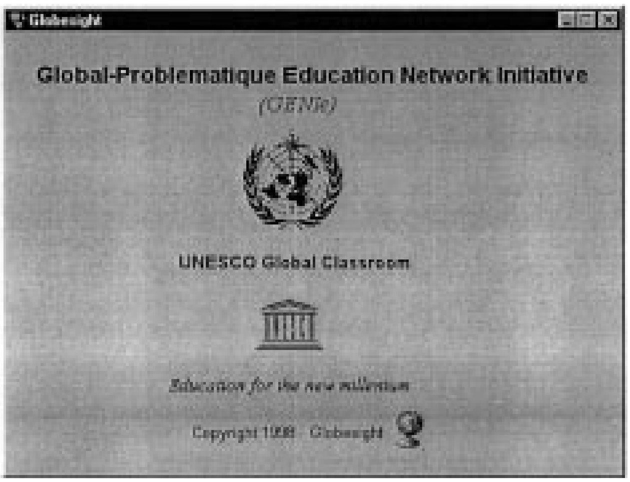

Figure 6.1: Splash Screen

Step 2: You can either close the Splash Screen window by clicking on ☒ at the top right hand corner of the window, or the window will disappear automatically after a few seconds.

You are now in the *Main* window (see **Figure 6.2**). The *Main* window is usually hidden behind the *Splash Screen* when you first open **GLOBESIGHT**.

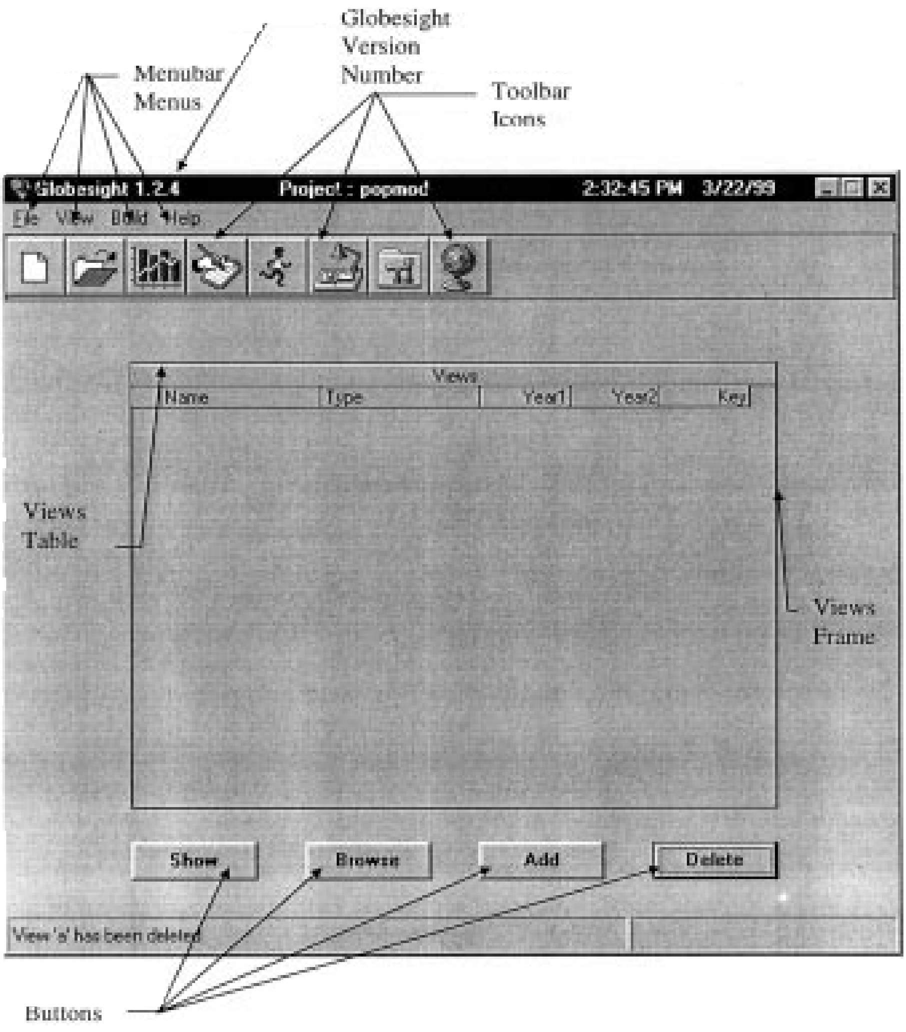

Figure 6.2: *Main* window

The *Main* window contains a menubar, a toolbar of picture buttons (icons), a table of views, and a set of buttons that manipulate the views. The complete functionality of **GLOBESIGHT** is available via the menubar; the toolbar serves as an iconic shorthand to access the menubar functionality. Observe the location of the *Menus*, *Icons*, *Table*, and *Buttons* on the *Main* window.

