HARVESTING ONE HUNDREDFOLD

KEY CONCEPTS AND CASE STUDIES IN ENVIRONMENTAL EDUCATION

By Donella H. Meadows

United Nations Environment Programme
1989

This book is a contribution to theUNESCO-UNEP International Environmental Education Programme, Environmental Education Series

Printed by afropress ltd., P.O. Box 30502, Nairobi, Kenya

This document was scanned from the original publication in November 2004. Compilation was done by Dr. Richard Kool and Kathie Sammons at Royal Roads University, Victoria, BC Canada, with the support of Diana Wright, Publications Manager and Manager of the Donella Meadows Archives at the Sustainability Institute, Hartland, VT USA.

Table of Contents

Foreword

by

Dr. Mostafa Kamal Tolba

Executive Director of the United Nations Environment Programme (UNEP)

The traditional basics of secular education are, in the popular phrase, the three "Rs" – the keys to literacy and numeracy. In the past decade or so, the three "Rs" have been joined in many, but still not enough, classrooms and curricula by an "E" – for environment.

As a subject combining science and philosophy the environment has intellectual attraction and challenge. This is especially true for young people, curious and questioning about the how and the why of the natural world around them. In many countries, sometimes in primary classes, more frequently in secondary schools and universities, the links and balances of that natural world – animals and plants, deserts and seas, rivers and the atmosphere – are taught.

The lessons that nature is not only beautiful to the eye but economically essential and irreplaceable are beginning to take hold in the generation that will have to make decisions about both the economy and the environment in the near future. No modern generation has been better informed about the environment. To this growing sensibility and sensitivity there is now being offered a new expression of a concept with historic roots: sustainable development.

Put at its simplest, it says: if we all care for the environment it will care for us – when we put the environment first, development will last.

How best to teach that truth – how to make it an instinctive part of daily thought and action – is the question address by this book. Its particular basis is the store of information and experience accumulated by the environmental education programmes of UNEP and UNESCO.

Over the past decade they have published much that is useful, from teaching strategies to classroom material and methods. This information has reached about 12,000 educators in 140 countries, a modest beginning to what remains an enormous task.

To speed and simplify this work in the era of the search for sustainable development, the essentials of environmental education need fresh definition. A firm first step is taken by this book.

Donella Meadows, and the group which did the preliminary work, have selected and integrated key concepts of environmental education. The result is a practical primer which I warmly recommend to teachers and communicators everywhere.

All who teach and speak about the environment will find it invaluable, particularly in helping the generation that will soon be shaping economic and environmental policies how to recognize and make the decisions that reflect their crucial relationship.

If you are thinking a year ahead, sow seed.

If you are thinking ten years ahead, plant a tree.

If you are thinking one hundred years ahead, educate the people.

By sowing seed, you will harvest once.

By planting a tree, you will harvest tenfold.

By educating the people, you will harvest one hundredfold.

Anonymous Chinese poet, 400 B. C.

The abundance of immediately consumable, obviously desirable, or utterly essential resources has been sufficient until now to allow us to carry on despite our ignorance. This cushion-for-error of humanity's survival and growth was apparently provided just as a bird inside the egg is provided with liquid nutriment to develop it to a certain point. Our innocent, trial- and error-sustaining nutriment is exhausted. We are going to have to spread our wings of intellect and fly, or perish.

R. Buckminster Fuller,

Operating Manual for Spaceship Earth.

Human needs and aspirations the world over can only be satisfied as environmental awareness leads to appropriate action at all levels of society, from the smallest local communities to the whole community of nations. Appropriate action requires a solid base of sound information and technical skills. But action also depends upon motivation, which depends upon widespread understanding, and that, in turn, depends upon education.

Mostafa K. Toiba,

Executive Director;

United Nations Environment Programme,

Tbilisi, 1977.

Author's Acknowledgements

This book has arisen from the ideas and energies of many people from many parts of the world, all of them brought together by the Environmental Education and Training Unit of the United Nations Environmental Programme.

Appreciation is due first of all to the three chiefs who presided over that Unit while this work was being prepared – Kasuka Mutukwa of Zambia, Edward Wright of the USA, and Michael Atchia of Mauritius. Also very instrumental in making the book happen were UNEP's Executive Director, Mostafa Kamal Tolba of Egypt, Director of Programme Genady Golubev of USSR and Senior Advisor Leon de Rosen of France.

Thanks are due to the international Task Force that provided the main ideas collected here – John Baines (U.K.), Mohamed Ibrahim (Qatar), Bindu Lohani (Nepal), Ricardo Luti (Argentina), Valentin Zaitsev (USSR) and especially its chairman Mohamed Kassas (Egypt). John Baines of that Task Force provided a crucially important first draft of this document.

Additional contributors and reviewers were Michael J. Caduto (USA), Dmitry Kavtaradze (USSR), Dennis Meadows (USA), Soneni Ncube (Zimbabwe), William Stapp (USA) and several UNEP staff members.

Though the contributions to this book came from a remarkable international group, the final manuscript was written by just one person, who, like any single person, has her own geographical, disciplinary, and cultural biases and limitations. Those biases inevitably color the ultimate publication. For them the author alone is responsible.

Donella H. Meadows,

Environmental Studies Programme,

Dartmouth College,

Hanover, NH 03755, USA.

Donella Meadows (1941 – 2001) authored and co-authored many books including *The Limits to Growth, Beyond the Limits,* and *Limits to Growth: The 30-Year Update.* She also wrote "The Global Citizen" newspaper column, taught at Dartmouth College, helped found the Balaton Group on sustainability, was a MacArthur Fellow, and lived and worked on an organic farm.

For more information on the work of Donella Meadows contact Sustainability Institute, 3 Linden Road, Hartland, VT. 05048 http://www.sustainer.org

I. INTRODUCTION

On the whole, human beings are not managing this precious and productive planet very well. Many of the resources that sustain life and wealth are being overused and abused. The basic needs of all people are not being met. The costs of this mismanagement in economic loss, environmental impoverishment, and human suffering are enormous.

Yet the earth has more than enough resources to meet all human needs. In every part of the world are people, communities, and nations who are preserving and enhancing the earth's resources, and using them productively. Never before has the human population had such technological power, knowledge, organization, and riches with which to manage resources wisely and to support all people sustainably.

* * *

Each day on this planet about 35,000 people die of starvation, most of them children. This human toll is the equivalent of 100 fully-loaded jumbo jet airplanes crashing and killing all their passengers every day.

Each day, because of human population growth, there are 220,000 more mouths to feed.

> Yet enough food is raised each year to feed with full nourishment and variety not only the 1988 human population of 5,000 million, but also the population of 6,100 million expected by the year 2000.

Each day hundreds of millions of tons of topsoil are lost to erosion. The amount of cultivated land lost to erosion each year is equivalent to the total area of Portugal or Hungary or Malawi.

Each day 50,000 hectares of productive land in desertification-prone regions lose their economic viability. The increase in desert every four years is equivalent to the area of Great Britain or Ghana or Laos.

> Yet the amount of food produced by the world's farmers has doubled over the past 30 years. Agricultural technologies are known, and in same places practiced, that produce high yields without degrading the soils or the waters or the surrounding wildlife.

One-fourth of the world's freshwater run-off is made unusable by human-generated pollution. In the developing countries 60 per cent of the people do not have access to clean, safe drinking water.

> Yet the amount of money that could provide clean water to everyone is only one-third the amount the world's people spend on cigarettes.

The annual loss of tropical forest is equivalent to the area of Austria, Sabah, or Sierra Leone. This deforestation results in floods and droughts, soil erosion, the silting-up of hydroelectric dams, the loss of species, and the destruction of roads, fields, human settlements, and native cultures.

At least half the forests of central Europe are dying from air pollution and acid rain; this phenomenon is also becoming evident in North America and China.

> Yet in some parts of the world forests have been carefully managed to produce wood products efficiently for decades and even centuries. In other places reforestation schemes are bringing back not only the trees, but the soil, the streams, and the wildlife that those trees protect.

* * *

The story of human culture and its interaction with the physical planet that supports it is, so far, a story of unfulfilled potential. In order to realize the potential of the magnificent planet called Earth and of the human race that inhabits it, all nations and people need to understand how the earth's natural systems work. They need access to information about the state of the planet, and they need tools and skills for wise, efficient, productive environmental management. They need to be committed to use the earth's resources sensitively and to share its bounty equitably.

> Providing the understanding, information, tools, and skills, and inspiring the commitment-that is the job of environmental education.

II. ABOUT THIS BOOK

This book is a conceptual introduction to environmental education. It is written for those involved in every kind of education or education planning; that is, for

- government leaders,
- teachers,
- curriculum planners,
- museum directors,
- youth and community workers,
- journalists,
- broadcasters,
- politicians,
- parents,

all of whom are educators.

The book is about the key concepts, methods, and tools that underlie environmental education in all parts of the world and at all levels, from nursery school to doctoral programmes, from formal schooling to informal public programmes.

It is possible to be general, to find a common core for environmental education, because Planet Earth is one and interconnected, and because people are people everywhere. The laws that govern the geochemical cycles, the ecosystems, and the energy flows of the earth are the same everywhere. Human beings learn those laws, interact with planetary forces, and rejoice in nature's beauty and fruitfulness everywhere. Environmental educators use common themes and methods, whether they work in a first grade in Dodoma or a graduate training programme in Dresden.

But of course the complexity of the laws of Planet Earth and of human nature also produce local circumstances of amazing diversity. For some people cold is the main environmental problem. For others the primary problem is drought, or humidity, or predators or parasites. Some people seek urgently to win from the environment their most basic needs; others need protection from an environment contaminated with the wastes of industrial production. Teachers and students in different parts of this one world find themselves in extremely different ecological, economic, and cultural environments.

Therefore environmental education uses local specificity to reveal the laws of planetary generality. And it applies the general planetary laws to local problems and opportunities. This going back and forth between the specific and the general, aiming toward an eventual integration of the two, is one of the key concepts of environmental education discussed later in this book. It is summarized by the environmental motto "Think globally, act locally".

Since this book is intended for a global audience, it is primarily about thinking globally. Teaching locally, the application of global generalities to the specific circumstance, depends on the ingenuity of each teacher and student. This book can only encourage that ingenuity and provide suggestive examples of how excellent teachers in different parts of the world have exhibited it.

You will find here the fundamental concepts, methods, and tools of environmental education, along with a few case studies to show how environmental education is carried out in various educational contexts. This is a guidebook, not a complete curriculum or textbook for environmental education. It provides ideas, and encouragement, from which educators can work out their own procedures, appropriate to their own situations. A reference list at the end suggests sources where more information can be found.

In the next Chapter (III) environmental education is defined, and its importance, purposes, and goals are listed. Then follows Chapter IV, the essence of environmental education, the key concepts upon which it is based. That is a rather dense chapter, full bf the ideas that are at the core of environmental understanding. It says nothing about how to teach these ideas; it only compiles the ideas themselves. Chapter V then discusses the educational methods and tools that are consistent with these key principles and that can be used to convey them to different kinds of audiences.

Chapter VI is made up of case studies of imaginative environmental education and training programmes throughout the world. They are included only as examples, ways of proceeding that work well in their own particular settings. They are meant to stimulate ideas, not to be copied intact.

After a general conclusion, a glossary is included, and a reading list for those who want more ideas, examples, and information. At the end is an appendix describing the history of the work of United Nations agencies such as UNEP andUNESCO in fostering environmental education around the world.

III. WHAT IS ENVIRONMENTAL EDUCATION AND WHY IS IT IMPORTANT

A. What is Environmental Education?

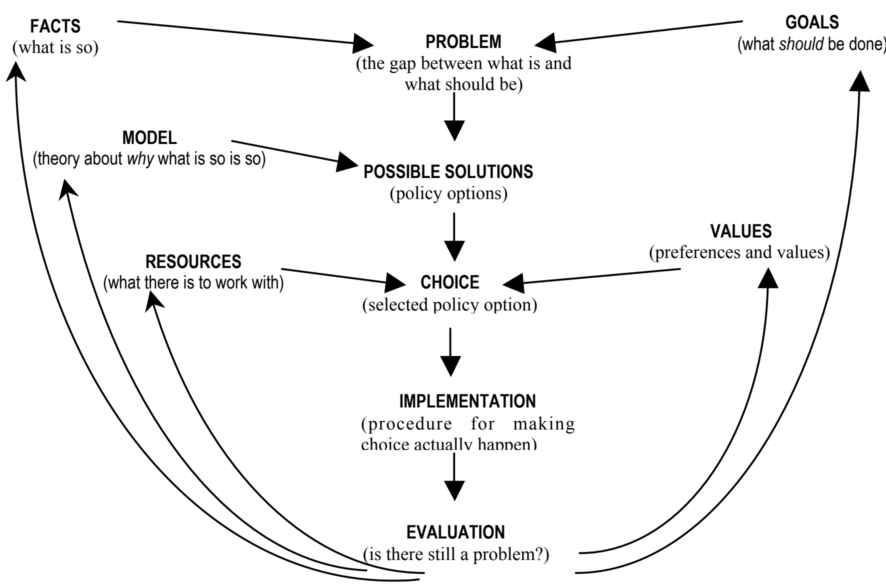
The American ecologist Garrett Hardin says that a citizen of the modern world must be educated to be literate (able to read and write), and to be "numerate" (able to understand and use numbers), and to be "ecolate"-able to understand and use sustainably the complex environmental systems of which he or she is a part.

There are many ways to define environmental education. *It is the preparation of people for their lives as members of the biosphere. It is learning to understand, appreciate, work with, and sustain environmental systems in their totality.* That kind of learning can take place at any level and any degree of specificity, from general public awareness (for example awareness of what the atmosphere is and what are the causes and cures of air pollution) to advanced technical training (for example-knowledge of how to design anti-pollution devices for cars or smokestacks). Above all, environmental education is learning to see the whole picture surrounding a specific problem like air pollution-the history, values, perceptions, economics, technologies, and natural processes that cause the problem and that suggest actions to cure it

Environmental education includes learning for the sake of pure (earning, but it also encompasses very practical purposes; it is */earning how to manage and improve the relationships between human society and the environment in an integrated and sustainable way.* Environmental education means *learning how to employ new technologies, increase productivity, avoid environmental disasters, alleviate existing damage, see and utilize new opportunities, make wise decisions.*

Environmental education is fundamentally education in problem-solving- but problem-solving from a philosophical basis of holism, sustainability, enhancement, and stewardship. The goal is not just to solve a problem with a narrow focus that makes some other problem worse, but to solve it thoroughly. Not just to solve it for a short time, but permanently. Not just to make a correction and restore the status quo, but to make things better.

The following diagram illustrates how the process of problem-solving works. It also shows how broad is the scope of environmental education.



The FACTS of the situation mean the objective description of what is happening-the water level in the wells is dropping, or the trees are dying, or agriculture output is not increasing. The GOALS express human desires, needs, or intentions; they are subjective, value-based ideas. We want the water to rise again, the trees to be healthy, the output to go up.

Obviously, if the FACTS are the same as the GOALS, there is no problem; things are the way they should be. A PROBLEM arises when the FACTS are different from the GOALS. To define a PROBLEM precisely, therefore, means defining two things: the FACTS and the GOALS.

The PROBLEM is:

> FACT: One-fifth of the babies are dying before they reach their first birthday.
>
> GOAL: All the babies should live to grow up and be healthy.

The PROBLEM is:

> FACT: The oil deposits in the country are being depleted; there are many oil-burning machines; more and more oil is being imported; that is costing much money, increasing our debts, and making us vulnerable to oil-suppliers and creditors.
>
> GOAL: We want to have the services our oil-burning machines give us, at a price we can afford, and we do not want to be dependent on the resources of other countries.

Once the PROBLEM is defined, one needs some sort of MODEL or explanation or theory about why the facts are as they are. The babies are dying because they are not immunized, or because they are drinking unclean water, or because they are poorly nourished. There is an oil problem because oil is being used wastefully, or because there has been no investment in discovering more oil or in developing other sources of energy, or because oil-intensive consumptive habits are being substituted for non-material human needs like status or recognition.

Notice that any MODEL automatically begins to generate ideas about what to do; that is, POSSIBLE SOLUTIONS to the problem. POSSIBLE SOLUTIONS arise naturally out of MODELS, and they are only as good as the models. A faulty model will suggest solutions that will not, in fact, solve the problem, or that will create other problems. A good model will suggest effective solutions. A comprehensive, complete model will suggest a large number of possible solutions, an incomplete model will suggest only a small subset of the actual solutions that may be available.

Given a set of POSSIBLE SOLUTIONS, the next step is to choose one and put it into effect. The CHOICE of which solution to try is by no means trivial. It requires an assessment of RESOURCES- money, time, people, materials- that could be applied to the problem. It also requires clarity about VALUES, priorities, how to make trade-offs. Some very effective solutions may compromise other goals, or they maybe morally repugnant. In order to choose wisely, an individual or society needs to be clear about values and about their order of importance.

Choosing a policy is not the end of the decision making process. That policy must be implemented. IMPLEMENTATION requires all the skills that translate a decision into reality. It involves organizing groups and understanding how social processes work, finding people and resources, convincing and persuading, setting up procedures and regulations, managing, keeping track of things, overcoming obstacles. Even if the perception of the facts and articulation of the goals has been perfect, even if the model is accurate, the resources adequate, and the choice good, the problem will not be solved if there is a failure at the stage of IMPLEMENTATION.

Finally, after implementation has taken place, effectively or ineffectively, there is a step that is too often forgotten in decision-making-EVALUATION. That requires an honest reassessment of every part of the process, every item on the diagram. Is there still a PROBLEM? Have the FACTS changed? Have they come closer to the GOALS? Have the GOALS themselves changed? Has anything been learned that would cause a change in the MODEL? Have new POSSIBLE SOLUTIONS become apparent? Perhaps the stock of RESOURCES has changed, or we see our VALUES and priorities in another light. Or maybe upon second thought we reaffirm our analysis of the problem and our CHOICE of solution, but we see a better way to IMPLEMENT it.

When it is taken apart into pieces and explained step by step, the decision-making process may sound daunting, but in fact it is natural to all human beings. It goes on all the time, sometimes quickly, sometimes slowly, sometimes with much public discussion, sometimes inside one person's head, sometimes deliberately and carefully, sometimes with several steps jumbled together. It goes on over and over, round and round the circle, or maybe upward or downward on a spiral, since a problem is seldom solved perfectly. As Buckminster Fuller once said, human beings get along in this world only because they can learn, and learning is the process of trial and error, error, error.