A description of all other icons is given in **Figure 6.3**. A subset of these icons appear in the other windows as well as in the bottom right hand corner. Clicking on any of these icons will invoke their appropriate functionality and bring forth their respective windows. Practice clicking any of the icons. Finally, from most screens you can access the *Main* window using the *Home* icon  found at the bottom right hand corner of the window.

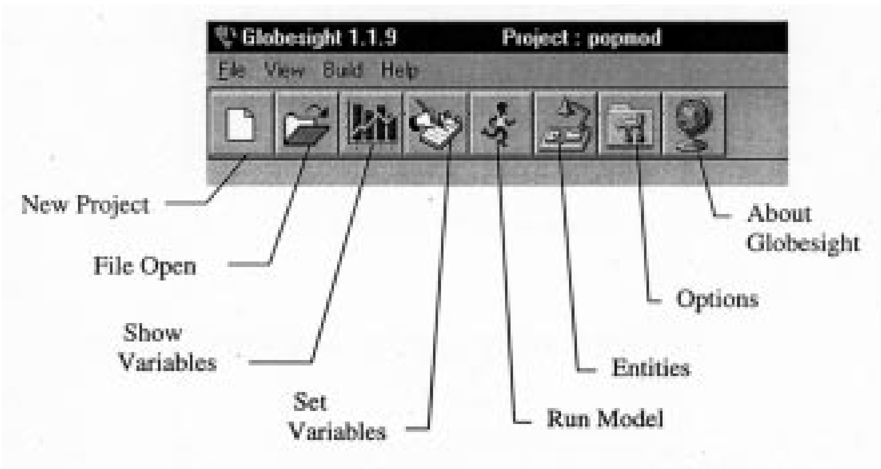

FIGURE 6.3: DESCRIPTION OF ICONS IN THE TOOLBAR

REMARK 1: In this tutorial:

(i) All references to windows, frames inside windows, and tables inside the frames used in **GLOBESIGHT** are in italics, e.g., the main window is referred to as *Main* window, the frame in *Main* window is the *Views* frame, and the table in the *Views* frame is the *Views* table.

(ii) All references to buttons are in bold, e.g., the "Show" button in the *Main* window is referred to as the **Show** button.

(iii) All menu choices in the menu are underlined, e.g., the menu choice in the *File* menu in the *Main* window is <u>Open Project</u> etc.

6.2. Working with Models and BaU Scenario

6.2.1. Population Model Summary

In the first level population model (see **Figure 6.4**) the inputs to the model are *Population First Level Rate* (*rpopf*), *Population First Level* (*popf*) at the year 1990 (this is commonly referred to as the initial condition), and *Population First Level Rate Multiplier* (*rpopfm*). Whereas all variables are loaded automatically when you initialize the model, the *rpopfm* is set to 1.0 for all year ranges indicating the data for the *Business-as-Usual* (BaU) scenario. The output of the model is the *Population First Level* (*popf*). We will use the *Show Variables* window to create a new view to plot the inputs.

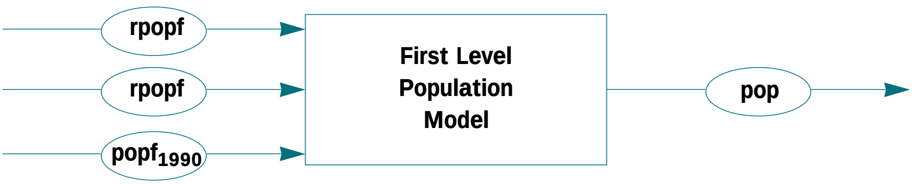

FIGURE 6.4: FIRST LEVEL POPULATION MODEL BLOCK DIAGRAM

6.2.2. Procedure for Creating Views

STEP 3: Use the scrollbar on the *Variables* table and scroll down till you see the variable *Population First Level Rate*.