Environmental education concerns itself with every one of the steps of problem solving. It tries to build up a person's ability to do each step better. That means environmental education enhances a whole variety of human attributes, from the most rational analysis to the most passionate caring. Environmental education includes:

experience, observation, monitoring, and *measurement*-direct encounters with environmental systems and problems, which helps to get the FACTS straight,

understanding- increased comprehension of how environmental systems work, improvement of MODELS,

management- knowledge about how to work in groups to make things happen; how to assess and muster RESOURCES, how to IMPLEMENT,

ethics- the ability to make conscious moral choices about social development in its interaction with the environment, how to make a CHOICE consistent with one's GOALS and VALUES while also respecting the goals and values of others,

esthetics- appreciation of the environment for its own sake; use of the environment for play, beauty, art, inspiration, and transcendence, realization of one's ultimate GOALS,

commitment- development of a feeling of personal care and responsibility for the welfare of both human society and the environment, willingness to engage in the problem-solving process from beginning to end, over and over, in spite of difficulty or discouragement, until the FACTS approach the GOALS.

All these elements have always been part of education, though often kept separate in different courses or disciplines. What is unique about environmental education is that it integrates them and presents both problems and solutions in their wholeness. It uses both the scientific approach of studying parts of environmental systems rationally and separately, with precision and depth, and the humanistic approach of taking responsibility for, the whole system caringly, with respect and reverence.

Environmental education does not replace or supersede academic disciplines. It needs and uses all the disciplines. A lesson on rising oil imports, for example, might draw on insights from history, economics, geology, engineering, statistics, political science, and sociology. People from all these disciplines and more can contribute ideas, combine them in new ways, integrate them, see them from new perspectives, and put them to new uses. Those who engage in the process usually find it intellectually exciting, as well as directly useful in solving real and pressing problems. They find a new, over-arching discipline in coming to understand the complexity, the beauty, and the coherence of the whole.

B. Why Environmental Education?

There has been environmental education as long as human beings have been interacting with the world around them and teaching their children to do the same. Native people everywhere have had a sophisticated perception of their surrounding natural systems, and a deep reverence for those systems. They have passed both their understanding and their reverence carefully from generation to generation. But the underlying reasons for doing so and the ways of doing so have changed over time.

At first environmental education was so intricately bound up with survival that it required no reasons. It was education about how to live in a world in which nature was external to and more powerful than human beings, affecting them but not much affected by them. One needed to know what berries are good to eat, where to find water in a drought, how to avoid lions, what kinds of plants made good building materials or good fires or good medicines. Environmental understanding was necessary to protect oneself against the onslaughts of nature and to make use of its gifts.

But the interaction between people and their environment has always been more than a matter of survival. From the beginning nature has also been a source of joy, beauty, personal identity and status, music, art, religion, meaning- all the things that one wants to survive for.

As human civilization evolved and urbanized, the perception of the environment changed drastically. Nature began to be seen as subservient to humankind. One had to learn about it to dominate and use it. That part of the environment that no one had found a use for was studied primarily to satisfy the curiosity of people about their world. Environmental education was either the practical science of extracting resources, or "nature study"-catalogues and descriptions of natural wonders. In either case, nature was considered somewhat separate from and inferior to human society.

Even this manipulative motivation for environmental education, however, had its transcendent side. Increasing scientific understanding revealed increasing wonders- the genetic code carried in the DNA molecules of the cell's nucleus, the balanced interdependence of all the species in a tropical forest, the expanding universe and the apparent uniqueness, preciousness, and loneliness of our well-watered, life-nurturing planet. The wonder too was transmitted to every new generation.

Formal education became institutionalized into schools. Environmental education was part of many subjects and disciplines, but was found especially in the sciences. The unspoken hope was that when all the sciences were put together, they would add up to a complete picture of how the planet works and how human beings can interact with it fruitfully.

But as the amount to be learned in each science increased, and people specialized more and more, no one could put together all the disciplines for a total view of the planet, much less an understanding of its interaction with human cultural and economic systems.

Furthermore, in the late 1960's and early 1970's, many real and urgent environmental problems became overwhelmingly apparent. Deserts were spreading, air pollution was threatening the health of city dwellers, lakes were drying, soils eroding. Many of these problems transcended national boundaries; they resulted from the derangement of regional or even global environmental processes, because of enormous impacts from human society. These problems did not fit within single educational subjects or scientific disciplines. They illustrated the fact that human life is supported by large-scale, interconnected, complex natural processes, that those processes cannot absorb any number of abuses, and that to keep them thriving somehow we must come to understand them better and to bring human activities into alignment with them.

Now nature was viewed as affected by human society, usually disastrously. Society became the aggressor, the environment the victim, and understanding was necessary to protect nature and right ecological wrongs.

All these historical reasons for environmental education are still valid. People still need to understand basic environmental functions in order to grow food, find water, and protect themselves from the climate. They still need to understand science and technology to shape and perpetuate the modern world. And they need to monitor the health of the environment and protect it against senseless assault. But a more complete and constructive reason for environmental education has emerged out of the combination of all the other reasons.

Environmental education is needed for the wise management of the total, interdependent economy/environment. Society and nature are in fact mutually interacting, each affecting the other powerfully, neither dominant, both vitally important. They rise or they fall together. Human beings are neither victims nor lords of nature, but stewards. Nature is neither something to be exploited mindlessly nor something to remain totally untouched. Understanding is needed to promote actions, inventions, and social organizations that respect the viability, stability, and productivity of both human society and natural systems in their myriad interactions.

The Belgrade Charter, written in 1975 by twenty world experts in environmental education, says the goal of environmental education is to:

> develop a citizenry that is aware of, and concerned about, the total environment and its associated problems, and that has the knowledge, attitudes, motivations, commitments, and skills to work individually and collectively toward solutions of current problems and prevention of new ones.

That goal alone is a sufficient argument for any nation to promote environmental education. What country does not need a citizenry like that? But there are other good reasons for environmental education, at many educational levels:

- to learn from the examples of others; to avoid their mistakes and replicate their successes,
- to foresee and avoid environmental disasters, especially irreversible ones,
- to make the most of a country's natural resource endowment; to manage that endowment efficiently, productively, and sustainably,
- to be able to implement policies, such as reforestation, recycling, or family planning, which require the co-operation of all the people,
- to save money, by preventing environmental
- damage instead of having to repair it afterward,
- to develop public understanding that prevents panic and exaggeration of environmental issues, but that respects their true urgency,
- to allow people to become informed, productive
- citizens of the modern world,
- to assure an environment that people can feel enriched by, secure in, connected to, and joyful about, in their economic, emotional, and spiritual lives.
-

IV. THE KEY CONCEPTS OF ENVIRONMENTAL EDUCATION

Environmental educators on every continent have developed materials and methods that are as varied as the different cultures and ecosystems of the earth. But they are also as similar as the underlying physical laws of the planet and the human natures of teachers and students. Though the particulars are different, the basic concepts of environmental education are common to all and applicable everywhere. In international meetings on environmental education, these concepts emerge again and again as an intellectual foundation. They are the core, the primary theses that environmental educators everywhere endeavour to communicate. ‘

This chapter of the book, which compiles the key concepts of environmental education, was distilled from a long list, which started with the suggestions of a special Task Force of environmental educators from all parts of the world, brought together by UNEP. The list was expanded by consulting publications and textbooks on environmental education. Several more items were added by asking educators directly, “what are the most important ideas you think environmental education must communicate?”

The many ideas resulting from that process were then grouped and shuffled and regrouped until they began to take on an order. They fell into eight categories, under each of which several points seemed to fit. That is the way they are presented in this section. They start with concepts about the physical world and the laws of the planet, progress to the interactions of human society and the environment, and conclude with concepts about human beings, their knowledge, cultures, values, and purposes.

Listing key concepts and trying to organize them in a logical order is a bit misleading, because the very process of categorization violates one of the concepts-the concept that the world is a whole, that everything is interconnected, that the separate categories we perceive are artifacts created by our minds out of the seamless web of nature. Each concept discussed here is intricately connected with all the others. There is no final way of categorizing or prioritizing or ordering them, or indeed of knowing that the list is complete.

But the human mind takes in information by categorizing, and when the information comes by way of written words, the words must come one after another, not all at once. So this section is presented according to a semi-logical order, one concept after another, in a list.

These words of warning are intended to dispel the notion that there is anything fixed or doctrinaire about the following list. It is the result of a good deal of thought on the part of quite a few people, but it is only A list, not *THE* list of key concepts of environmental education. The reader is invited to add to it, rearrange it, join in the ongoing search for the most essential things to teach and to learn about the wondrous complex system we call Planet Earth.

The key concepts elaborated in this chapter are:

A. Levels of Being

1. There are three distinct levels of being: human, biological, and physical, each of which obeys its own laws plus those of all lower levels.
2. Since all environmental systems obey the same underlying physical laws, they behave much the same everywhere, although their complexity can lead to enormous local variation.
3. The various levels of being operate on very different time-scales, which can make management difficult.
4. The levels of being are distinguished by profound and mysterious qualities: life, consciousness, and self-awareness. Human beings are the only creatures that possess, perceive, and appreciate all these qualities, which gives them a special responsibility for stewardship of all the levels of being.

B. Cycles

1. Matter cannot be created or destroyed. The material of the planet stays on the planet, undergoing continuous transformations, powered by the energy of the earth and sun.
2. The materials necessary for life- water, carbon, oxygen, nitrogen, etc.- pass through biogeochemical cycles that maintain the purity and the availability of these materials for living things.
3. The biogeochemical cycles combine to form a complex control mechanism that maintains conditions hospitable for life. One can think of the planet itself as a self-maintaining, living organism.
4. The natural forces propelling the planetary cycles are enormous compared to human forces. They perform priceless services. They are easier to work with than against.

C. Complex Systems

1. Everything is connected to everything else.
2. Systems are more than the sum of their parts; they are dominated by their interrelationships and their purposes.

3. Systems are made up of interconnected stocks and flows. The stock/flow configurations of nonrenewable and renewable resources are different; therefore these two kinds of resources need to be managed differently.
4. Systems are organized into hierarchies, which means that everything is connected to everything else, but not equally strongly.
5. Nature's complex systems are finely tuned, stable and resilient. Diversity usually increases this resilience.

D. Population Growth and Carrying Capacity

1. Populations of living organisms tend to grow exponentially, when they are able to grow at all.
2. The limit to the rate of production of any renewable resource base puts an upper bound, called the carrying capacity, on the number of organisms that can be sustained on that resource base.
3. The carrying capacity is defined by its most limiting, not its most abundant, component.
4. Carrying capacities can be enhanced or degraded by human activity.
5. Efficient use of resources-doing more with less-increases the number of people that can be carried on a resource base.
6. Restoration of a degraded carrying capacity is far more difficult than preservation; prevention of damage is cheaper than cure.

E. Ecologically Sustainable Development

1. Human wealth and economic development ultimately derive from and depend upon the resources of the earth.
2. The earth's resources are sufficient for all living creatures' needs, if they are managed efficiently and sustainably.
3. Both poverty and affluence can cause environmental problems.
4. Economic development and care for the environment are compatible, interdependent, and necessary.

F. Socially Sustainable Development

1. The key to development is the participation, organization, education, and empowerment of people.
2. Development must be appropriate not only to the environment and resources, but also to the culture, history and social systems of the place where it occurs.
3. Development must be equitable.
4. Development involves the continuous balancing of opposites and the breaking down of barriers and separations between freedom and order, groups and individuals, work and play, settlements and nature.

G. Knowledge and Uncertainty

1. We don't fully understand how the world works; we don't even understand how much we don't understand.
2. We make decisions under grave uncertainty. When the results can be devastating and irreversible, we must manage the risks very carefully.
3. In a situation of uncertainty, the appropriate method is careful assessment and slow experimentation, followed by constant, truthful evaluation of results and willingness to change strategies.
4. It is possible to complement rational analysis by non-rational or super-rational analysis-by intuition, insight, deep familiarity, respect, compassion.

H. Sacredness

1. Nature has its own value, regardless of its value to humans.
2. A healthy, beautiful environment is not a luxury, it is a basic human need, both materially and non-materially.
3. A harmonious relationship between human beings and the environment is not only essential for well-being; it is also intrinsic, effortless, spontaneous, natural.

The following explanations of the key concepts will be condensed and in the language of adults, not children. Many elaborations and illustrations can be found in the examples later in this book and in the reading list at the end. Although they may sound sophisticated, all these concepts can be communicated to children and to the general public, visually or orally, through plays, symbols, poems, songs, through direct hands-on activities and environmental encounters, and through media such as radio and television. Ideas for how to do that will be given later.

A. Levels of Being

I. There are three distinct levels of being, human, biological, and physical, each of which obeys its own laws plus those of all lower levels.

We can think of the earth as divided into three main levels or systems of being:

1. the physical planet, its atmosphere, hydrosphere (waters), and lithosphere (rocks and soils), all of which obey the laws of physics and chemistry,

2. the biosphere, all living species, which obey the laws of physics, chemistry, biology and ecology,

3. the technosphere and sociosphere, the human created world of buildings and machines, governments and economies, arts and religions and cultures, which obey physical, chemical, biological and ecological laws, and also further laws of human devising.

An example of a *physical* law obeyed by all these levels of existence is the law of entropy, known to physicists as the Second Law of Thermodynamics. One way of stating this law is that the entropy, or disorder, or unavailable energy, of a closed system continuously increases and never spontaneously decreases.

Because of entropy machines slowly wear out; they do not automatically renew or repair themselves. It takes outside energy to make or repair a machine, and the harnessing of that energy creates disorder (and wears out machines) somewhere else in the system. Hot things inevitably cool down; they do not heat themselves back up. It takes outside energy to heat them up, and that withdraws useful energy from somewhere else. Animals maintain their internal order by the constant use of the energy in food. Without that energy, they die and dissipate into disorder. Houses do not clean themselves up; they fall naturally into disorder and it takes continuous effort to keep them clean. The available energy of the gasoline in the automobile tank is converted into the disorder of combustion gases, motion, and heat. Those things cannot be reassembled into gasoline again without a tremendous insertion of energy.

All things living and non living, human and nonhuman, are bound by the law of entropy. No human being ever has escaped it. One implication of this law is that there can never be a perpetual motion machine (some energy must continually be applied from outside to keep things moving). Another implication is that energy and effort are constantly required to maintain the integrity of life, machines, social arrangements, physical structures. The more ordered and structured those things are, the more energy it takes to maintain them.

An example of a *biological* law applicable to all forms of life is that the chemical composition and organization of any individual is determined by the genetic code carried on the long molecules called DNA within every cell. That code only, and no characteristic learned or acquired during an individual's lifetime, is biologically transmitted to the next generation. Therefore, no matter how educated each person becomes, no matter how complex human society becomes, each baby is born only with the information contained in the genetic code. That is a complex and magnificent set of information-the ability to speak a language (the actual language must be taught), the ability to grow, learn, love, create, all sorts of reflexes, instincts, and potentials. But the development of that potential and the transfer of all specific knowledge, must be seen to by each generation for the next through social organization and human effort, not through genetic transmission.

The *human-generated* laws that regulate societies and economies are immensely varied and changeable. They are not equivalent to the natural laws that apply everywhere and without exception. However, there are some human laws that seem to be recognized by virtually all societies. Killing, stealing, lying are always disapproved and punished in some fashion, because if they were allowed to persist, they would destroy society. Hierarchies of authority nearly always exist; they may be secured by heredity, common agreement, physical power, or election. Laws, written or unwritten, exist in every society to govern marriage and the perpetuation of families, the production and exchange of goods, the forms of government.

Social laws change with time and circumstance. Underlying them are the unchangeable biological, chemical, and physical laws. Like other animals, human beings must be born and must die, must breathe in oxygen and breathe out carbon dioxide, must have food and water. Humans are held together by the forces that hold together all creation. We absorb, store, and use energy according to the laws of thermodynamics. We are made up of the atomic particles that make up all matter. We probably do not yet understand all the natural laws by which we exist and function, but whether we understand them or not, we are bound by them.

2. Since all environmental systems obey the same underlying physical laws, they behave much the same everywhere, although their complexity can lead to enormous local variation.

Human beings are more fascinated by differences than by similarities. We divide ourselves according to nations, ideologies, religions, and races, and we forget the common biological and physical heritage that unites us, and our common problems and opportunities in living on this planet.

Forests grow the same way in the Soviet Union, the United States, and Europe. Arid-land water management techniques work the same way in Israel, Arabia, India, and Africa. The search for and extraction of minerals follows the same pattern everywhere. Environmental lessons learned by people in one part of the planet can be useful to others.

Along with the similarities come amazing planetary differences. Though water everywhere evaporates, condenses, runs downhill, and carves out watersheds, a watershed in a desert, where dry washes arc only rarely converted into flash floods, looks very different from a watershed in a tropical rain forest where water is abundant at all times, or in a tundra where the water is usually frozen. Populations everywhere age and are renewed according to the basic biological patterns of fertility and mortality, but some populations in Africa are doubling every 18 years, while others in Europe are very slowly declining. Agriculture in temperate climates, where soils can contain great amounts of humus and where insect populations are reduced each winter, must be managed quite differently from agriculture in tropical climates, where constant heat burns up the humus, and where insects breed all year long.

Similarity and difference, common physical laws and great variety in the manifestation of those laws-these opposites characterize the planet. Environmental education must emphasize the underlying regularities, while maintaining respect for the different ecosystems and human cultures of the earth. That double duty to recognize the global similarities while effectively interacting with the local specificities is summarized in a common environmental slogan:

Think globally, act locally.

3. The various levels of being, physical, biological, and human, operate on very different time-scales, which can make management difficult.

Mountains thrust up over tens of thousands of years and wear down over millions of years. A molecule of water may spend 100,000 years in a glacier, or 1,000 years in a seam of groundwater, or 7 years in a lake, or 10 days in a river, or a few hours in an animal. It has taken millions of years for the species of life now on earth to evolve; because of human destruction of habitat, about one species becomes extinct every day. It takes about 300 years to form 3 centimetres of good topsoil; bad farming can remove that soil within 10 years; one violent storm on unprotected land can remove it in 24 hours.

These different time-scales make for difficult management problems, especially since human managers tend to see things on human time-scales. We are very aware of things that happen over days of are very aware of things that happen over days or over months or years; we have history that tells us of things that happen over decades or centuries; we can hardly imagine things that happen over millennia. We are often in a great hurry to build, to harvest, to mine. Sometimes we are very slow to notice that something has changed, to adopt new ways of doing things, to create regulations on our own behaviour.

So we make mistakes, especially when dealing with very long time-scales. In the western United States and northern Mexico huge agricultural enterprises have been built, based on pumping groundwater that will be used up on a scale of decades but only recharged on a scale of centuries. In some countries, to solve decade-scale energy problems, nuclear wastes are being created that have half-lives of hundreds or thousands of years. People make decisions about family size based on present needs and desires and do not realize that a population growth rate of 3 percent per year means, if continued for a century, a 19-fold multiplication of the population.

Long time-scales can be understood and taken into account, the geological, biological, and human rates of change can be made harmonious, but only if people are educated to see and understand them.

4. The levels of being are distinguished by profound and mysterious qualities: life, consciousness, and self-awareness. Human beings are the only creatures that possess, perceive, and appreciate all these qualities, which gives them a special responsibility for stewardship of all the levels of being.

It need not be human-centered arrogance to imagine the levels of being discussed here as levels of a hierarchy, the human above the biosphere, the biosphere above the atmosphere, hydrosphere, and lithosphere. Each higher level is governed by an increasingly complex set of laws, all the laws of the lower level, plus additional ones. Furthermore, each level possesses a set of qualities not possessed by the levels below; qualities that we do not fully understand, but that we consider precious and profound.

At the lowest level, rocks, waters, air, as far as we know possess only the simple quality of *existence.* They are passive objects, moving and changing by physical laws.

On the next level plants possess the quality of existence, but also that mysterious quality we call *life.* A plant organizes itself, adapts to some extent to changing circumstances, interacts with its environment to promote its own existence, reproduces itself, and changes its environment in the process.

An animal possesses not only existence and life, but another, even more magical quality, which we might call *consciousness.* An animal can actively intervene in its surroundings, perceive, learn, pursue a purpose. It can feel fear, suffering, comfort, disappointment, happiness. It can play.

Human science understands much about biology, but it has no full explanation for the phenomena of life and consciousness.

The human being possesses existence, life, consciousness, and something beyond even those, which is what we recognize as quintessentially human. Call it thinking, an ego, intelligence, a consciousness of our own consciousness, *self awareness.* No single word suffices, but every human recognizes this unique quality; one can see it develop as a baby becomes a child.

Human beings possess the unique ability to recognize all the levels of being and the special qualities that distinguish them. We cannot define life, or consciousness or self-awareness, but we know them when we see them, and we know their absence. We have been given the ability to destroy, but not create, these special qualities. We can render a man or an animal unconscious; we can also kill it; but we cannot create life or consciousness where it does not already exist. We have developed nuclear weapons that can so disorder and transform existence that virtually all self-awareness, consciousness and life on the planet could be destroyed, but we have no idea how to restore life, consciousness, self-awareness once they are gone.

Each level of being has power over the ones below, power to organize and utilize them for its own purposes. That means that humankind; at the top of the hierarchy, has special power over all other levels of being. That power can be interpreted arrogantly as license to use the earth and its creatures in any way at all. But more appropriately, it means a tremendous *responsibility* to be stewards of the planet and its levels of being, to protect, conserve, nurture, enhance. To carry out that responsibility we need to draw on another poorly-understood but easily-recognized attribute of humanity-that attribute called wisdom, morality, compassion, *conscience.*

B. Cycles

All the rivers run into the sea,
Yet the sea is not full;
Unto the place from which the rivers come,
Thence they return again.
Ecclesiastes 1:7

In the biosphere there are grandiose, specific, chemical, circular migrations of atoms, of which living organisms are an integral, regular, and often major part. Living organisms are a regular function of the biosphere. This is normally forgotten, and living organisms are erroneously opposed to the environment, as if they were two independent things.

Y.I. Vernadsky

.

1. Matter cannot be created or destroyed. The material of the planet stays on the planet, undergoing continuous transformations, powered by the energy of the earth and sun.

Neither matter nor energy can be created or destroyed (although, Einstein discovered, matter and energy can be converted into one another under special conditions). No form of life, and no human technology, however sophisticated, can create something out of nothing, nor can anything discarded become nothing. The constant flow of material needed to sustain a living being or an economy must come from somewhere. The constant stream of wastes that is emitted goes somewhere and does something in the environment. As environmentalists say:

There is no such thing as a free lunch.

Everything goes somewhere.

There is no Away to throw things to.

With the exception of cosmic particles entering, outer atmospheric gases leaving, and radioactive elements decaying, the matter of the earth is fixed. It has been the same throughout known history and will be the same as far as we can see into the future. The elemental compositions of the lithosphere, atmosphere, hydrosphere, and biosphere are well known and stable.

But of course, tremendous changes take place on earth every day. Though the total quantities of materials may be nearly fixed, the distribution and mix of the materials of the planet are in constant flux. Forests grow or die or burn. Vast quantities of water evaporate from one place and rain back in another. Volcanoes erupt and spew forth ash and molten rock that can create new islands, or bury cities. Each year human beings extract billions of tons of metals and fuels from the earth and chemically transform them. Humans even create each year from the basic raw material of the planet thousands of new chemicals, molecular recombinations, which never existed before.

All this activity is powered by just two sources: the residual heat of the earth's core (generated by radioactive decay), and the incoming radiation from the sun. Energy sources such as oil, coal, and gas are the fossil remnants of plants that once used the sun's energy to fix carbon from the atmosphere. Hydroelectric energy comes from the sun's constant evaporation and transportation of water. Geothermal energy comes from the heat of the earth's core. Nuclear energy comes from the concentration and harnessing of the radioactive elements of the earth's crust.

Only one form of energy is not derived directly or indirectly from solar or geothermal sources: fusion energy arises from the transformation of matter into energy. The sun operates through fusion energy, but until human beings discovered how to generate it, fusion energy never occurred on earth. So far humans have not been able to control this energy source for sustained, peaceful purposes; it is used only for bombs.

In other words, materially the earth is a nearly closed system; very little matter enters or leaves it. Transformations upon or within it must come from combinations of the matter already there. Energetically, however, the earth is an open system. It receives constant energy from the sun, which it must re-radiate back out into space in order to maintain a controlled temperature. Energy flows to the earth and away again. Matter must flow in cycles.

2: The materials necessary for life-water, carbon, oxygen, nitrogen, etc.-pass through biogeochemical cycles that maintain the purity and the availability of these materials for living things.

Living creatures are material flow-through systems. They sustain life by constantly taking in and passing out materials. They take in low-entropy, ordered nutrients, from which energy and matter necessary for life are extracted. They emit higher-entropy, disordered wastes. Since it is a finite planet, those wastes must somehow be transformed back into nutrients again, or soon all the nutrients would be depleted and all the wastes piled up unusable.

Take the element nitrogen, for instance, which is an integral part of proteins, nucleic acids, and many other molecules essential to life. Human beings, like all animals, get nitrogen, already bound into handy organic building-blocks called amino acids, from food, either from plants or from animals that have eaten (and gotten nitrogen from) plants. Human beings excrete nitrogen, still in organic form, in their urine and feces.

How does the nitrogen get back into plants to complete the cycle? There are two ways, both dependent on micro-organisms that live in the soil.

Some microbes attack and break down animal and plant wastes-crop residues, manures, dead leaves, any organic material-reclaiming the nitrogen in them, and releasing it into the soil as ammonium or nitrate, dissolved in the soil water, to be taken up by plant roots.

Some bacteria and algae are able to fix nitrogen directly from the air and to convert it into ammonium or nitrate. They reclaim nitrogen that is lost from the biosphere into the atmosphere and bring it back into the biosphere again.

If these cycles that bring nitrogen back into the soil water to be taken up by plants ever stopped, virtually all life on earth would stop.

There are many other such cycles. Water, soiled by wastes and salts, is evaporated by the sun and recondensed into clouds and eventually rained down again in pure form. Carbon dioxide, exhaled by animals, is taken in by plants in the process of photosynthesis. It is converted into sugars and other complicated organic molecules, which animals ingest and burn and re-release as carbon dioxide.

Nature operates by making the output of one process the input to some other process; that is necessary on materially-closed planet. A dead leaf on a forest floor is food for a fungus. The fungus may be food for a soil mite. The soil mite's excrement provides nutrients taken up by a plant root. The plant is eaten by an insect; the insect by a bird; the bird's droppings are attacked by bacteria; the dead bacteria become soft humus, slowly releasing nutrients for plants. And so in goes. Everything is food for something else, and every kind of waste is an input to something else.

The human economy also operates on a materially closed planet, and eventually it must be organized on the same principle-all waste must be input to some useful process. Many traditional agricultural systems work that way. Crop wastes and excrement from livestock and people are returned to the soil; the soil grows plants to feed the animals and people. Very little is lost from the system.

But industrial systems operate on an open, flow-through basis. Raw material is introduced at one end, and wastes are emitted at the other. Small systems of this sort can be accommodated within the great cycles of the planet. But enormous systems, such as whole industrial economies, cannot be sustained. At one end raw materials are depleted; at the other end wastes accumulate. The wastes are at the least a nuisance, and at worst they poison people and other species and interfere with natural cycling mechanisms.

Humans are just beginning to learn how to design a complex, modern, high-productivity industrial economy that follows the planetary requirement for cycling. Organic wastes from crops and cities can be composted and returned to the soil. Metals, paper, glass, and plastics can be reclaimed, refabricated, and reused. Exotic chemicals can be captured and used, or entered into other manufacturing processes, often at great economic as well as environmental benefit.

3. The biogeochemical cycles combine to form a complex control mechanism that maintains conditions hospitable for self-maintaining, living organism.

Oxygen makes up about 21 per cent of earth's atmosphere. If the concentration were only a few percent higher, the forests and grasslands would spontaneously burst into flame. If it were a few percent lower, the metabolic functioning of most forms of life would stop.

If the average temperature of the earth fell by just 5 or 6 degrees, there would be a severe ice age. If the temperature rose by the same amount, the polar ice would melt, the levels of the oceans would rise, large areas of the continents would be flooded, and rainfall patterns would change everywhere. Most species of life would have to either migrate or die.

Though there have been oscillations in temperature and in the composition of the atmosphere, the planetary conditions have been remarkably stable over the 2,000 million years since green plants evolved and the earth's oxygen-rich atmosphere was formed. Clearly some powerful control mechanisms are in place, keeping the planet's chemical and thermal balance within the fairly strict bounds required for life to persist.

As far as we understand them, those control mechanisms are mediated by life itself. That is, the living organisms on earth's surface, especially the microorganisms, by their own biochemical functioning and their population expansions and contractions, keep the earth's atmosphere, and hence its surface temperature, regulated. Furthermore, they hold the atmosphere in an anomalous composition of gases, far different from those that would be found in chemical equilibrium on a lifeless planet.

For instance, the gas methane cannot exist for long in an oxygen atmosphere-it is oxidized to carbon dioxide. But there is a steady-state concentration of methane of about 1.5 parts per million in the earth's atmosphere. It is there because methane is constantly being released-about 2,000 million tons of it each year-by fermenting, micro-organisms. This atmospheric methane is one of the "greenhouse gases" that help maintain the anomalously warm temperature of the earth.

Similarly, the earth's albedo or reflectivity, which determines how much heat from the sun is absorbed or bounced back into space, appears to be regulated by two factors. One is the cloud cover, which is greatly determined by the location and extent of forests, and the other is populations of microflora on the sea, the land, and even the ice caps, which expand or contract, darkening or lightening the surface.

Similarly, the amounts of oxygen and carbon dioxide in the atmosphere are primarily regulated by the photosynthetic action of the earth's green plants.

Some scientists have come to think of the entire planet, including the life forms on it, as a self-organizing, self-maintaining organism, which they name "Gaia" after an ancient Greek earth goddess. Gaia's living creatures continuously use the sun's energy and the planetary raw material to maintain the earth's surface as a rare place in the universe, uniquely appropriate to life. A hundred kilometres below the earth's surface the rock is white-hot and molten. Thirty kilometres above the surface the temperature is perpetually below freezing. In the narrow band between flourish all forms of life-because the life forms themselves actively maintain their own protective global greenhouse.

4. The Natural forces propelling the planetary cycles are enormous compared to human forces. They perform priceless services. They are easier to work with than against.

Each year the world's farmers spread on the land 50 million tons of commercially-produced nitrogen fertilizer. Great factories, millions of human labourers; and enormous quantities of fuel and money are expended to produce this fertilizer. At the same time each year the nitrogen-fixing bacteria of the earth's soils fix from the atmosphere 90 million tons of nitrogen fertilizer. They do it with renewable solar energy, no one has to oversee them, and they charge nothing.

Honey bees on one bright sunny day in June pollinate an estimated one trillion apple blossoms in New York State. The apple crop is absolutely dependent on the services of those bees. Human beings are a long way from designing a device to pollinate apple blossoms (and make honey in the process) as efficiently elegantly, and cheaply as a honeybee.

Micro-organisms, sunlight, and oxygen clean up millions of tons of organic wastes in rivers. Natural predators control far more crop pests than human-devised pesticides do, and they do not leave a residue of poison behind. Forests control temperature and humidity, restore soil fertility, hold water and prevent droughts and floods. Natural rains water far more farmers' fields than human-designed irrigation systems do.

We could never calculate the economic value of the services that the planet performs for us, when it is healthy and functioning well. We could duplicate these services only with enormous effort, if at all. Wise human managers protect these free services and use them maximally.

For example, many modern farmers systematically return organic wastes to their soils and interplant or rotate legume crops (whose roots harbour rhizobium bacteria that fix nitrogen). By cleverly using these free natural sources of nutrients they can obtain high yields and purchase no commercial fertilizer at all.

Other farmers encourage the natural enemies of plant pests to keep those pests under control, and therefore they have to buy little or no commercial pesticide.

Knowledgeable foresters know just which older trees to leave in place after harvest, at just what density, to guarantee reseeding, wind protection, and proper shade and water retention, so that a new forest will be established without effort or cost.

Some engineers keep streams clear-running, eliminate, snags, and reduce floods by using bulldozers, power shovels, concrete embankments, and other expensive, machinery-intensive and energy intensive methods. But it has been found to be both cheaper and more environmentally sound to use the force of the running stream itself, instead of machinery and fossil energy. A small insertion of a baffle at the right place can direct a current against a sandbar and wash it away. A line of trees holds the bank and absorbs the force of the current better than concrete. Channels can be straightened or deepened with almost no effort, just by skillful redirection of the stream's own energy.

These examples, and there are many more, illustrate ways of working with the natural forces and cycle nature. The concept is the same as that of the martial arts such as karate and judo. Don't directly oppose the force of your opponent, but understand it, and cleverly redirect it to your own purposes.

C. Complex Systems

> All things are connected like the blood which unites one family. Whatever befalls the earth befalls the sons of the earth. Man did not weave the web of life; he is merely a strand in it. Whatever he does to the web, he does to himself.
>
> *Chief Seattle.*

1. Everything is connected to everything else.

In order to understand the world, our minds divide it up into concepts, pieces, categories, and disciplines. But the world itself is a single whole. There are no clear dividing lines between chemistry and physics, between land and sea, between Iran and Iraq, between man and nature, except lines made in the human mind.

With every breath you draw in, a part of the environment becomes part of you. With every breath you give out, a part of you becomes a part of the environment. The cycling waters of the earth flow through you, as do the cycles of carbon, of oxygen, of nitrogen, and of the other elements that make up your structure. Though you may not see the connection between an automobile's exhaust and your lungs, or between the health of the soil and the health of the people who eat food grown in that soil, those connections are there.

Even when people recognize the world's complex interconnections, they are often surprised by them, especially by causes and effects very far apart in place or time. A drought in Kansas affects wheat prices in Ghana. Air pollutants released in England kill trees in Sweden. Pesticides applied to agricultural fields may show up in groundwater 10 years later, and cause cancer 30 years after that. Many of these connections are traceable and knowable, if we are looking for them. But if our minds are not used to crossing conceptual categories and seeing interrelationships, we wilt not manage things very well, and we will receive some unpleasant surprises.

It is useful to think of the world as organized into *systems.* A system is an interconnected set of elements that is coherently organized around some purpose. That is, a system consists of three kinds of things: *elements, interconnections,* and a *purpose.*

Your digestive system consists of *elements* such as teeth, tongue, stomach, intestines, and enzymes. They are *interrelated* through the physical flow and transformation of food and through a whole set of chemical regulating signals. The *purpose* of the system is to extract the nutrients from food and pass them into the blood stream (another system), while discarding toxins or unusable wastes.

The system called a football team has elements balled, players, coaches, field and ball. Its interrelationships are the rules of the game, the coach's strategy, the players' communications and the laws of physics that govern the movement of the ball. The purpose of the system could be to get exercise or to have fun or to win games or to make money. (Notice that these different purposes could cause quite different system behaviours, even with the same elements and interrelationships).

A school is a system, and so is a city, a factory, a national economy. An animal is a system. A tree is a system, contained within the larger system of a forest. The earth as a whole is a system (Gaia) and so is the solar system and the galaxy.

What is *not* a system? Anything that has elements with no particular interconnections or purpose. A heap of sand is not a system. When a living thing dies it loses its "systemness", its interrelationships no longer function, and it dissipates. Some people say that an old city neighbourhood where people know each other and maintain a social order is a system, but a new apartment block full of strangers is not, until acquaintanceships slowly build a system again.

When you begin to see things as systems, your mind draws boundaries and makes distinctions in new ways. For example, most people see a coal-burning power plant as a complex of machinery that takes in coal and puts out electricity. But as a total system the coal plant also takes in human labour, air, cooling water, financial capital, and the metals and other materials of which it is composed. It puts out- in addition to electricity- wages, profits, discarded or obsolete equipment and buildings, heated-up water, ash, and a number of air pollutants. The pollutants are no more secondary or "by-products" than the electricity; they are an integral result of the operation of the system.

Similarly, a non-systemic view of the practice of spraying pesticides is that the farmer sprays them, and the pest die. But from a systems point of view many other things happen. The pesticide may kill other insects than the target pest. Among them may be helpful insects that enrich the soil, or predators that would have eaten up the pest. Removing those predators may allow the pest to come back in larger numbers, because it no longer has natural enemies. Or the presence of the pesticide may cause the insect to evolve immunity to it. The pesticide may leach into groundwater and poison human beings. It may break up into other compounds, which may be harmless or may not. Residues of it may cling to the harvested crops. Managing pesticide use means managing this whole system. When you see things in systems, you know that:

You can never do just one thing.

Nothing is really a "side effect".

A systems view of development means developing all sectors of the economy in balance: investing in the capacity to produce energy at the same rate as the economy needs energy; not slower and not faster; educating the labour force to be able to handle the jobs that are actually available; keeping roads and communications links sufficient for the loads put on them; enhancing, not degrading, basic productive resources like soils and forests.

2. Systems are more than the sum of their parts; they are dominated by their inter-relationships and their purposes.

It is an age-old observation, beginning with the ancient story of the blind men and the elephant, that a system is more than the sum of its parts. You may be able to name all the parts of the elephant- its trunk, its ears, its legs, its tail- but that does not tell you how the elephant will behave, or how to control it. To know that, you have to know the wholeness, the entirety, the total system called elephant.