STEP 4: Select the variable *Population First Level Rate* (*rpopf*) by double clicking on it. The variable *Population First Level Rate* will now appear in the Selected Variables table (see Figure 6.5). The *Subscript* 1 column contains the subscript of the first dimension of the variable *Population First Level Rate*. You will see "Egypt" since this is the first entry in the dimension Regions of the variable *Population First Level Rate*.

STEP 5: To select another subscript, first click once on "Egypt" in the *Selected Variables* table under the column *Subscript 1* and then double click again on "Egypt". A popup menu of subscripts will appear (see **Figure 6.6**). Click on *Africa* in this menu.

REMARK 2: If you made a mistake, you can clear the selections by pressing the *Clear Selections* button. This clears the entire *Selected Variables* table. Or, you can just click on the variable in *Selected Variables* table to clear it.

STEP 6: In the *Year* frame set the *First Year* to be 1990 and the *Last Year* to be 2100.

STEP 7: Select *Line* as the type of graph you want to see in the *View* frame.

STEP 8: In the *Format* frame choose *Long* in the *Names* combo box. Enter *10* for *Skip Points*. Leave the *Min* and *Max* boxes empty (this will be chosen automatically by the system unless you enter the minimum and maximum range to plot).

STEP 9: Enter a title in the *Title* entry in the *View* frame by typing *Population First Level Rate*.

STEP 10: Save the current state of the *Show Variables* window as a view by pressing the **Save** button. This will save the view with the above title in the *Main* window. Now whenever you want to view the population growth rate of Africa all you need to do is go to the *Main* window and double click on the view *Population First Level Rate*.

STEP 11: Change type of graph in the View frame to *Table*. Change *Precision* in the *Format* frame to 2. Press **Save** button and save the view. You have now saved a table view of the variable *Population First Level Rate*.

STEP 12: Press **Clear Selections** button and press **OK** on the alert window. This will clear the *Selected Variables* table. Repeat steps 1 to 8 for the variable *Population First Level Rate Multiplier* with an appropriate title for the view in step 9.

REMARK 3: To display the graph, press the **Show** button.

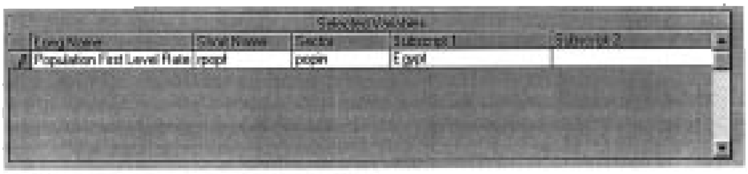

FIGURE 6.5: SELECTED VARIABLES FRAME

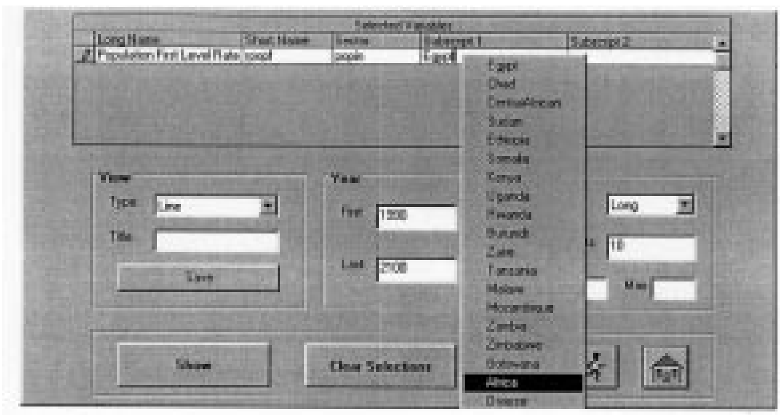

FIGURE 6.6: LIST OF SUBSCRIPTS

STEP 13: Go to the *Main* window by clicking on the *Home* icon . The *Views* Table should appear as in **Figure 6.7**. Double click on the first view (Population First Level Rate) and a table as in **Figure 6.8** should appear. Repeat this for the second view and now a graph as in **Figure 6.9** should appear. To print this graph, right click on the graph and a new window should appear as shown in Figure 6.9. Scroll down to *Export Dialog* and click on it. Another window should appear as in **Figure 6.10**, which then you should select *Printer* to print. Double click on the third view and once again you should see a graph. (Population First Level Rate Multiplier –this should be 1.0 all the way through). Print this graph too.

REMARK 4: You can also store the graphs in the *Windows Metafiles* (*.wmf) format by selecting the *File* option in the *Export Dialog*. The saved graph file would be utmost useful when developing project report documents for word-processing and presentations.

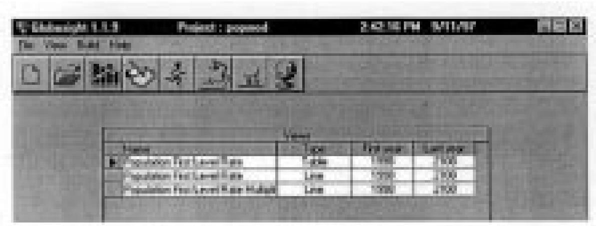

FIGURE 6.7: VIEWS TABLE

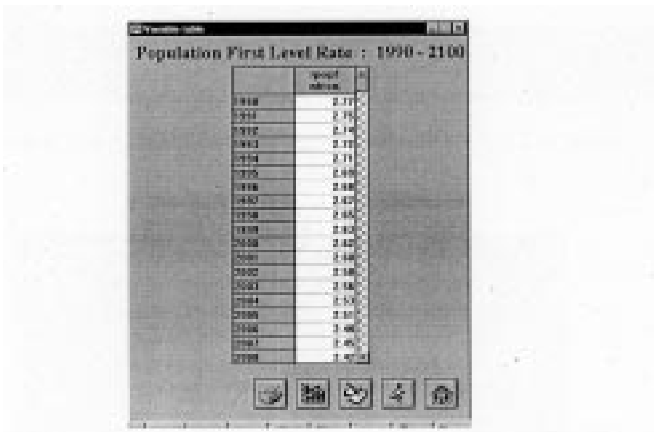

FIGURE 6.8: POPULATION FIRST LEVEL - BAU SCENARIO IN A TABLE FORMAT

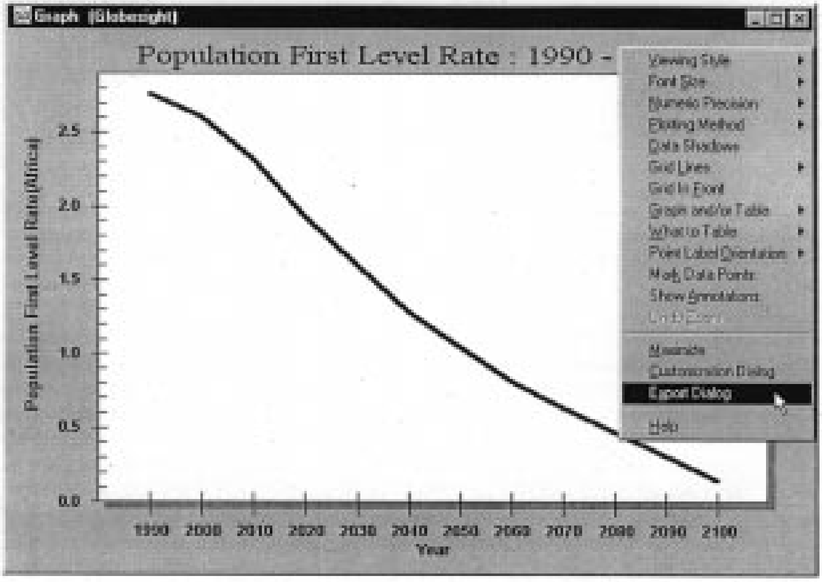

FIGURE 6.9: LINE GRAPH OF THE *VARIABLE POPULATION FIST LEVEL RATE* (*RPOPF*)

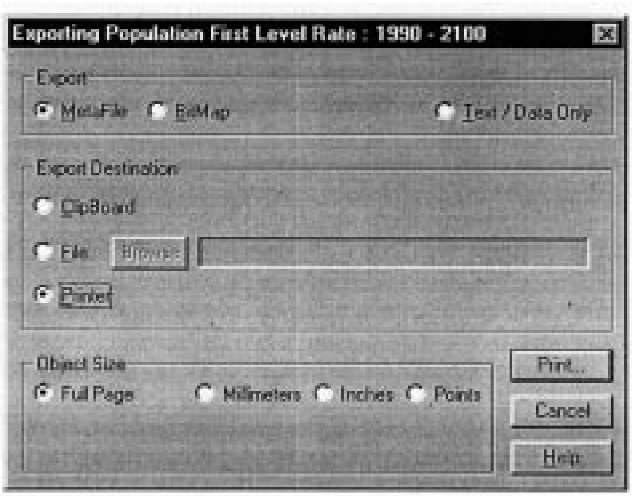

FIGURE 6.10: EXPORT DIAGOL WINDOW

6.3. Creating other Scenarios

6.3.1. Overview

In this section you will learn how to change some inputs in order to create different scenarios.