It is easier to see a system's parts, its elements, than to see its interrelationships and its purposes. Therefore, we usually try to fix or control systems by changing parts. If a team plays badly, we replace the coach or players. If a company performs badly, we fire someone. If a body is unhealthy we try to heal or even replace whatever organ seems to be malfunctioning. Sometimes that works. Often it doesn't, because the problem is in the interrelationships or the purpose. Putting a different element in the same system just produces the same behaviour.

For example, telling people to conserve energy does not usually produce energy conservation. Putting new people in the system will not change the result. Giving them different appliances that use less energy will help. But changing the information flows (information is always part of the *relationships* in the system), can produce amazing results, even with the same people and the same appliances.

There are cars whose dashboards show the instantaneous rate of fuel consumption-that information changes people's driving habits and saves fuel. Once a housing development in the Netherlands put the electricity meter in the front hall, so people could watch how fast they were consuming electricity (before the meter was in the basement, where people seldom went). Consumption dropped by a third, though nothing changed except the availability of information.

A very powerful piece of information in any economic system is price. If all subsidies are removed from energy production, so that people pay the true cost of the energy (including the cost of repairing environmental damage), energy consumption habits usually change very quickly.

An even more powerful lever on a system is its purpose. A medical system behaves quite differently when its purpose is preventing disease, rather than treating disease. An enterprise works very differently when its purpose is to make a high-quality product than when it is trying to make a high-profit product or a high quantity of product. A national economic system geared toward producing an ever-higher flow of goods and services (called the Gross National Product or GNP) will be very different than one designed to provide basic human needs for everyone, or one designed to increase real human welfare with a minimum of material flow-through.

The amount of water in a reservoir is a stock. The amount being released from the reservoir into a downstream river is a flow. The amount of oil under the ground is a stock. The amount being pumped out by oil wells is a flow. The volume of wood in a forest is a stock. The amount by which the forest grows each year is a flow into the stock; the amount of wood cut down is a flow out.

The concepts of stock and flow are simple and basic, but they are often confused. For example, there has been a suggestion that the massive stock of water in North America's Great Lakes- 14,000 cubic kilometers, about 20 per cent of the earth's fresh water could be diverted to irrigate the arid American West. But irrigation requires a flow of water, not a stock. The Great Lakes are an immense stock maintained by relatively small inflows and outflows. The St. Lawrence River, which is the outlet of the Great Lakes, represents the maximum sustainable flow that could be taken from the Lakes without draining them away. Its flow is only 210 kilometers a year. If more water than that were taken out for irrigation, the stock of water in the Great Lakes would decline, and they would slowly become the Great Mud Holes.

Non-renewable resources, like oil, coat, or non-recharged groundwater, are huge stocks with no significant inflows. There is only so much of them. Human beings can drain them at almost any flow rate, but the faster the stock is used, the sooner it will be gone.

3. Systems are made up of interconnected stocks and flows. The stock/flow configurations of non-renewable and renewable resources are different; therefore these two kinds of resources need to be managed differently.

The use of non-renewable stock- resource such as fossil fuels or fossil groundwater can be only temporary. The primary decision in managing them is the choice of how fast they should be used up, how long they should last. Obviously they should be used with utmost efficiency and never wasted- they are irreplaceable. The best use of a non-renewable resource is to finance the creation of a stock of capital, technology, and training for the inevitable shift to a substitute renewable resource.

Renewable resources, such as forests, rivers, fish, soil nutrients, are moderate-size stocks with significant inflows. Furthermore, the inflows depend to some extent on the size of the stocks (up to a limit). More wood will be added to the forest if there are already more trees there. More fish will be brad the more parent fish there are.

Human beings can only draw from renewable resources at a limited flow rate- only so much water flows down the river at a time- but if the resource is managed sustainably, that rate of use can go on forever. *The sustainable yield from a renewable-resource stock is its inflow rate, not its entire content.* A forest can yield sustainably each year not the total amount of standing wood, but only the amount by which it grows. If more than that is taken, the stock declines, and so does the yield. The same is true for fish, for groundwater, for pasture grass, for livestock, for wildlife.

Proper management of renewable resources involves balancing the flows; never permitting more outflow than there has been inflow. It also involves building up the size and health of the productive stock and protecting the soils, waters, air, and other factors that nourish that stock, so that the inflow, and hence the sustainable yield, can be as high as possible.

4. Systems are organized into *hierarchies,* which means that everything is connected to everything else, but not equally strongly.

Fortunately for our ability to understand the world, the interconnections in systems are not equally dense everywhere- so we don't have to think about absolutely everything all the time. Most systems are organized into subsystems, which are partially decoupled from each other.

For example, a cell in your liver is a densely connected and semi-autonomous subsystem of the liver. The liver itself is a semi-autonomous subsystem of your body, which is a subsystem of several social groups-a family, an athletic team or musical group, a working place-and those groups are subsystems of the nation and the global socioeconomic system. When we are dealing with one level of this hierarchy, we usually don't have to focus on other levels. If we are talking about your job, we don't have to think about your liver cells (usually), or about global trade patterns (usually).

There are just enough exceptions to this rule (your work performance may suffer because you are an alcoholic and your liver cells are dying, or your job may be eliminated because of economic competition from another country) to make the point- everything is connected to everything else. But all the connections are not important all the time. The problem is to recognize when one has to pay attention to the whole hierarchy, and when it is sufficient to concentrate on one level or piece of it. To do that, one has to be able to back off periodically and see the whole- to think globally.

Natural systems, such as the human body or a tropical forest ecosystem, are designed so that subsystems take care of most of their own needs and purposes yet simultaneously serve the needs of the larger aggregate system. This harmony between the subsystems and the total system creates tremendous stability, resilience, and efficiency. Every species in a rain forest maintains its own integrity yet contributes to the interlocking web that constitutes a productive ecosystem. Every organ in your body "does its own thing" but in such a way that the health of each organ adds up to the health of the whole organism.

Systems can malfunction if the balance between subsystem welfare and total-system welfare is disturbed. If a team member is more interested in personal glory than in the team winning, that can cause the team to lose. If a single cell starts to multiply wildly without regard to the surrounding organ, it is a cancer, and eventually it kills the system. A subsystem's goal cannot be allowed to subvert the total system's goals.

Inversely, too much central control at the expense of subsystems can also be a problem. If the coach of a team tries to control every move on the field, that interference with the players' natural instincts and on-the-spot perceptions can undermine the team's play. If the brain had to dictate every detailed process within every organ and cell, it would be overwhelmed with information, signals would be delayed and garbled, and co-ordination would break down.

A system functions best if its individual parts have just the right amount of autonomy and the central coordinating mechanism has just the right amount of authority. Overview and coordination of the whole is necessary, but freedom for subsystems to respond to local conditions and deal with minor problems on their own is necessary too.

5. Natural systems are finely tuned, stable and resilient. Diversity usually increases this resilience.

The chemical reactions in the human body can proceed only at temperatures within a small range around 37 degrees centigrade. Higher or lower temperatures cause a breakdown of the system and death within a short time. Therefore the body has powerful control mechanisms to keep its temperature stable within the necessary range- shivering, sweating, differential blood flows, changing metabolic rates, and the instinct and intelligence to seek shelter, develop clothing, invent heating and cooling machines. Because of these mechanisms, humans can exist within wide temperature extremes.

But there are limits. As the surrounding temperature becomes hotter or colder, the system becomes more stressed. It can endure the stress for shorter and shorter periods. Though the temperature-regulation system of the body is extremely resilient, sufficient stress can overcome it.

Every natural system has a range of endurance, within which things remain stable, beyond which things fall apart. A tropical forest can sustain a small patch of clearing and regenerate itself, but as the patch becomes larger, the recovery time becomes longer, until a :point ‘is reached when recovery is no longer possible. A river or lake can process a certain amount of organic waste and keep itself clean and its living species alive and healthy. But if the rate of waste input exceeds the self-correcting capacity of the system, the micro-organisms that do the cleaning can be poisoned, and the system can turn quite suddenly from a living waterbody into a dead and stinking sewer.

Usually the more complex and diverse a system is, the more species or different kinds of elements are in it, the more interrelationships and control mechanisms it has; the more ways it has to fight against outside stresses, the wider is its range of stability. It is more resilient. Conversely, as diversity is decreased, a system becomes less resilient, more vulnerable.

A soil full of many species of microorganisms and much organic matter can muster natural enemies to fight against pathogens. It has numerous ways of absorbing and holding water. It can produce just the right organism to release nutrients from any form of organic matter. It can resist erosion. A nearly-dead soil with few species can do none of these things and is likely to be infertile and easily eroded.

A forest or a salt-water estuary with many interdependent species holds together like a strong net with many interlinkages. If one species decreases in number, its predators will be able to find something else to eat for awhile, while that species recovers. A surge of some nutrient will produce a population increase of some species that eats that nutrient, thereby bringing the nutrient back into balance.

In human affairs too, diversity can increase stability. If the whole world were dependent only on oil for energy, then any interruption of the oil supply would threaten everyone. With many technologies that use many kinds of energy, there is less vulnerability to supply interruptions. The more ideas, the more different ways of doing things, the more diverse the resources used and the products produced, the more stable- and the more interesting, lively, and innovative- is the economy.

Since a self-sustaining system can take a good deal of abuse before it is pushed beyond the threshold of its resilience, its breakdown can come as a surprise. We have always put our sewage into this lake and it was clean, now why has it suddenly turned dirty? We have always cut firewood from this hillside, now why have the trees stopped regenerating and the soils washed down the hill? By putting more chemicals onto this field we have been getting higher yields, now why with still more chemicals are the yields going down? We have always fished here, now where are the fish? Unpleasant surprises like these do not happen when the self-correcting mechanisms in the system are enhanced, when internal diversity is preserved, and when the system is not pushed beyond its limits.

D. Population Growth and Carrying Capacity

> Every human society is faced with not one population problem but with two: how to beget and rear enough children, and how not to beget and rear too many.
>
> *Margaret Mead*

.

1. Populations of living organisms tend to grow exponentially, when they are able to grow at

One bacterium divides into two. The two divide into four. The four become eight, sixteen, thirty-two, sixty-four. After 10 divisions there are over 1,000 bacteria. After 20 divisions there are over 1 million!

Every population of living organisms, when it grows at all, has this potential to grow explosively. Mathematically, this kind of growth is called *exponential;* it means that the amount added to the growing quantity is a function of the quantity already there. The more bacteria are there, the more new bacteria will be added. The more plant biomass, the more new plant material can be generated. The more cattle, the more new calves can be born. The more people, the more new babies.

It is no accident that living things grow exponentially, when they grow. They do so because they grow out of themselves-the more there are, the more can be generated. Rates of exponential growth vary tremendously. A population of bacteria can double within half an hour. A population of human beings doubles, at the fastest, within about 20 years.

But the basic exponentiality- small numbers added at first, then more and more as the breeding population increases-is characteristic of all life. It is the reason for the exuberant numbers of all kinds of living creatures everywhere on the planet.

Of course exponential growth cannot persist for very long within any finite place. If every bacterium really did double every half-hour it would only take a few weeks for a mass of bacteria to become greater than the mass of the entire earth. Most of the time populations are held in check by some limit- food or water or living space-which keeps birth and death rates equal and populations roughly constant. Only occasionally are resource limits lifted so that there is a possibility of exponential population growth. Every population of living creatures is ready for such an occasion; empty ecological niches are quickly filled.

2. The limit to the rate of production of any renewable resource base puts an upper bound, called the carrying capacity, on the number of organisms that can be sustained on that resource base.

The carrying capacity of any ecosystem or resource base is the number of creatures that can be sustained indefinitely by that system. The concept of carrying capacity was first formulated by pasture managers. It was the highest number of cattle or sheep that could be stocked on a range without degrading the soil or vegetation.

The determination of carrying capacity for a single species-cattle-eating a single or limited number of species-grass-is not too difficult. But even in such a simple case, the carrying capacity cannot be stated very precisely. It depends on the rate at which the grass grows, which in turn depends on uncertain and variable factors such as weather. It depends on the activities of the grazing species, which might manure the land, or tear up the soil, and it depends on human management, like fertilization or irrigation.

Though theoretically it is difficult to take all these factors into account, empirically a carrying capacity can be measured. Put different densities of cattle on the range for long periods of time, and observe whether the grass and soil are improving, staying constant or declining. The number of cattle at which the productivity of the range stays constant is the carrying capacity.

Natural ecological, systems maintain populations at or below carrying capacity automatically. Human-controlled systems have to do it by management. Though the maintenance, of populations below the carrying capacity is a complex task, it is crucial for long-term sustainability. Exceeding the carrying capacity can destroy the resource base entirely, or reduce the carrying capacity irreversibly. Therefore it is essential to be aware of the carrying capacities of more complex systems, which have far more important implications than pasture-stocking. Most difficult and most important of all is the maintenance of the human population below the carrying capacity of the earth.

The carrying capacity for the human population depends upon what flows of products a single human being demands (which varies with lifestyle and with efficiency), what technologies are being used to convert resources into finished products, and what is happening to the wastes from the human economy. These factors are constantly changing, and they all affect each other. The carrying capacity for human life and society is not simple or fixed; it is complex and *dynamic:* it moves up and down, depending on how wel1 human beings manage their environment.

3. The carrying capacity is defined by its most limiting, not its most abundant, component.

When you bake bread, you must put in yeast to make it rise. If you leave out the yeast, it doesn't matter that you had enough flour and water. The bread depends on all its ingredients, and its success is limited by the single most limiting factor.

Maize needs nitrogen in the soil to grow. You can put on phosphate, but that will not make the maize grow if nitrogen is insufficient. The rate of growth of the maize is determined by whichever of more than 40 known nutrients is most limiting, not by the ones in excess.

Similarly, although energy constitutes only about 5 per cent of the input cost of a typical industrial economy, if there is no energy, all industry lies idle, no matter how much labour or raw material or capital may be available.

The carrying capacity is defined by its most limiting factor. It is like a chain whose strength is determined by its weakest link.

The most limiting factor may change over time, and one limiting factor may change another. Nitrogen may be the limiting factor slowing the growth of maize, but putting on nitrogen fertilizer will allow growth only up to the point where phosphate becomes limiting, or water, or something else. Soil acidity or alkalinity may not be a limiting factor in itself, but it may cause the soil to bind and make inaccessible a limiting soil nutrient.

A system with high variability, such as a grazing range subject to periodic drought, has a lower carrying capacity than a similar range with rainfall that comes in a more regular pattern. The carrying capacity is defined by a system's *minimum* ability to support life, not its average. Therefore, technologies that smooth out variations, such as reservoirs to store variable rainfall, effectively raise carrying capacity.

4. Carrying capacities can be enhanced or degraded by human activity.

All species actively affect the carrying capacity of their own resource base, but human beings, with their intelligence, tools, technologies and organization, do so most of all. We have an enormous ability to tear down, or to build up, the fruitfulness and stability of our environment.

On a global average, humans are probably doing more tearing down than building up. In many places soils are eroding faster than they are being formed, forests are being cut faster than they are growing, groundwater is being pumped up faster than it is being recharged, pasture is being grazed faster than it is growing back.

But there are also places in which human care, effort and cleverness are clearly increasing carrying capacities. Here are just a few examples:

- A 360-acre grain-and-cattle farm in Kutztown, Pennsylvania, USA is being managed according to modern, soil-conserving organic technologies. No commercial fertilizers or pesticides are used. Soil nutrients are built up through return of manure to the soil and rotation of grains and legumes; pests and weeds are controlled by rotation, knowledgeable timing of planting, and cultivation. Yields are at or above the county average. Soil erosion is minimal. The soil is improving in organic-matter, fertility, and water holding capacity.
- South Korea's villagers have planted over 800,000 hectares of village woodlots. These carefully managed woodlots are now supplying all village fuelwood needs, have raised village income an average of 15 per cent, have controlled water runoff patterns and reduced flooding and drought, and have resulted in a variety of small businesses in much rooms and wood products.
- The Afforestation and Sand Control Institute in Xinjiang, China is now raising melons and grain where there used to be nothing but desert. 14,000 hectares of arable land were created by leveling sand dunes, mixing them with the soil, and digging irrigation ditches. The new fields are protected from the harsh desert wind by a checkerboard pattern of shelter belts- strips of trees selected for their ability to grow in arid climates. Because of the protection of the trees, wind speeds average 30 per cent lower than outside, and evaporation is 12-25 per cent less. Grain yields have gradually risen from 1,500 kg/ha to 3,000 kg/ha.
- In Senegal a programme of interplanting millet and peanut crops with a nitrogen-fixing acacia trees is doubling crop yields and at the same time reducing the need for purchased fertilizer, reducing erosion, and catching and holding more water.

5. Efficient use of resources-doing more with less-increases the number of people that can be carried on a resource base.

A cow on a grazing range does not have much choice about how much grass it needs to eat to be healthy and grow. By choosing different breeds with different feed absorption efficiencies, human beings might be able to, stock a few more animals on a range, but basically that carrying capacity is better increased by improving the productivity of the range than by reducing the consumption of the cow.

The same is not true for human beings, who through their own ingenuity have a wide variety of choices for how to satisfy their needs. For instance, if a house is heated by electricity made from burning oil, the majority of the energy in the oil is lost as waste heat at the electrical generating plant. By this process not many houses can be heated with a given amount of oil. More can be heated if the waste heat at the generator can be captured and piped into houses through a district heating system; still more if the oil is burned directly in the houses without being made into electricity. If the houses could be designed to be heated by the sun and could be well-insulated so little heat is lost, no oil would be needed at all. All these options produce a well-heated house; some of them use much less oil resource than others.

Good farmland can produce up to 6,000 kg of grain per hectare; enough to feed 20 people if the grain is consumed directly (300 kg of grain per year provides more than a subsistence diet). If, however, the diet is that of atypical North American, 800 kg of grain per person is required, most of it fed to animals to produce meat and milk products. At that living standard, a hectare can support fewer than eight people.

Industry is an enormous consumer of resources, a great burden on the earth's carrying capacity, but some elegant industrial technologies provide amazing examples of doing more with less. Silicon chips with micro-circuitry permit everything from radios to computers to be made from far less material and at the same time to perform faster and more reliably. With new fiber technology one hair-thin strand of ultrapure glass can carry as many telephone conversations as 625 copper wires, and with greater clarity. Biotechnology offers the possibility of carrying out complex chemical reactions with less heat and pressure, less energy, less industrial plant, and less pollution than before. Superconductors may increase enormously the efficiency of electrical transmission. Light bulbs are now made that are so efficient that, if they were installed everywhere in the United States, at least, 50 nuclear power stations would no longer be necessary, but the amount of illumination would be the same.

In terms of drain on the earth's resources, the average Swiss using current Swiss technology consumes as much as 40 Somalis. The carrying capacity of the earth is 40 times lower for people living in Swiss lifestyle than for people living a Somali lifestyle.

The point is not that the Swiss or the Somalis live the right or wrong lifestyle; nor is it that everyone's living standard should be reduced to a minimum in order to allow the earth's carrying capacity to be loaded to the maximum. The point is that there are many choices, and many ways to do more with less. More food can be grown on less land, houses can be heated or cooled with less energy; food can be cooked with energy efficient stoves; electronic signals can be transmitted with less metal; and human happiness can be attained with less material and energy flow-through. All those choices reduce the danger of the earth's population exceeding its as-yet-poorly-understood carrying capacity.

6. Restoration of a degraded carrying capacity is far more difficult than preservation; prevention of damage is cheaper than cure.

The Dalmatian coastline of Yugoslavia used to be a great forest, from which the Venetian empire harvested lumber to build ships. Now, after centuries of deforestation and erosion, the mountainsides of that coast are bare white rock, supporting almost no vegetation. Only the barest of livings, after great effort, is possible from those bleak hills now. It would take unimaginable effort and expense to reestablish the forests and soils that were once there.

Lake Balaton in Hungary has become so polluted from tourist settlements and agricultural runoff that the fish are dying, the waters are murky, and the tourist industry is threatened. Hungary has made the commitment to restore the lake's water quality, at an expense of hundreds of millions of dollars. Recovery measures include the installation of sewage treatment plants and storm drains, the dredging of lake basins, the banning of the use of phosphate-containing detergents, and the restoration of thousands of hectares of swamps that used to filter nutrients that otherwise would go into the lake. It would have been much less expensive to preserve the swamps in the first place, and to install proper sewage treatment facilities as development occurred, than it will be now to take those measures after the damage has already been done.

In 1973 the U.S. Army Corps of Engineers straightened and shortened the Kissimmee River in Florida in order to drain swampland for development. The project cost$ 21 million. Now the state of Florida is spending $150 million to undo it. The straightened rivers turned out to increase both floods and droughts; it increased the pollution of Lake Okeechobee into which it flowed; and it caused the elimination of many wetland species of life. It is hoped that restoration of the river to its original channel will slowly repair the environmental damage.

Seagrass beds in shallow tropical waters are often disturbed or destroyed by pollution or by dredging, filling, and construction. Natural recovery, if it occurs at all, takes decades. Without the seagrass to breed in and feed on, fish and shellfish populations decline. Bottom sediments that were held in place by the grass roots begin to drift with the waves and often fill in the harbours or channels that were the cause of the seagrass destruction in the first place. Seagrasses can be replanted, painstakingly and expensively. A recent restoration project in Biscayne Bay in Florida cost nearly a million dollars to restore 15 hectares.

Once a species of life disappears, no amount of money or effort can bring it back.

In short, it is usually far less expensive to prevent damage to an ecosystem through proper management than to repair that damage once it has occurred. Some kinds of damage cannot be repaired at any price.

E. Ecologically Sustainable Development

Under the influence of intellect and human labour the biosphere changes into a new state-the noosphere. In the noosphere humans for the first time become a mighty geological force. They can and must reconstruct the sphere of their lives with the help of their labour and intellect. *V.I. Vernadsky* .

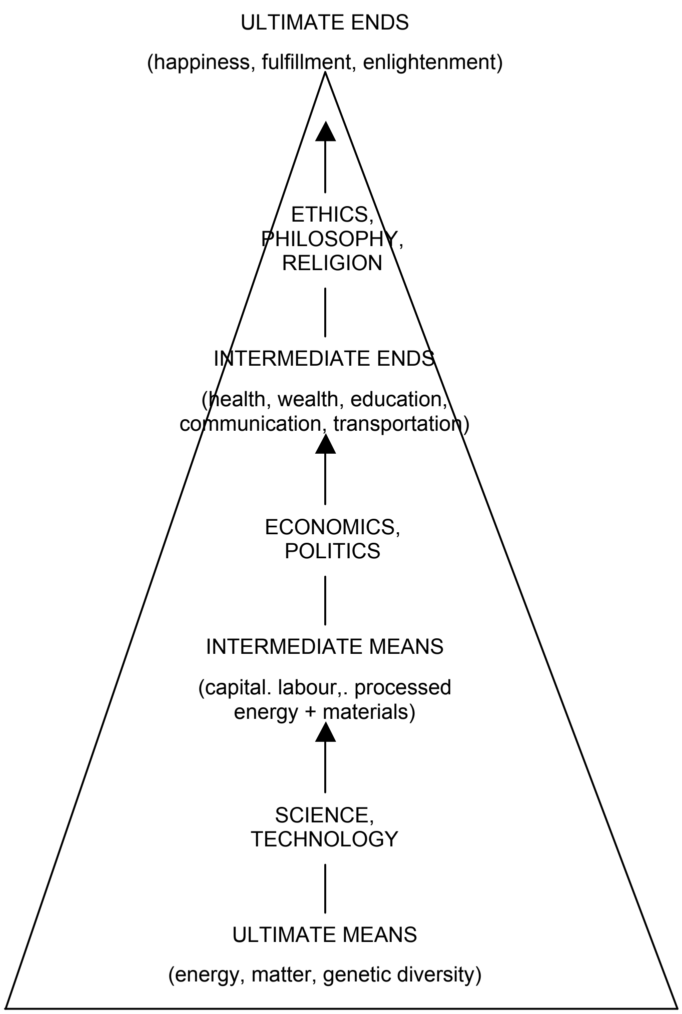
1. Human wealth and economic development ultimately derive from and depend upon the resources on the earth.

There are many arguments in the economic literature about what is the basis of all wealth, the one thing without which economic activity could not occur. The first theorists thought the basis of wealth was land. Marx said it was primarily human labour. Capitalist economists thought that capital, either in the form of tools and machines, or in the form of money and credit with which to purchase tools and machines, allows all production to happen. Recently, during periods of energy shortage, a theory of energy as the basis of all value has been developed.

All these theories are partly right and not complete. The productive system requires all these things and others too- land, labour, capital, energy, technology, credit, skills, raw materials, water, management and the natural cleansing and recycling services of the environment. Whichever factor is most limiting at any one time is the one that determines the actual level of production. Therefore, one can say equally correctly that labour is the source of all wealth, or that capital is, or that the energy and materials of the earth are.

More useful than arguing over which of the factors of production is most important is to understand how they interrelate. Herman Daly draws the economic system as a pyramid, with the earth's resources at the bottom, and the ultimate human purposes at the top.

The *ultimate means*, at the bottom of the pyramid are the fundamental matter and energy of the planet-sunlight, water, minerals, soils, fossil fuels and living things from bacteria, earthworms, honeybees, forests and



fish, to crop plants, domestic animals, and human beings. Included in the ultimate means are the store of genetic information for all the species of life, and the large-scale biogeochemical cycles that make up the life-support system. These ultimate means are all he material and energy that humans have to work with to do anything. We have not created them, we cannot increase them, though we can, through mismanagement, diminish or destroy them.

Intermediate means, the next level up, are ultimate means that have been refined and processed by human beings toward human goals. They include productive equipment of all kinds, tools and machines, processed raw materials, tapped and usable forms of energy, and organized human labour at every level of skill. Intermediate means are generated from ultimate means through knowledge, technology, and social organization. When we say that more know-how allows humanity to "create more resources", what we mean is that the ultimate means can be converted more easily or cheaply or thoroughly into intermediate means.

Intermediate means are what economists would call inputs to the next level up the pyramid, the *intermediate ends*. These are the things societies usually measure as outputs and achievements health, wealth, production, education, transportation, communication, gross national product. The conversion from intermediate means to intermediate ends is governed by political and economic systems. These systems are more effective and efficient if they allow intermediate ends to be achieved more easily, with fewer intermediate means.

At the top of the pyramid are the *ultimate ends* whatever human goals are good in themselves and not as a means toward any other end. Ultimate ends are not concrete, not easy to measure or define, but they can be suggested by abstract words such as enlightenment, fulfillment, happiness, love, harmony, community, identity, satisfaction, quality of life. Intermediate ends are transformed into ultimate ends by the precepts or insights of philosophy, ethics, religion, culture, individual inner wisdom.

The attainment of ultimate ends depends on every part of the pyramid and on effective processes at every step: Having plenty of material goods, health, and education does no good, if one does not know how to turn them into happiness and fulfillment. Having land, labour, capital, energy in abundance does not help, if the political and economic systems use them wastefully or inequitably. Having a bountiful earth is not enough, if there is no effective technology for harvesting the bounty. And, of course, having technology, politics, economics, and ethics all in place does not help, if the foundation of the pyramid, the earth's material, energy, and biological systems are not healthy.

Real development means improving the operation of the entire pyramid, at every stage of conversion, while preserving the integrity of the ultimate planetary means that are the foundation of it all. And there should be no doubt about it; sustained development is simply impossible if environmental degradation *is* allowed to continue.

2. The earth's resources are sufficient for all living creatures' needs, if they are managed efficiently and sustainably.

There is enough food raised on the planet every year to provide every person with a full, varied, and healthy diet. There is enough clean water to support at least one more population doubling. The solar energy falling on the earth's (and area each day averages eight thousand times as much energy as our current worldwide civilization uses from all other sources.

Gandhi said: "the earth is sufficient to provide for everyone's need but not for everyone's greed."

Numerous studies have attempted to measure the quantity of fresh water, soils, minerals, fuels, and arable land on the planet and to calculate whether these resources are sufficient to support the earth's present and future populations. None of these studies can be said to be definitive; there is much we don't know about the earth's capabilities and about future human requirements. But all the studies conclude that, as far as we know, and except for some local cases, there is as yet no absolute resource scarcity. There should be enough soils, waters, materials, and energy to meet the basic needs of at least one more population doubling on earth, *if* those resources are wisely managed an equitably distributed.

The human mind seems to perceive the earth's resources either through a context of *scarcity*- there is not enough to go around- or a context of *abundance*- there is so much that it is inexhaustible. Neither of those perceptions agrees with the facts as we know them, and neither leads to good management.

A context of scarcity leads to frugality and conservation, but also to hoarding and injustice. If there is not enough, then I have better get my share and hold onto it, no matter whether you have enough.

A context of abundance permits generosity, creativity, and playfulness, but also waste and squandering. If we will never run out, there is no need to use what we have efficiently or wisely.

In between the two extremes of scarcity and abundance is an intermediate range called *sufficiency*: there is enough to satisfy the needs of everyone, but not more. Generosity can be supported, but not wastefulness; frugality is in order, but not miserliness. Sufficiency best expresses our actual knowledge about the fruitfulness of the earth, and it is clearly the best assumption to make to guide wise management.

3. Both poverty and affluence can cause environmental problems.

In the industrialized countries at least 3,000 km^2 of prime farmland disappear every year under new buildings and roads.

In the non-industrialized countries the rural poor, because they have no other fuel source, burn 400 million tons of dung and crop residue every year, material that should go back to the soil to restore nutrients.

In the world's rich countries about half the surface water and a significant amount of groundwater has been polluted with industrial wastes.

In the world's poor countries, 60 per cent of the people have access only to water that has been contaminated with human and animal wastes.

Environmental problems do not occur exclusively where people are rich or where people are poor; they occur everywhere. Becoming rich and industrialized does not automatically solve environmental problems: rather it generates a whole new set of them.

The environmental problems of the poor usually come from a high dependence on nearby resources, and a lack of choices. Simply to survive they must strip forests for cooking fuel, overstock grazing ranges, cultivate hillsides where the soil washes away in the rain, overhunt or overfish. They often know that they are destroying their productive base with these activities, but they have no alternative.

Education and wealth can solve these environmental abuses by offering more choices. For those who can afford them, kerosene or electricity or more efficient stoves can cook the food and save the forests. Higher yields using modern agricultural methods on flatlands can reduce the necessity of cultivating hillsides. Other productive activities can replace the need to overharvest forests, animals, or fish.

But economic development brings with it a much higher demand for the earth's resources. The 25 per cent of the world's people who live in the industrialized world consume 80 per cent of the resources mobilized each year. Furthermore, development tends to put a large physical and mental distance between production and consumption. A person can turn on an electric appliance without thinking that that electricity requires coal to be strip-mined, to be trucked to a generating plant, to be burned with the release of acids and heavy metals into the air. The environmental problems of industrialization come not so much from lack of choices as from lack of awareness, lack of regulation, lack of information, lack of an attitude of stewardship, lack of a holistic perspective.

The simultaneous presence of poverty and affluence on our planet creates not only the distinct kinds of environmental problems resulting from poverty and affluence, but also some problems that come from linkages between the two. If a rich person owns all the good land in the valley, then the poor people will be forced to farm the erosion-prone hillsides. If a rich country offers good prices for imported beef, a poor country will cut tropical forests to graze cattle to produce that beef.

Just as environmental problems are not a simple function of wealth, neither are environmental solutions. Some societies that are poor in material terms have evolved sophisticated ways of protecting their environment and using it productively and sustainably. The natives of the South Pacific island of Tikopia, for example, had strong rituals that controlled their birth rate, so that the island would never be overpopulated. Traditional homesteads on Bali incorporate complex systems of intercropping, aquaculture, and animal care that recycle virtually all organic matter, never leave the soil bare to erosion, reduce pest infestations, and maintain high productivity. The Native American societies carried out hunting, fishing, and agriculture for many generations with no known degradation of the ecosystem.

Similarly, some highly-industrialized societies are finding ways to use their technical sophistication to solve environmental problems:

- Several small cities in Japan have clean, mechanized waste-recovery centers that return every form of urban waste to a useful purpose organic matter is composted into 'fertilizer, bottles are washed and refilled, metals are reclaimed, paper is either recycled or burned to produce heat and electricity for homes.
- The German Democratic Republic uses careful pest monitoring and a computerized information network to reduce pesticide spraying only to times when there is an actual pest outbreak (and in the process has reduced use of some pesticides by 80-90 per cent).
- Israel has pioneered water-conserving technologies so efficient that over the decade 1968 to 1978 it doubled agricultural production while water use per hectare of irrigated land fell 21 per cent.
- The average new car produced in the United States in 1987 traveled 90 per cent farther on a litre of gasoline than the average new car of 1973. The average new refrigerator now uses only one-third as much electricity as the refrigerators of 1972. Between 1973 and 1986 the United States saved, the equivalent of 10 million barrels of oil per day through more efficient energy use, thereby producing less pollution and saving $30 billion per year in oil imports.

Economic development in itself is neither the cause nor the cure of environmental problems. It can help to solve those problems, but only if it is accompanied by an attitude of responsibility and stewardship for the earth.

4. Economic development and care for the environment are compatible, interdependent, and necessary.

Too often environmental protection and economic development are seen as conflicting goals. Our un-systematic minds perceive a separation between nature and humanity and tell us that we must choose one or the other, defend one against the other, or sacrifice one to preserve the other.

Of course that apparent trade-off between man and nature is nonsense. Human beings are part of the environment. The economy is derived from and sustained by nature. To be stewards of the planet means not only to care for other species, not only to care for the planetary cycles and processes, but also to care for each other. To be our brothers' and sisters' keepers, to love and serve, feed and clothe humanity; also means to love and serve the planet that sustains humanity. When we see the system whole, that becomes obvious.

Nevertheless, in the short term, there are very real trade-offs. A new hydroelectric dam will flood farmland or wilderness. If the tropical forest are not turned into grazing land, income from beef exports will be lost. If nuclear waste materials are not dumped into the ocean, the cost of nuclear energy will be much higher. If the fishing fleet stays within sustainable catch limits, less fish will be caught.

Sometimes there are indeed stark and difficult sacrifices of environmental resources for economic resources, or vice versa. But many apparent dilemmas of this sort come from looking at the problem with too narrow a focus, over too short a time horizon.

Catch limits can cause some fishermen to be unemployed, but if overharvesting destroys the fish population, all of them will be unemployed. Just as a manufacturing industry is not economically healthy if it is letting its productive stock of machines deteriorate, a fishing industry is not sound if it is using up its basic productive capital, the breeding stock of fish. A total-system long-term view makes it clear that fish catch should be limited to sustainable levels, and that some compensation or retraining may be needed if there ate too many fishermen.

Improper disposal of nuclear waste may make nuclear-generated electricity seem less expensive than other energy sources, but that is bad accounting. Damage caused by wastes is a real cost, though it may occur in some other part of the economic or ecological system. To make rational choices among alternative energy systems, we have to take all costs into account. That may make some undertakings look more expensive, but the truth is that they are more expensive. When that truth is revealed by proper accounting, better decisions are made about what technologies to adopt.

Even the most destructive economic activities can be carried out in a way that respects the environment, and often doing things in an ecologically-conscious way, which always pays in the long term, pays in the short term as well:

- A deep molybdenum mine has been opened in the middle of a beautiful national forest in the mountains of Colorado. It was designed with the consultation of local environmentalists. Great care is being taken so that the forest will not be disturbed. The tailings and waste water will be disposed of through an underground tunnel into a containment area far away. When the mine is finally exhausted, it will not be possible to tell it was there.
- In Hungary soft coal is strip-mined from under prime agricultural fields. The topsoil is saved and returned to the site, drainage patterns are restored, soil fertility is carefully rebuilt. A few years after the mining is finished, the area is growing wheat again.
- In mountainous, rainy Costa Rica the building of a road usually means landslides, a clogged or flooding stream, and severe disturbance of a whole watershed, not to mention a continuous need for expensive repairs of the road. A group of hydrologists and watershed experts has worked with engineers to lay out roads with the water flow patterns in mind, so as to disturb the streams as little as possible. As a result there is less silt and flooding downstream, and much less road maintenance is required.
- The 3M Corporation in the United States re-designed its manufacturing processes to eliminate each year 90,000 tons of air pollutants, 10,000 of water pollutants, 1 million gallons of waste water, and 15,000 tons of solid waste. As a result the company also save $200 million per year in operating expenses.
- While financing a large hydroelectric dam on the island of Sulawesi in Indonesia, the World Bank also included enough money to protect 300,000 hectares of forest in the watershed above the dam. The trees regulate water runoff and prevent the dam from silting up and losing its storage capacity. The forest also protects many endangered species and is becoming a research station in tropical ecology, bringing in foreign exchange from visiting scientists.

High productivity, modern technology, and economic development can co-exist with a healthy environment. They must co-exist, or the development will not be sustainable. In fact it will not even be real development, unless it integrates all, parts of the triangle, from the resources of the planet to human satisfaction and fulfillment.