The scenario we consider demonstrates the concept of demographic transition due to the effect of (i) various explicit policies (e.g. family planning, primary education for women, etc.), and (ii) due to the side effects of various other societal changes and other policies (economic growth, consumerism, women entering workforce, etc.).

For the first level population model you will investigate the scenario wherein the population growth rate will decrease to 70% of its original value (Johns Hopkins/World Bank projection data) by the year 2100. This is implemented by changing the value of the variable *Population First Level Rate Multiplier* (*rpopfm*) from 1.0 in the year 1990 to 0.7 in the year 2100 as a straight line (linear interpolation). Notice that the *Population First Level Rate* will not decrease as a straight line. This gradually scales down the growth rate *Population First Level Rate* (*rpopf*) to 70% its original value by the year 2100, since the actual population rate will be = *rpopfd*∗ *rpopfm*. This technique is adopted so as not to destroy the BaU scenario data. Notice that setting *rpopfm* to 1.0 for all the years will result in the BaU scenario.

6.3.2. Procedure for Creating Scenarios

Now that you have backed up the business-as-usual scenario you can start creating other scenarios. To create scenarios at the first level you should change the numerical values of the variable *Population First Level Rate Multiplier* (*rpopfm*).

Step 14: Choose Set variables from the *View* menu in the *Main* window. Alternately use the *Set Variables* icon  in the toolbar.

Step 15: Scroll through the variable names in the *Variables* table, and double click on *Population First Level Rate Multiplier* (*rpopfm*). Choose *Subscript 1* in the *Selected Variables* table to be *Africa* again by double clicking on the mouse.

Step 16: Click on the *Value* frame and enter in 1 and 0.7 for the values in the First Year and Last Year boxes respectively (see **Figure 6.11**). Select the interpolation type to be linear in the *Interpolation* frame. Then click on the *Interpolate* button. This action, linearly interpolates the values of *rpopfm*, from 1 to 0.7.

Remark 5: There are other techniques for interpolation that have been implemented in **GLOBESIGHT**, that is, “constant growth rate” and “variable growth rate”.

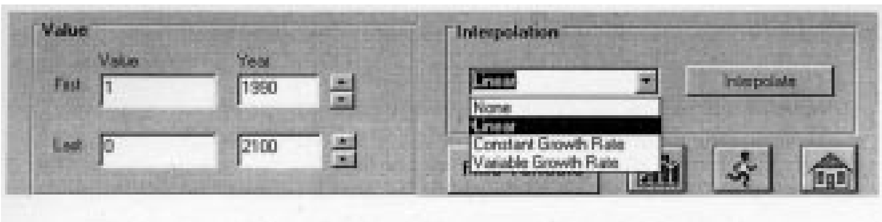

Figure 6.11: Enter data for scenario
(*Population First Level Rate Multiplier – rpopfm*)

Step 17: Now click on the Run Model icon  at the bottom right hand corner of the window. Go through the procedure of running the model as you did earlier in Section 5.

6.4. Viewing and Plotting Results

6.4.1. Overview

In this section you will compare the results of the BaU and the 70% rate reduction scenario illustrating the concept of demographic transition. You will learn to plot the time series of the variables in the model to compare these scenarios.

6.4.2. Procedure for Creating a View

The *Show Variables* window is used to define new views. To create a new view click on *Show Variables* icon  . This will open up the *Show Variables* window. The output of the model is the *Population First Level* (*popf*). We will use the Show Variables window to create a new view to plot the output.

STEP 18: Use the scrollbar on the *Variables* table and scroll down till you see the variable *Population First Level*.

STEP 19: Select the variable *Population First Level* by double clicking on the row. The variable *Population First Level* will now appear in the *Selected Variables* table (see **Figure 6.12**). The *Subscript 1* column contains the subscript of the first dimension of the variable *Population First Level*. You will see “Egypt” since this is the first entry in the first dimension *Regions* of the variable.