F. Socially Sustainable Development

> If the people are to be able to develop they must have power. They must be able to control their own activities within the framework of their village communities. The people must participate not just in the physical labour involved in economic development, but also in the planning of it and the determination of priorities. At present the best-intentioned governments-my own included-too easily move from a conviction of the need for rural development into acting as if the people had no ideas of their own.
>
> *Julius K. Nyerere.*

1. The key to development is the participation, organization, education and empowerment of people.

E.F. Schumacher points out in Small is *Beautiful* that at the end of the Second World War both Europe and Japan had greater political and social disruption, less capital, fewer functioning factories, fewer natural resources and less wealth than many Third World countries did. Yet in the forty years since, Europe and Japan have experienced astonishing economic recoveries. The essence of that development could have had nothing to do with initial material advantage. Rather, it must have sprung from a history of education, motivation, and organization of the people.

"Organization, education, and discipline" are the characteristics Schumacher identifies as essential to development. We might add to that list unity-the cultural habit of emphasizing commonalities rather than differences-and empowerment-the idea that problems can indeed be solved and that people are capable of solving them. Schumacher elaborates:

> Economic development is something much wider and deeper than economics. Its roots lie outside the economic sphere, in education, organization, discipline and, beyond that, in political independence and a national consciousness of self-reliance. It cannot be produced by skilful grafting operations carried out by foreign technicians or an indigenous elite that has lost contact with the ordinary people. It can succeed only if it is carried forward as a broad, popular movement with primary emphasis on the full utilization of the drive, enthusiasm, intelligence, and labour power of everyone.

Many ideas about development are production centered. They focus on credit and machinery, on exports and imports and competition on world markets. They measure success in GNP- the output of final goods and services-without asking who benefits from that output, who. pays the costs, what uncosted environmental resources may have been degraded, who participated in production, whether ultimate human purposes have really been served, or how long the production stream can be sustained into the future.

Sustainable development is not production-centered but people-centered. It assumes that the primary resource for development is the creative initiative of the people, and that the primary purpose of development is their material and spiritual well-being. It knows that in functioning communities, even where there is poverty, there are also ingenious survival strategies. People-centered development respects those strategies, and asks how to enhance the ability of communities to solve their own problems. It assumes that if people are not meeting their own needs, or if they are degrading their environment, there must be formidable obstacles preventing them from acting more effectively. It focuses on removing those obstacles.

For- example, Jaya Arunachalam of the Working Women's Forum in Madras, India, noticed that the poorest women of Madras had evolved a number of small businesses-laundries, butcher shops, mat weaving-but that these women were in debt to local money-lenders and paying usurious rates of interest. Jaya arranged small, low-interest loans from the Bank of India for these women, so the profits from the businesses could go to family welfare, rather than to interest payments. The women organized themselves in small groups to support each other in repaying the loans. The result was a doubling of family income, expansion of businesses, and a growing organization, now 20,000 strong, of women who have set up their own credit, educational, and political network, and who are helping each other help themselves.

Lack of reasonable credit is one obstacle to self-reliance. Others may be lack of knowledge- how to treat the blight on the cacao trees or how to avoid schistosomiasis- or lack of access to critical resources such as land or water, or a deep and debilitating lack of self-confidence. When these obstacles are removed and people pull together to solve their problems, miracles can happen.

The Sarvodaya Shramadana movement in Sri Lanka, a village self-help movement that began among the nation's poorest people, in one year built eight times as much roadway as the government, at one-eighteenth the cost, while it was also building schools and houses and irrigation canals. Here is a glimpse of how it was done:

> A village joins the movement by inviting a team of Sarvdaya organizers to visit (there are now 27,000 full-time organizers). A meeting is called in the temple, church, or mosque, and the people talk about what the village most needs. Then the planning begins, with everyone participating.
>
> "You say you have waited two years for the government to clean that canal? You can keep on waiting while your fields bake. But where is your own power? Your power is not in Colombo, it is in your heads and hands."
>
> "How can we clean the canal? We have tools but no pans to carry away earth. Is there a substitute for pans? Yes, we can use sheaves of leaves. How many people to do the job? Two hundred, working four days. How many volunteers can each one bring one other? Right, who will feed them?" A landowner volunteers to supply food. The canal is finished, not in four days but in the afternoon of the first day, and the people are ready to take on the next job.

Through processes like that one, in many parts of the world, forests have been planted, check dams have been erected to prevent erosion, clean water systems have been created, industries have started, all with little money and few resources except the crucial resource of organized, empowered people.

2. Sustainable development must be appropriate not only to the environment and resources, but also to the culture, history and social systems of the place where it is to occur.

Forty years intensive effort toward economic development have produced many case studies of both success and failure. Unsuccessful projects can usually be seen (sometimes only after the fact) as in some way inappropriate to their setting. Ideas, technologies or processes that have worked well in one part of the world are grafted hastily onto another part, where they may not fit at all. Temperate-zone agricultural methods are applied unthinkingly to the tropics. Hydroelectric dams are constructed on a scale too large for the region's electricity needs. Machinery is installed that requires more skilled maintenance or spare parts than are available. Export-based industries are started where what is really needed is basic subsistence for the local population.

Many successful projects, on the other hand, have been uniquely fitted to their circumstances. They have been based on a thorough-going knowledge of and respect for the people, the ecosystem and the indigenous natural resources. Often they are originated by the people themselves, who are, after all, the best experts on the local situation. The following are characteristics of these appropriate development projects:

- They are based on renewable and local resources rather than non-renewable or distant ones,

- They sustain and increase the yield of natural resources and they use resources efficiently, rather than exploiting them for short-term increases in production,
- They are undertaken on a scale small enough to permit diversity, flexibility and resilience against mechanical or social breakdown, rather than on a scale chosen for purposes of international comparative advantage,
- Ownership is broadly-based rather than concentrated, and owners are local and directly involved, rather than far away,
- Projects occur where the greatest numbers of people and the greatest needs are, which in most places means rural and agriculture-based development, rather than urban and industrial based,
- The projects produce basic foods and goods for the local population,
- They build on the strengths and skills already present in the population, but they also encourage the development of realistically attainable and useful new skills; they permit individual and social growth and evolution; they use not only human muscles, but also the human mind and human creativity,
- They respect and enhance the variety and productivity of the local ecosystem.

Some examples of appropriate technology have become world-famous. The barefoot doctor system of China departs from the curative and machine-intensive Western medical system and utilizes village health workers trained in the most basic (and largely preventative) first-aid hygiene techniques that were the most urgently needed by the population.

The system of "stone dams" in Africa reduces erosion and flash floods with the simple device of stone walls laid out along the contours of the land-and the contours are surveyed with great accuracy by watching how a drop of water runs along a string tied between two sticks. It is a system that can be adopted by anyone, with little training and with resources near at hand.

The oral rehydration therapy saves the lives of children suffering with diarrhea not with expensive antibiotics, but with a sugar/salt solution that any mother can make.

The interplanting of coffee fields with *Eryhrina* trees-a trick long known to Central American farmers-shades the coffee, holds down erosion, and provides nitrogen-rich leaves either as a mulch for the ground or as feed for the animals.

Appropriate technologies like these sound simple and are relatively simple to execute, but they are based on sophisticated understanding of local needs and resources.

3. Development must be equitable.

No social system can be sustainable over the long run when the distribution of goods and bads within it is grossly unjust, especially when some pact of the population is consigned to chronic debilitating poverty. Whatever the allocation system is, it does not need to produce absolute *equality,* but it does need to produce *equity,* meaning fairness. People need to understand the reasons why some have more than others, they need to approve of those reasons, and they need to feel included, motivated, and fairly rewarded by the economic system. If there is no way, even by the hardest work, that people can provide decent lives for themselves and better themselves, they will eventually drop into sullen non-co-operation or rise in outrage.

"The rich get richer" is an old saying with a real grounding in the way social systems work. If a little bit of wealth or power gives a person even a slight advantage to gain more wealth and power, a vicious circle is set in motion by which the rich do get richer and the poor get increasingly disenfranchised. It is like a game in which the winners gain the power to win more, but the game never ends, the cards are never shuffled and re-dealt, the playing field is never leveled, the sides are never changed, some people have to play all their lives with the sun in their eyes and the wind against them.

Some social practices have evolved to interrupt or counter the vicious circle of accumulating wealth and power. Some native American tribes had ceremonial occasions in which wealth was formally redistributed so all had an equal share. More modern redistributive arrangements include universal education; inheritance taxes so that each generation starts afresh; progressive taxes that put the major burden of government funding on the rich; public subsidy of basic needs like health care and transport; anti-trust regulations; democratic elections; removal of discriminatory hiring practices; various kinds of welfare and income-transfer programmes; famine relief systems.

Like technologies, mechanisms for social equity have to be appropriate to the culture and history of the people. But some means of establishing and preserving equity must be present, preferably a way that does not demean recipients, a way that does not raise the question of the worth of any person in society but rather that affirms the large social purposes of equitable distribution. Without such an equity restoring mechanism, the economy is likely to become grossly inefficient, because so many people are unengaged from it. It is also likely to become unstable and subject to violence.

4. Development involves the continuous balancing of opposites and the breaking down of barriers and separations between freedom and order,

groups and individuals, work and leisure, settlements and nature.

E.F. Schumacher distinguishes between *convergent* questions that have clear and correct answers (like: how far is it from the earth to the moon?) and *divergent* questions that need to be asked and answered over and over, with the answer constantly changing (like: how much discipline and how much freedom should a growing child be given?) Convergent questions tend to be scientific ones, about the physical nature of the planet. Divergent questions tend to be social, about the balancing of opposites in the course of living life.

The human mind perceives opposites everywhere and then has trouble integrating them. Freedom versus order, the individual versus the group, work versus play; man versus nature. We set up in our mind difficult either/or questions about these dualities. Which should have more power, the individual or the society? Which is more basic to life, work or leisure? Which should one do, follow the rules or think fog oneself? We search vainly for the Final Answers to these questions, which are wrongly formulated in the first place. The choice is almost never either/or, it is: both/and. The question is how to achieve at appropriate balance. And there is no Final Answer the: answer changes constantly as the circumstance: change.

Ivan Illich recognizes the need for balance between freedom and social limits on freedom when he describes what he calls a convivial society:

> "A convivial society would be the result of social arrangements that guarantee for each member the most ample and free access to the toots of the community and limit this freedom only in favor of another member's equal freedom..: No one person's ability to express him- or herself in work will require as a condition the enforced labour or the enforced learning or the enforced consumption of another... A convivial society should be designed to allow all its members the most autonomous action by means of tools leas controlled by others. People feel joy, as opposed to mere pleasure, to the extent that there activities are creative."

And here are three comments on work, all of which are trying to break down the mental barriers we erect between our work and the rest of our lives:

> "To organize work in such a manner that it becomes meaningless, boring, stultifying, or nerve-wracking for the worker would be little short of criminal; it would indicate a greater concern with goods than with people.... Equally to strive for leisure as an alternative to work would be considered a complete misunderstanding of one of the basic truths of human existence; namely that work and leisure are complementary parts of the same living process and cannot be separated without destroying the joy of work and the bliss of leisure." *(E.F Schumacher)*

> "The craftsman himself can always, if allowed to, draw the delicate distinction between the machine and the tool. The carpet loom is a tool, a contrivance for holding warp threads at stretch for the pile to be woven round them by the craftsmen's fingers; but the power loom is a machine, and its significance as a destroyer of culture lies in the fact that it does the essentially *human part of the work*." *(Anarala Coomaraswami*

> "The trouble is, they don't make jobs big enough for people any more." (A *Chicago steelworker)*

Production does not need to be organized in a way; that endangers or diminishes people. Cities do not need to be designed to exclude nature. Societies can be orderly while individuals have freedom. Machines can enhance the expression of creativity and humanity without oppressing, demeaning, or physically harming the people who work with the machines. Production and profit can be consistent with craftsmanship and art. Human beings can see themselves as both part of nature and ultimately responsible for nature, as creatures who are both strongly predetermined and also capable of exerting free will. Economic development can be people-centered and nature centered, without sacrificing production.

The primary barrier to the simultaneous achievement of both sides of such dualities is the deep-seated belief that both are not possible, that the problem is to make a permanent choice, rather than a continuously re-examined and re-adjusted balance.

G. Knowledge and Uncertainty

Knowledge alone or ignorance alone leads man into darkness. The union of fitting knowledge with fitting ignorance is the nectar of eternity. *Vinoba Bhove.*

1. We don't fully understand how the world works; we don't even understand how much we don't understand.

Sometimes when we see the stars on a dark night, or look into microscope, or hear physicists talk about sub-atomic particles, or touch a newborn baby., we remember what mystery we live within. Sometimes when we see a dog respond to a wavelength we can't hear, or a honeybee navigate by polarized light we can't see, or watch a flight of birds on a migration across continents, we realize there are powers we do not have and whole throbbing bands of radiation around us and within us that we do not perceive.

We do not know what the world really is. We have no grasp of its totality. We have only the models in our minds; complex abstractions of reality, wonderful ones that have made us a uniquely successful species, but simplifications after all, not the Whole of it. We have words for concepts like life, love, gravity, entropy, intuition, truth; electrons, evolution, but we don't know what they really are. We don't know what our minds are, or how they work. We don't know how we know what we know, and we cannot guess how much there is that we don't know.

And the amount we do seem to understand and the rate at which we learn are truly amazing. We can send spaceships to intercept comets; we can process information with microchips; we can transplant hearts. We are probing the depths of the oceans, the tops of mountains, the polar ice. We can read the genetic code and split the atom. Yet somehow, the more our curiosity and scientific progress reveal about our world, the deeper the mystery gets, the more questions are raised, the more wondrous everything seems.

We need to acknowledge two apparent opposites, both of which are true- we are remarkably knowledgeable and profoundly ignorant. Our pride in our accomplishments is appropriate, but it needs to be mixed with deep humility.

The incompleteness of human understanding of the world used to be a problem primarily for individual human beings, who would suffer their own losses from their own mistakes. As human numbers and powers have grown, however, more and more people, species, and ultimately the whole biosphere are in danger from the mistakes and misunderstandings of only a few people.

There are about 400 nuclear power plants on our planet, each of which produces radioactive waste products with half-lives of up to 24,000 years. Nuclear technology has been pursued as if someone knew with great certainty how to protect those plants from catastrophic failure, how to decommission them safety when their productive life is over, how to keep their wastes away from the biosphere and hydrosphere for tens of thousands of years. But no one knows these things. We are proceeding under an assumption of much greater knowledge that we actually have, and the risk in case of failure is tremendous. The same could be said, even more strongly, for the world's 50,0000 nuclear weapons.

2. We make decisions under grave uncertainty. When the results can be devastating and irreversible, we must manage the risks very carefully.

Human knowledge of how to manipulate genetic material bears great promise both for increasing the productivity of agriculture and for conquering human illnesses. But it also poses a threat to ecosystems and to society. No one knows how a genetically-manipulated bacterium or virus or grass might behave when released into the interconnected, balanced systems of the biosphere. No one knows what all the biological, economic, and social effects will be when bacteria implanted with cacao genes start producing chocolate in laboratories, so that it no longer has to be grown in the tropics. No one has thought through what it will mean when some people have power over genetic information and other people don't.

As the populations of Africa double and then double again, we do not know how many human beings can be supported on the magnificent but fragile resource base of that continent. As the world's industries create hundreds of new chemicals each year and manufacture them in enormous quantities, we do not know the effect of exposure to these chemicals on the human body or on other species. As the world burns billions of tons of fossil fuel and releases the resulting carbon dioxide into the atmosphere, we do not know how much of a climate change will be induced, when, or where; we do not know how the temperature, wind, and rainfall patterns of the planet are being disturbed.

We are doing things on a massive scale with the pretense of far more certainty that we actually have. The risks we are taking are breathtaking- in some cases we are risking the survival not only of present civilizations but of all future ones, not only of our own species, but of all species. We are not being honest about the risk. We are not behaving in a way that is appropriate to our true uncertainty.

3. In a situation of uncertainty, the appropriate procedure is careful assessment and slow experimentation, followed by constant, truthful evaluation of results and willingness to change strategies.

The need for a feeling of certainty comes from a particular managerial style that probably originated in the cultures of the West. It is a style of decisive leaders, definitive policies, boldness and vigour. It is not permissible in this mode. for a leader to admit that he (it is usually a he) does not know the answers, even if in fact he does not. Tremendous progress can be, and has been, made from this approach; tremendous mistakes, too.

There are many situations in which boldness, adventurousness and certainty are appropriate. But there are also situations, especially when there is deep uncertainty and great risk, when boldness is dangerous and foolish. In those situations a mode of careful assessment and experimentation is needed; a mode of learning, so that uncertainties can be resolved before irreversible damage is done.

There are formal methods of impact assessment, cost-benefit analysis, and risk evaluation, which can and should be applied to any large social endeavour, from a new hydroelectric project to a new defense system. Some governments have offices of technology assessment or long-term planning to help see as far as possible down the path of a new technology, to anticipate problems, and to design technical applications to produce as high a benefit and as low a cost as possible. For example, the years of discussion that went into the environmental assessment of the trans-Alaska pipeline produced a line that was better designed, not only for environmental protection, but also for the uninterrupted delivery of oil.

Assessment and forecasting techniques usually pay for themselves in improved design and the avoidance of mistakes. But they cannot foresee everything. Even after the best known evaluation tools have been applied, many new endeavours still involve stepping out into the unknown. That stepping out is necessary and will occur; progress depends on it and human curiosity guarantees it. But it should be done in a deliberate mode of learning.

Learning depends on small experimental steps and continuous evaluation. It presupposes that mistakes will be made, and therefore goes slowly, insuring that mistakes will be small and correctible. Each mistake is received as an opportunity not for blaming but for learning and for correction. Mistakes are not hidden, denied, ignored or forgotten; they are expected and openly examined to draw out the lessons they contain. Truth-telling is the key. It is sometimes embarrassing to tell the truth about a mistake, and yet learning can only come from telling that truth fully, absorbing the lesson from each step before taking the next one.

Learning in experimental mode is the base of the scientific method. Unfortunately, it is practiced more in the small experiments of science than in the large experiments of technical and social change.

4. It is possible to complement rational analysis with non-rational or super-rational analysis with intuition, insight, deep familiarity, respect, compassion.

Objective experimentation and evaluation is the scientific, rational method of learning. It is essential and valuable; scientific knowledge is a source of great human achievement. But rationality is not the only human gift and it is not the only way of knowing something.

If you tried to explain to someone rationally, movement by movement how to walk, you would have difficult time. Walking is something you learned through experience, without concepts or words, without rationality. A good cook confronted with fresh ingredients knows how to translate them into a wonderful meal; that knowledge has been acquired through experience, practice, memory of smells and tastes, not all of which is rational. A good farmer or forester knows much that is wordless about the soils, the plants, the animals, the trees-that understanding comes from familiarity, instinct, intuition, a sort of resonance with or tuning-in-to or empathetic observation of the living world. It is not objective observation; to the contrary it is subjective; it involves caring, entering into, identifying personally with the farm or forest or livestock.

Our normal waking consciousness, rational consciousness as we call it, is but one special type of consciousness, whilst all about it, parted from it by the filmiest of screens, there lie potential forms of consciousness entirely different.

William James

So-called “primitive’ people respect these intuitional sources of knowledge, and they consciously develop and enhance their non-rational powers, including dreaming, dancing, and listening to spirits. They can do things that awe the more rational minded. A Kalahari Bushman can perceive a human track in the desert and can tell out of hundreds of possible people whose track it is. The Bushman can find water and food in a drought, can find wandering herds, can capture or kill large, dangerous animals with a simple bow and arrow, can do dead-reckoning navigation over trackless “wasteland”, can die at will. There is a tremendous amount of knowledge in the Bushman culture, though there is little of it we would call scientific or rational.

In Western societies intuitional knowing has fallen into disrepute. A logical argument, preferably backed up by statistics, is likely to win, in a debate over a qualitative, difficult-to-articulate hunch. As a result, many unwise decision are made. It may make rational economic sense to grow heavily-fertilized continuous maize and wear down the organic content and tilth of the soil, but it does not make intuitional or moral sense (in the long run, it does not even make economic sense). A farmer who operates from love and respect for the integrity of the soil maybe called irrational, but maybe using an important source of knowledge that is actually more complete than a calculation of short-term profits and losses.

People who recognize both the rational and non-rational sources of knowledge often set them up in opposition and attempt to discredit one in favour of the other. Both are needed. Both are precious human gifts. Above all, they need to be brought into harmony. The best decisions make sense both rationally and intuitively, both economically and morally. Any decision that seems to violate either rational analysis *or* the non-rational sense of rightness and appropriateness probably ought to be examined further and pursued with caution.

H. Sacredness

> In that instant I could feel no doubt of man's oneness with the universe. The conviction came that that rhythm was too orderly, too harmonious, too perfect to be a product of blind chance-that, therefore, there must be purpose in the whole and that man was a part of that whole and not an accidental off-shoot. It was a feeling that transcended reason; that went to the heart of man's despair and found it groundless. The universe was a cosmos, not a chaos; man was as rightfully a part of that cosmos as were the day and night.
>
> *Richard E. Byrd, Diary at the South Pole, 1934*

1. Nature has its own value, regardless of its value to humans.

Human societies could not exist without natural systems. Human being are themselves a part of nature. But the dualistic human mind likes to distinguish its own "humanness" from "mere nature". Having made that distinction, we then fall into the trap of having to defend "nature" because of its perceived value (usually economic value) to "humanity". If we can't see the immediate economic value of an insect, or forest, or wetland, or prairie, we feel that we can interfere with or destroy it.

That thinking is wrong from beginning to end. First, the line of distinction between nature and human beings is harder to find the closer you look. Second, the assumption that we know the role of a species or a wetland in the ecosystem and that we can assess its utility to us assumes more knowledge than we actually have. Third, economic value is only the narrowest kind of value. And fourth, even if there were no perceivable value, direct or indirect, economic or spiritual, to some part of nature, our human responsibility, our role as stewards for the planet, does not allow us to declare it worthless.

Our attitude toward anything created on this planet ought to be (and is for many people) an attitude of reverence. Though we may not perceive its purpose, we cannot assume it has none. Though we cannot account its value to us, it has value in itself. Nothing in nature has to justify itself to us in order to have the right to exist.

The great ecologist Aldo Leopold put this principle into a moral statement he called the "land ethic":

> A thing is right when it tends to preserve the integrity, stability, and beauty of the biotic community. It is wrong when it tends otherwise.

2. A healthy, beautiful environment is not a luxury, it is a basic human need, both materially and non-materially.

The people of the Sarvodaya Shramadana movement have listed the ten basic human needs in the following order:

1. A clean and beautiful environment.
2. A clean and adequate supply of water.
3. Simple clothing.
4. Food.
5. Health care.
6. Communications.
7. Simple housing.
8. Energy requirements.
9. Total education.
10. Spiritual and cultural needs.

To some it may be surprising that a clean and beautiful environment is listed as the first priority by poor people who can satisfy so few of their material needs. But p6or people are more likely than most to know that a healthy environment is an essential source of material needs, such as food and clean water and air, and also that material needs are not necessarily more basic than spiritual ones. To suggest that cleanliness and beauty and a healthy environment are luxuries, not needed by the poor, is to misunderstand not only the poor, not only the essential role of the environment in material production, but also the whole meaning of being human.

Material needs are basic, of course. Their absence threatens survival, and without survival no higher human goal can even be considered. But the moment that survival is assured, the next question becomes survival for what? That is a question about the quality of life, that ultimate end of human existence. Those ends are not material. They are also not luxuries, not trivial, and not unimportant to the poor or to any human being.

A modern philosopher named David Spangler talks about human needs in terms of a number of different kinds of "hungers", some of which are hungers for higher meaning, for wholeness, and for unity between man and nature:

> The first level of hunger is biological. The key need here is SURVIVAL as a physical entity. Hunger can be for, nourishment, for food, for shelter, for protection from disease-for anything that enables us to function well as biological, physical organisms.
>
> The second level of hunger is emotional. The key need here is for CREATIVE, MEANINGFUL IDENTITY. Hunger on this level is for emotional sustenance, for love, for relationship, for

affirmation, for a sense of personal power and esteem-for everything that affirms and identifies us as sensitive, feeling human beings.

The third level of hunger is mental. AWARENESS is how I summarize the basic need here. It is hunger for knowledge, for understanding, for insight, for wisdom, for skills of thinking, for discrimination, for everything that helps us to focus our beings in appropriate and adequate ways.

The fourth level is spiritual and the basic need is for WHOLENESS. Here hunger is for transcendence, for integration, for synthesis, for community, for communication, for communion, for divinity. Here hunger begins to transcend personal needs and becomes hunger for the well-beingness of others, for society, for the world.

Each level affects the others, so that any solutions to end "hunger on the earth must embrace all four levels. Ultimately, no one hunger can be satisfied at the expense of the others.

One path toward transcendence is through the experience of "nature". Walking through a forest, watching the sun set over the ocean, feeling the power of a storm, experiences like these are more than pleasant for most people, they are inspirational. A deep attunement with the earth seems to be a part of human completeness and a source of wisdom and of peace of mind. The feeling of oneness and harmony with the earth is treasured by all cultures, all religions. It is basic to humanity, one of the foundations of human unity.

3. A harmonious relationship between human beings and the environment is not only essential for well-being, it is also intrinsic, effortless, spontaneous, natural.

It is also practiced everywhere, to the greatest extent possible, even where economic considerations have pushed nature into a diminished, distant presence. The spontaneous behaviour of human beings everywhere shows how important it is for them to be in some kind of contact with nature. In cities people buy flowers and flock to parks. High-rise office buildings have green plants in the foyers. In the poorest villages people decorate their bodies with colourful shells or flowers and their dwellings with plants. All over the world the most popular leisure-time activities are gardening of fishing or hunting or hiking in forests or mountains.

In all cultures people keep pets, if they possibly can. The pictures and decorations they surround themselves with show beautiful scenery or flowers o: animals. When people have a chance to travel, to vacation, to indulge themselves, they usually go to someplace beautiful, someplace "close to nature" And many of the places in the world considered the most sacred are mountaintops, waterfalls, forest groves, places where nature is an imposing presence.

Human beings are intrinsically attracted to natural beauty, to other forms of life, to the wonders of the living world. Of course there are other deep, inborn attitudes toward nature, including fear of its power and the desire to conquer and grasp its wealth. But love, awe, respect for the environment are there too intrinsic to human nature. Environmental education is a matter of pointing to that inner attraction and drawing it out, not a matter of creating something that is not already there.

I. Conclusion

The world thus appears as a complicated tissue of events, in which connections of different kinds alternate or overlap or combine and thereby determine the texture of the whole. *Werner Heisenberg.*

The material object becomes... something different from what we now see, not a separate object on the background or in the environment of the rest of nature but an indivisible part and even in a subtle way an expression of the unity of all that we see. *Sri Aurobindo.*

If we ask, for instance, whether the position of the electron remains the same, we must say "no"; if we ask whether the electron's position changes with time, we must say "no", if we ask whether the electron is at rest, we must say "no"; if we ask whether it is in motion, we must say "no". *Robert Oppenheimer.*

It moves. It moves not.

It is far, and it is near.

It is within all this,

And It is outside of all this. *The Upanishads*

Many of the key concepts of environmental education listed here require a reconciliation of opposites- there is incredibly complicated interdependence and connectedness, there is also autonomy and wholeness; there are limits and yet there is tremendous unrealized potential; human life is based on a material foundation and yet strains toward non-material purposes; human knowledge is astounding but also astounding is the vastness of human ignorance. All these concepts are seemingly contradictory and yet simultaneously true. They are in one sense new and in another sense timeless.

They can be found in the writings of spiritual leaders and of modern physicists, as the quotes above indicate. The latest findings of science confirm them, as do the teachings of every religion. They do not contradict the practicality of economic thinking, especially when that thinking is expanded to encompass complete systems. They affirm the wisdom of every academic discipline and show how those kinds of wisdom can be integrated. They also affirm the wisdom of ancient traditions and of the folkways of many people. Above all, they affirm the common sense and the deepest values within every human being.

That must be so. If environmental education is to draw its concepts from the basic laws of the planet, as far as we know them, and from fundamental human nature, as far as we understand it, it cannot be at odds with any branch of human knowledge. If environmental education involves the search not just for truth but for *whole* truth, it must be able to encompass all the partial truths of the many different ways of seeing. If it is to help human beings survive, flourish, and do work on this earth, it must square with the practical views of disciplines like economics and engineering. And if it is to help human beings realize meaning, happiness, and transcendence in their lives, it must embrace spiritual wisdom as well.

The continuous re-discovery and re-articulation in many parts of the world of the concepts listed here indicates that, though they may be incomplete and though our understanding of them may still evolve, they are close to fundamental.

Yet in many parts of the world people do not live by these concepts. Too often we live:

- as if human beings and nations are separate and unconnected, instead of rising or falling together,
- as if we could assault the environment without assaulting ourselves,
- as if we could escape the physical laws that govern the earth,
- as if there were an endless treasury of resources to draw from, and an infinite and far-removed sink into which to throw our wastes,
- as if our economic existence were independent of the sustaining processes of the planet,
- as if economic development were a mechanical and economic process independent from the needs and the talents of people,
- as if one group of people know how to “develop” another group of people,
- as if our material needs were the only ones we have,
- as if we knew what we were doing.

Environmental education is about exposing these misconceptions, and encouraging people to live their lives and design their societies according to the laws of the planet and according to their own inner wisdom.

V. METHODS AND TOOLS OF ENVIRONMENTAL EDUCATION

One of the oldest maxims of education says: “I *hear* and I take notice. *I see* and I remember. I do and I understand.”

If the key concepts of environmental education include ideas of whole systems, of the integration of physical science and spiritual values, of decision-making under uncertainty, of widespread participation in problem-solving, then insofar as possible the *process* of environmental education should let learners experience those concepts by *doing* as well as by hearing and seeing. That is why the methods and tools of environmental education are often so varied and imaginative- and so activity-oriented. They rely on considerable hearing and seeing, reading and repeating, but above all they rely on doing.

Of course environmental education can and does use the classic methods and tools of any kind of education-classrooms and teachers, books and blackboards, films and posters, lectures, tests and practice exercises. But it supplements these tried-and-true devices with much more. Weeds from the schoolyard. Puppets. Field trips. Songs, dances, and poems. Debates. Role-playing and games. Interviews with local citizens. Student-run tree nurseries or gardens or recycling centers. Involvement in real community problems, where there is no simple answer at the back of the book.

Above all, the learning environment itself, the school or the camp or the workshop, becomes a working example of the principles of environmental education. In the very course of their education students can learn to be careful with discarded materials, not- to waste energy, to do more with less, to respect nature, to respect each other. Paper can be recycled. Kitchen wastes can be composted used to grow seedlings (there is even a compost heap and a box of growing cabbages on the roof of a school in the center of a poor’ neighbourhood in the middle of New York City).

Even when there is straightforward factual material to be taught, it can be conveyed in a memorable, experiential fashion and it can transcend the basic facts to raise questions of ethics and values. For example, one could simply deliver a lecture about the formation of the earth, its geological and biological history, and the relatively recent advent of man and of recorded history. Or one could physically walk a geological time-line, as suggested by Michael J. Caduto, an international consultant on environmental education and an instructor at the Vermont Institute of Natural Science.

* * *

EXAMPLE. Walking a Geological Time-Line.

Outside on the school grounds or along a road or trail mark a line at least 30 meters long. Do this by driving stakes into the ground at the points indicated in the accompanying diagram and then stretching a string or rope between the stakes. You let the line extend well beyond 30 meters, to indicate the future.

At each historic point, position a sign or attach a card to the line, indicating what major event took place at that point in the, earth’s history. As you walk along the trail with the children, stop at each point and have one child read what events happened at that point (help with the reading, if the children are very young).

The beginning of the line signifies the formation of the solar system and the earth 4.5 billion years ago. After about 6 meters comes the first appearance of microscopic life in the sea, 3.5 billion years ago. At 2.5 billion years ago, or. 13 meters along, the earth’s atmosphere becomes filled with oxygen. It then takes 14 more meters (450 million years ago) to come to the first appearance life on land. The things begin to happen fast. One more meter brings the appearance dinosaurs, and a little less than a meter later the dinosaurs become extinct. The first human being appears within .2 centimeters (3,000,000 years) of the present. Farming begins within .006 cm of the present, and the industrial revolution within .00006 cm.

Standing at the point representing the present time, let the children discuss how long it has taken to evolve all the kinds of life there are on earth, and what a recent newcomer homo sapiens is. You can also discuss some of the enormous changes human beings have made on the planet, especially since the industrial revolution. Then you can look down the line into the future. Ask the children what they think we will bring to future generations as a result of what we are now doing on earth. Ask what they would *like* to have happen in the future. Point out that the smallest actions each of us take, when they are all added up, can have enormous impact on what happens to the earth and its creatures from now on. Ask what actions *they* might take to help the future go in the direction they would most like.

* * *

WALKING A GEOLOGICAL TIMELINE

(1 inch = 4 million years
1 cm = 1.57 million years)

Measurements given in distance from present time
(Presentation not to scale)

4.5 billion years ago → 94 feet (28.7 meters)
formation of solar system and earth

3.5 billion years ago → 73 feet (22.3 meters)
life begins on earth

2.5 billion years ago → 52 feet (15.9 meters)
appearance of oxygen in the atmosphere

500 million years ago → 9.4 feet (3.2 meters)
first fishes

450 million years ago → 8.4 feet (2.6 meters)
first life on land

360 million years ago → 7.5 feet (2.3 meters)
first insects

200 million years ago → 4.2 feet (2.3 meters)
dinosaurs appear

136 million years ago → 2.8 feet (0.9 meter)
flowering plants appear

65 million years ago → 1.7 feet (0.4 meter)
dinosaurs disappear, formation of Alps, early primates

20 million years ago
formation of Himalayas

1 million years ago
worldwide glaciation, first stone tools

500,000 years ago
first use of fire

100,000 years ago
Neanderthal man

10,000 years ago
farming begins

200 years ago
industrial revolution begins

PRESENT DAY THE FUTURE

At a more advanced level the lesson about the relative newness of industrial civilization can involve students in a research project, like this one, which also offers a wonderful opportunity to learn about people, history, and ecosystems all over the earth. It is adapted from an assignment used by Professors Kenneth and Elise Boulding in an introductory social science class at the University of Colorado, USA.

* * *

EXAMPLE.- Sampling Human History

Get two bowls from which students can draw slips of paper. Fill one bowl with slips on which are marked historical dates, beginning about 4000 B.C. and going in 100-year increments to the present. Fill the other bowl with slips on which are written the present names of the countries of the world. Ask the students to work in groups of two or three; ask each group to choose one slip from each bowl. One group might end up with Thailand, 500 B.C., for instance; another might draw Colombia, 1400 A.D. or Poland, 400 A.D.

Ask each group to go to the library and learn all they can about the country they have drawn at the time they have drawn. Suggest that they consult not only history books, but books of anthropology, natural history, climatology, geology. The students may have trouble finding anything about their designated place and time; encourage them to speculate from whatever information they can find, and to label their speculations clearly, to indicate their degree of uncertainty, and to describe what information led to them- that is, conduct a small lesson in drawing conclusions with integrity from insufficient information.

Ask each group to prepare both a written and an oral report describing what the landscape was like, what natural ecosystems were there, what the peoples' lives were like, what technologies they used, what kinds of government and religion they had, what historical events, if any, took place.

All the reports together will add up to an impression of human history quite different from the impression one gets from history books alone. With this truly random sampling through time and space, students are unlikely to draw a place for a century in which "historic events" were happening. Most of human history has in fact been "uneventful" and unrecorded. Life has been simple and strenuous and relatively peaceful. Cultures have evolved very slowly, civilizations have risen and fallen. National boundaries and place names were generally. 'different from the present ones, and ecosystems were often very different. There is a very low probability that any group will draw an assignment that covers any country in the industrial age.

Let all these points come out in the discussion. Go on to discuss the reasons why civilizations rise and fall, the interactions of those civilizations with their environments, the slow adjustment times of cultures and social mechanisms, the different rates of change of ecosystems, social organizations, individual human beings, and technologies. Ask the students to comment on the accuracy of aphorisms such as, "Forests precede civilization; deserts follow," and "He who does not understand history is destined to repeat it." Ask the students what the term "sustainable development" might mean, whether it is possible, what it would take to attain it.

* * *

Because of its *problem orientation* and orientation toward *whole systems,* environmental education is naturally and easily *interdisciplinary.* Real problems and real investigations of the holistic nature of the world almost never can be confined neatly to one discipline. Environmental education uses the *resources at hand,* including the school itself; the school grounds, the community. It often involves *activity in groups,* group discussion, drawing good ideas from the group; both because group activity illustrates the key concept of development through peoples' participation, and because it is useful to give students training in teamwork-so many activities in life require group skills. Environmental education also includes open acknowledgement and discussion of *values and ethics,* especially the relation between human beings and nature.