STEP 20: To select another subscript, first click once on “Egypt” in the *Selected Variables* table in the *Subscript 1* column. Now double click again on “Egypt” and a popup menu of subscripts will appear (see **Figure 6.13**). Click on *Africa* in this menu.

STEP 21: Repeat *Step 1* through *Step 3* for the variable *Population First Level - BaU Scenario*. If you made a mistake you can clear the selections by pressing the *Clear Selections* button. This clears the entire *Selected Variables* table.

STEP 22: In the *Year* frame set the *First Year* to be 1990 and the *Last Year* to be 2100.

STEP 23: Select *Line* as the type of graph you want to see in the *View* frame.

STEP 24: In the *Format* frame choose *Long* in the *Names* combo box. Enter *10* for *Skip Points*. Leave the *Min* and *Max* boxes empty (this will be chosen automatically by the system unless you enter the minimum and maximum range to plot).

STEP 25: Enter a title in the *View* frame by typing "Population First Level - Demographic Transition".

STEP 26: Save the current state of the *Show Variables* window as a view by pressing the *Save* button. This action will save the view with the above title in the Main window. Now whenever you want to view the population of Africa in comparison to a scenario that you have run all you need to do is go to the main window and double click on the view *Population First Level - Demographic Transition*.

REMARK 6: To display the graph, press the *Show* button. In this case you will get the graph shown on **Figure 6.14**. You can do that whether you have saved the graph or not.

STEP 27: Click on the *Home* icon  to invoke the *Main* window. Click on the view *Population First Level - Demographic Transition*. You will get **Figure 6.14**.

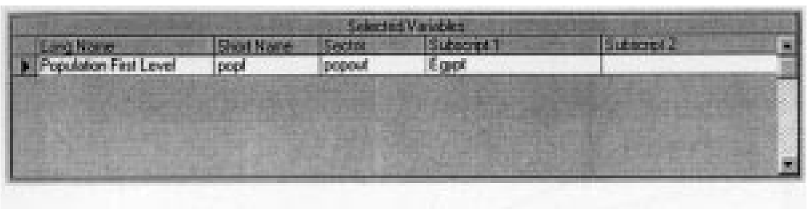

FIGURE 6.12: SELECTED VARIABLES FRAME

FIGURE 6.13: LIST OF SUBSCRIPTS

FIGURE 6.14: *POPULATION FIRST LEVEL - DEMOGRAPHIC TRANSITION VIEW*

Chapter 7

The Intranet of GENIe

UPC Computer Services,
Josep Xercavins

7. The Intranet of GENIe

UPC Computer Services, Josep Xercavins

7.1 GENIe and the UPC Computer Services

As previously mentioned, the **UNESCO UNITWIN GENIe** (Global-problematique Education Network Initiative) is a network of universities that form part of the **UNESCO-UNITWIN Program** whose fundamental objective is to provide an integrated multidisciplinary (scientific and humanistic) education, in a university context, on global issues regarding mankind and nature (population, global warming, carrying capacity, famine, poverty etc.) with a view to establishing a sustainable world.

A common element of all member groups participating in the network is the use of the same software: GLOBESIGHT (GLOBal forESIGHT), a support and graphic representation tool for setting up future scenarios for the above-mentioned global issues.

Since the beginnings of the network, the possibilities provided by ICTs (Information and Communication Technologies), especially the Internet, have been regarded as an indispensable tool. Joint work by lecturers and students including countries from all over the world is only possible in this context. Formulating questions, discussion and the final configuration of future scenarios of global issues is only possible by working online and virtually on the Internet. Physical attendance, obviously, is possible only occasionally, often only once a year.

What ultimately made the project viable for the network was the design and use of the ATENEA solution for the GENIe network.

7.2 The ATENEA Solution: The Intranets of GENIe

ATENEA is a UPC technological support for providing ICT services aimed at long-term training, communication and collaboration. Conceptually, ATENEA may be seen as a network of **digital discussion forums** in which the various virtual communities find the following integrated features: the necessary systems, instruments and tools for their educational and/or collaborative work. The Intranets of GENIe are an example of one of these digital discussion forums.

The first Intranet was designed and started up in 1998 to aid the collaborative work of lecturers and students in the UNITWIN GENIe network, with regard to the formulation, discussion and final joint configuration of future scenarios of mankind-nature global issues.

We are currently developing the Digital Campus of GENIe, a plethora of several intranets (see **Figure 7.1**; this screen explains the main features of the Digital Campus).

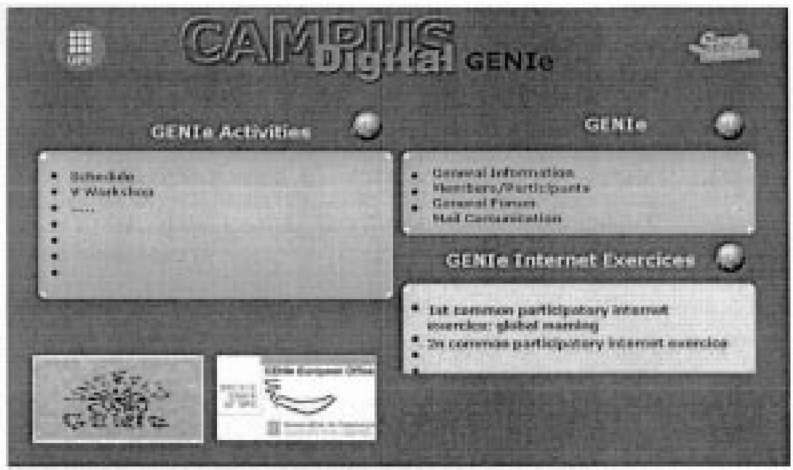

FIGURE 7.1: DIGITAL CAMPUS OF GENIE

General information about GENIe can be found in the World Wide Web site http://genie.upc.es. From there you can connect the Digital Campus of GENIe, the intranets of GENIe. Access it is only permitted by providing the **username** and **password**.

7.3. The Intranet of the First Common Participatory Internet Exercise: Global Warming

During the **FIRST JOINT PARTICIPATORY EXERCISE** future scenarios of CO2 EMISSIONS were developed in order to analyze the possible success or failure in attaining the Kyoto agreements. The first Intranet of GENIe was used as a tool of intercommunication. The main window is the gateway to different types of information. To access the links, you have to click on the icons (see **Figure 7.2**).

- **General Information**: You will find some generic information about GENIe, GLOBESIGHT, and the GENIe Internet Exercise. Only the GENIe Co-ordination Center can submit new documents to the *General Information* link.

- **Exercise's Processing**: You will find information, data, and documents about the First GENIe Common Participatory Internet Exercise on Global Warming. All GENIe participants can submit documents with text and attached files.

- **Forum**: The Forum is a common place to share ideas and point suggestions or comments among the GENIe members, including exercises and other topics of interest.

- **Mail Communication**: This is the link to the GENIe WebMail. This is most useful to announce new entries to other GENIe members.

- **Member/Participants**: It includes the list of people with access to the GENIe Intranet.

- **Previous Documents**: This area includes documents concerning old phases of the exercise.

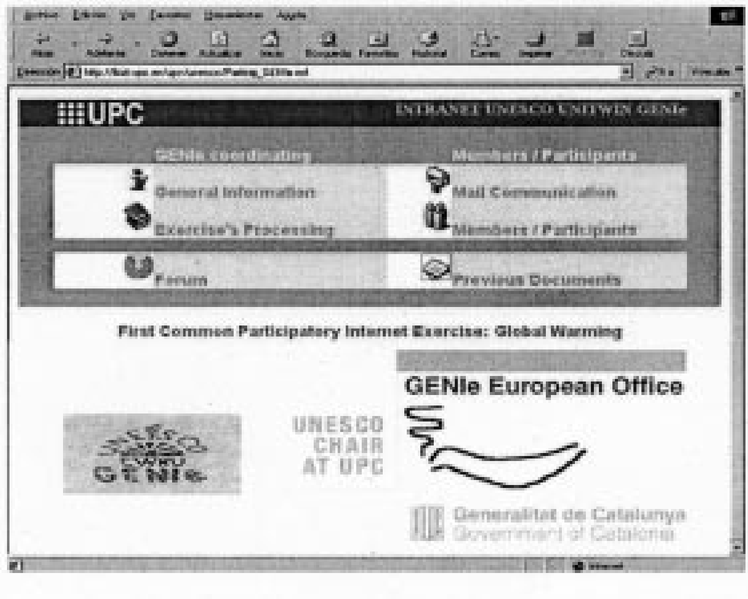

FIGURE 7.2.

Note 1: This Intranet was developed with the special collaboration of Lluís Miret and Oscar Sahun, students of the Technical University of Catalonia (UPC).