In short, the methods and tools of environmental education are:

- participatory and experimental,
- problem-oriented,
- interdisciplinary,
- integrated into the nearby surroundings,
- group-oriented,
- value-based.

There are not characteristics that are common to formal education in many countries, and many teachers have not been trained in, have not even experienced, such education. Yet all over the world teachers are pioneering, using the simple and natural technique of choosing an interesting, nearby problem and following wherever it leads, often learning right along with the students. When that happens, when the teacher is learning too, an extremely powerful thing happens. The students are not only learning about acid rain or desertification or the preservation of endangered species, or whatever the particular content of the lesson is, they are also *learning how to learn*. By watching the teacher's own curiosity and resourcefulness in solving a problem, by seeing how the teacher asks questions, confronts new information and overcomes obstacles, they are picking up toots for learning that will last them all their lives and will guide them in their own self-induced, *lifelong* environmental education.

Case studies of environmental education in action are given in the next section. The sample unit below is more general, not adapted to any particular educational context, just to give an idea of how one subject, the disposal of solid waste, can be taught in a participatory, interdisciplinary, problem-solving way that will force everyone, including the teacher, to do a lot of learning.

EXAMPLE: Waste Management

A Sample Unit for Environmental Education.

(This presentation is ordered by key concepts. Each concept may be presented directly through lectures and readings, or deduced from activities and exercises. The suggested activities following each concept are only rough illustrations that can be adapted to different cultures and types of students. The activities are listed in increasing order of sophistication. The first ones are most suitable for primary schools or general education, the later ones for more technical and advanced training.)

Concept One: Life as a Process of Material Flow.

Human life and all forms of human production require a constant input of materials and energy and a constant output, or discard, of wastes. Each human body takes in water, oxygen, food, and discards carbon dioxide, water, salts, and excrement. Each person uses a stream of clothing, containers, tools, toys and other objects, which are thrown away when they wear out or become dysfunctional or uninteresting. Every factory uses raw materials and produces some kind of waste. The material stream flowing through each human life differs greatly in different places and at different economic levels, but some such flow exists wherever there is human activity.

Activities:

1. What do you throw away? Make a list for a day of all the things you or your family discard. Be sure you notice what goes up chimneys, out windows, down drains.
2. What does your school throw away? Go to a local shop or business or factory or farm and find out what it throws away. Make lists or draw pictures of the wastes that are generated by your school or a local industry.
3. Take what your family throws away in a day and multiply it by the number of families in your town (neighbourhood, city) and then times 365 to calculate roughly what all those families throw away in a year. What would you guess all the town's businesses and factories throw away in a year? How accurate do you think your estimate is? How would you go about making that estimate more accurate?
4. How could you estimate the total discards of your *country* in one year? Are there any statistics that could help you? How were they gathered? How' accurate do you suppose they are?
5. See if you can find some statistics that give you an idea of the *change over time* of waste generation in your city, state, or country. Is the amount of waste going up or down? Why, do you suppose? If the change continues at the same rate, how much waste will be emitted in 20 years? In 50 years? What factors might change those forecasts?
6. Make a diagram of the complete material flow through streams for your family, your school, or a production process near you. Follow all chemical conversions as completely as possible and estimate the flow rates quantitatively, as accurately as you can.

Concept Two: There is no "away".

Everything that is discarded goes somewhere. It may leave the attention of the person or organization that discards it, but it does not disappear. Wastes may be buried in the ground, carried away by air or water, chemically transformed into something else. They may be taken up into other living beings. They may lie inert for years or centuries. They may be or become harmless or even helpful, or they may cause tremendous problems. But they do not disappear.

Activities:

7. When you throw away paper, what happens to it next? What happens to it after that? After that? Draw a map showing where the paper goes. Where does the dirty water from your household go? The scraps from your kitchen? The smoke from your chimney? See how far you can follow their path through the environment. Write a story about the journey of one thing that flows through your life and then flows on.
8. Walk along your road or around your neighbourhood with a big bag or basket and pick up any litter of waste you find there. How did it get there? If you hadn't picked it up, what would have happened to. it?
9. If there are facilities near you for handling wastes (sewage treatment plant, solid waste landfill, recycling or composting station, junkyard), visit them and find out how they work. In what form do the wastes leave them? What is their capacity for handling wastes, and how near to capacity are they operating now?
10. Make the most reasonable forecast you can of what the future waste generation of your city, state, town will be over the next ten years and the next fifty years. What might make your forecast change; how certain of it can you be? Estimate what facilities

might be needed in the future to handle that waste. Where do you think these facilities should be sited? How much do you think they will cost?

11. Take several kinds of common wastes (agricultural runoff, industrial effluent, household sewage, power plant stack emission) and make the most complete list you can of their chemical composition. What would you expect to happen to those chemicals as they travel through the environment?

12. Devise some monitoring experiments to test that hypothesis. How might these wastes be measured in various parts of the environment? How much is actually present? How might that be expected to change over time?

Concept Three: Everything comes from somewhere.

The materials that are thrown away always go somewhere, and they also always come from somewhere. One can follow the stream of material not only forward, to where it goes when it is discarded, but also backward, to where it originated. If you follow back far enough, you find that it originated in the earth's resource base; in a mine, a forest, a stream, a farm. Some of these resources are renewable and, if used wisely, can keep yielding materials for our use indefinitely. Others are nonrenewable and constantly depleted by our production and consumption. Some day they will be gone.

Activities:

1. Go back to the list you made of the things you throw away. Where did each of those things come from? By what processes were they obtained, manufactured, and brought to you? Visit, if you can, a nearby farm or mine or forest or well that is a source of the material that flows through your life.

2. On a map of the world, show where all the foods you ate yesterday originally came from. Show where the clothes you are wearing were made. Show where the energy burned by the cars, trucks, and buses in your town came from. Where did the cars themselves come from? What about the metal, glass, and rubber in the cars?

3. Take your list of yearly discards in your town, city, or country, and calculate as far as you can how much metal, wood, water, fossil fuel, and other basic resources they contain.

4. 4For some of those basic resources, find out how large the available stocks of those resources are in your country and in the world. If materials containing those resources go on being used at the same rate, how long will those stocks last? If the rate of use goes up at 1 per cent or 5 per cent per year, how long will they last?

5. Which resources are renewable and which nonrenewable? For one renewable resource, such as forest, calculate the rate at which it regenerates itself every year and compare it to the rate at which it is being harvested or drawn down every year. Is the use of this resource sustainable? For one nonrenewable resource, such as copper, coal or oil, calculate the rate of new discoveries versus the rate of removal. Learn about how the discovery process works. For how long do you expected new discoveries to continue?

6. See if you can state a basic *ethic* about the best way renewable resources and nonrenewable resources should be used. If they are not used that way now, why not?

Concept Four: Maximum welfare with minimum flow.

The stream of materials through your life and your society enables and enriches human life, but it also depletes resource stocks at its source and creates pollution at its sink. Clearly an excellent policy for managing that stream would be to keep the flow as slow as possible, to minimize the depletion and pollution, while maximizing the human welfare the materials provide while in use. Here are some ways of doing this:

- increase product lifetimes through sturdy design and easy repair,
- design products and processes with end-use, rather than maximum flow in mind,
- use products efficiently, distribute products equitably,
- measure economic progress by real welfare, not by flow rate.

Activities:

1. Look at the list of things you throw out. How long did they last white you were using them? Could they have tasted longer? Could they have given more service or pleasure before they were thrown away?

2. Who in your community repairs things? Go visit them and watch them work. How much do they add to the lifetime of the things they repair? How might things be repaired more easily, or be designed better, to last longer?

3. One aspect of human welfare is the ability to move around, to get to where one wants to be, and to be able to carry cargos there as well. List the forms of transportation- walking, bicycling, buses, cars- available to you. What wastes does each one produce? What resources does it use? See if you can find or calculate the amount of fuel use per passenger per kilometer or per kilogram carried per kilometer. Which forms of transportation provide the greatest service with the leaf resource use and least waste?

4. Carry out the same kind of welfare-based analysis for other human needs- cooking food, heating rooms, storing food, etc.

5. How much food is consumed in your town (city, state, nation) each year? How well nourished is everyone? How much food does it take to nourish a human being properly? Is there any way the same flow of food could be used to provide greater or better human nourishment, or to nourish more people? What would have to be happen to get the maximum per cent or 8 percent amount of human nourishment from given flow of food?

6. Find out what the term Gross National Product (GNP) means. What is the GNP per capita of various nations, including yours? What does GNP per capita actually tell you about human welfare? If the GNP goes up, is that change necessarily good or bad? What other measures would you like to have for a society, to determine the quality of that society or the welfare of its people.

Concept Five: *Ultimate recycling*

In natural ecosystems there is no waste. The output of one species or process becomes the input or nutrient for another species or process. Everything is recycled. Human economic systems could also be designed that way.

Activities:

1. What are the waste products of a forest? What happens to them? What are the waste products of a farm animal? What happens to them?

2. Of the things your family throws away, how many are re-used for some purpose? How many others could be used for something? Why aren't they so used? What would have to happen so they could be?

3. Build a composting system for the organic wastes of your family or school or community, and a garden to use the compost. Set up a system for recycling paper, or metals or glass and putting them back into use.

4. Find out how many of the metals used in your country are reclaimed after use and recycled. If possible, go to a place where metals are recycled and find out how it works.

5. Can you find other examples of factories or business that take wastes from some other factory or business and make those wastes into something useful? What other possibilities do you see for such wasted materials? What would it take to make them happen?

6. Write a science fiction story about a country sometime in the future in which every form of waste is reused. Be as detailed and specific as you can.

Concept Six: Undoing the damage.

The ultimate solution to the problem of waste is minimal flow, maximal welfare (which requires a clear definition of welfare), and maximal recycling. While that solution is being worked out, however, there is ongoing harm from waste streams that are already disposed of poorly, and continuous new waste streams that will not simply stop and wait for a new kind of economy.

These wastes must be disposed of as well as possible. The process of doing that is complicated, because there are so many different kinds of waste with very different properties and toxicities, and there are also different receiving media. For example:

Some Types of Waste	*Some Receiving Media*
Organic biodegradables	*air*
heat	*ocean*
gases	*rivers*
heavy metals	*lakes*
radioactive substances	*soil*
fertilizer runoff	*rock*
paper	*fire*
glass	*groundwater*
industrial chemicals	*salt*
plastic	*living species*

The problem is to match the type of waste with the best receiving medium to minimize damage to the ecosystem. This requires considerable technical knowledge, about the waste and its breakdown products, and about the receiving medium and its capacities.

At this point the educational process becomes more detailed and specific; wastes are usually studied one by one, as case studies, and often as disputed local issues, such as:

- What should we do with our town's sewage?
- Where should we store the wastes from nuclear power plants?
- How can we clean up toxic chemicals in our groundwater?
- Who is responsible for the air pollution that is killing the forests?
- Should the local paper plant be forced to install expensive air pollution controls?

Excellent educational opportunities arise from these specific issues, including learning how to measure and monitor pollutants, how local economic and political processes work, how the natural processes of the biosphere work.

Activities:

1. Take one specific type of waste that you know is a problem somewhere near you (this could be, in different societies, human excrement, spent nuclear fuel rods, pesticide residues, industrial dumping, sulfur dioxide or many other things). Trace the material back as far as possible toward its source and forward as far as possible into the environment after it is thrown away. How much material is in these flows? What are the quantities likely to be in the future? What people and institutions in society profit from this flow? Who suffers the worst damage?

2. Is there any short-term possibility for decreasing the flow of material by using it more efficiently? What needs to be done to make that happen?

3. Is there any place to put this waste that could be less harmful than where it is being put now? Is there some method of treating the waste to make it less harmful? Is there damage that has already been done that could be repaired or cleaned up? How could this happen?

4. Is there any possibility of using the substance for some useful purpose rather than discarding it? How could this happen?

5. Talk to people in your community about how they feel about the waste problem, and what they think should be done about it. Be sure you've talked to all kinds of people and heard all sides of the issue. If possible, design and carry out a proper opinion survey.

6. For each possible way of dealing with the waste that you can think of, or each way that is being publicly suggested, trace the likely path of the material through the environment. Make the best estimate you can of the total costs and benefits of each option, including the indirect (and hard to estimate) environmental and social costs and benefits. Which option do you prefer? Why? What value trade-offs have you make in coming to your decision? What uncertainties in your understanding of the situation could cause you to change your mind? How could you obtain better information to clear up those uncertainties?

7. Do some small thing to help solve a waste problem near you. Get other people to help you. Pick up litter on the roadsides. Dig a latrine or make a compost pit. Collect bottles, cans or paper for recycling. Hold an educational session for the community. Go visit your public officials and ask them to help you organize a way of collecting household hazardous waste products. These are just a few ideas-you come up with your own!

VI. SOME CASE STUDIES IN DIFFERENT EDUCATIONAL CONTEXTS

A. Primary. School

United States volunteer-based environmental education (communicated by Michael J. Caduto, International Consultant in Environmental and Cultural Education, Norwich, Vermont 05055, USA. For further information, see Jenepher Lingelbach), *Hands-On Nature Information for Exploring the Environment with Children,* Vermont Institute of Natural Science, Woodstock VT USA, 1986).

In an overgrown field in autumn, a group of children are walking along, pulling behind them pieces of string with old socks tied to the trailing ends. After awhile the children look at the socks and finds seeds attached to them by a variety of burrs, bristles, hooks, and sticky surfaces. The children have learned first-hand that, although plants cannot move, they have ingenious strategies for spreading their seeds over long distances.

This is one of the field activities of the ELF (Environmental Learning for the Future) programme at the Vermont Institute of Natural Science (VINS), a programme that brings environmental education to thousands of children each month, using the nearby environment, volunteers from the local communities, simple materials, and a very limited budget. ELF focuses on children ages 5 through 12. It aims to foster understanding, positive attitudes, and concern, as a foundation for wise environmental stewardship.

ELF began when a group of parents and the Institute staff began conducting volunteer-run environmental education workshops in the local elementary school. The programme was popular, and it spread. Now two full-time staff people and dozens of trained volunteers run programmes for 4,300 children a month in 32 schools.

The ELF workshops emphasize direct experience and involve students' thoughts, actions, and emotions. They operate from the belief that positive learning environments, in which students feel good about themselves, their peers, and their leaders, produce caging and stewardship. Science learning skills are also employed, such as observation, careful recording, comparison, and the synthesis of information.

During any given year each participating school chooses one of five possible concepts: Habitats, Adaptations, Cycles, Designs of Nature and Forces of Nature. Each school allocates class time for the workshops and pays a fee, scaled according to its available financial resources, to cover costs.

Every month a training workshop, facilitated by VINS staff, is held for volunteers. The training workshops take place in schools, homes, churches, wherever there is suitable space in the community. The volunteers are parents, teachers, farmers, foresters, people from the local community. At the training workshops the volunteers become "children" and experience for themselves the activities they will teach. Then they gather into classroom teams to plan their presentations to the children and to assemble their materials.

Complex materials, such as puppets of murals, are usually made by one person or group and then shared with others. Slides or nature collections are borrowed from state fish and wildlife departments. Common school supplies are provided by the schools. Many of the materials, such as weeds or shoe boxes, are brought from home.

The time actually spent with the children ranges from one hour to a whole day. The regular classroom teacher may help out, or attend the workshop and do the ELF teaching, or not participate at all. Activities are a combination of fund and serious study; they include puppet shows, role-playing, creative arts, language arts, mathematics and games.

Here, for example, is an ELF educational unit called "Meet a Tree".

THE SUM OF MANY PARTS

Objectives: to show how different parts of a tree function. The volunteer brings to class a young sampling, or previously collected parts of a tree, or pictures. These are passed around for the children to touch, while the volunteer explains each part of the tree (leaf, twig, bark, root, annual rings, etc.) and what its functions are.

For review the children DRESS A TREE. The volunteer shows them a tall plain vertical stick and passes out to each child a card with a tree part written on it. The children use construction paper, cloth scraps, string, pipe cleaners, pieces of wood, scissors, and tape to make their assigned tree parts and attach them to the "tree". As they attach each part, they explain what it does for the tree.

REACH OUT AND TOUCH

Objective: to get to know a tree using other sense than eyesight. The group splits into pairs and gathers outside. One of each pair puts on a blindfold. The seeing partner carefully leads the blindfolded partner to a tree and asks some questions to help guide the exploration. Can you reach around the tree? Can you reach any branches? What does the bark feel like? Can you find the roots? Find a leaf? Does the tree have a sound? A smell?

Both return, blindfold still on, to the starting place. Remove the blindfold and have the partner who was blindfolded find the touched tree. Switch roles and repeat the activity with another tree.

MEET A TREE QUESTIONNAIRE

Objective: to familiarize children with a particular tree. Have small groups of children select a tree (maybe one from the previous exercise) and fill out for that tree a Meet a Tree Questionnaire:

- In what kind of habitat or surrounding is your tree growing?
- Stand back from your tree. Draw a picture of its shape.
- Does it have seeds, nuts, fruits, cones?
- Find a leaf on or under the tree. Make a drawing of it, or tape it to your questionnaires.
- Look at the bark. Write down words to describe its colour, texture, smell, markings. Draw a picture of the bark.
- What kinds of plants are growing under or on your tree? (Be sure to notice the lichens, moss, fungi, vines.)
- Are there any signs of animals, insects, or birds on your tree? Any holes in or under the tree? Estimate the tree's height by having someone of known height stand next to the tree and estimate how many times that person's height the tree is. Estimate the circumference around the tree by measuring your hand or arm and reaching around the tree.
- Is your tree healthy? How do you know?

(The children. will need help in answering some of these questions, and may have other questions. Older children can learn to use an identification key to learn what kind of the tree they have chosen and can read a guidebook to learn more about that kind of tree.)

TREE POEM

Objective: to see a tree from different perspectives and record its image in a poem; to practice language skills.

Divide the children into small groups and assign each group to a tree. Designate one person in each group (or one volunteer if the children are too small to write) as secretary with paper and pencil. Place each child at a different distance from the tree- far away, a few paces away, under it looking up, nose to the bark, arms around it. After a moment's thought each child should give 3 words to describe the tree from his or her perspective, and the secretary should write them down. The group then creates together a poem about their tree, using all the words. All the groups share their poems with each other, either introducing their tree or asking the others to find it from the description.

STAY IN TOUCH

Encourage the children to visit their tree in different seasons and notice how it changes.

Evaluation of ELF activities is incorporated into the training workshop. The first half hour of each workshop is devoted to feedback from the volunteers on the previous exercise. This session is extremely valuable, raising issues of teaching techniques, environmental ethics, and effectiveness, as well as bringing forth humorous and touching stories. Volunteers and teacher also fill out formal evaluation questionnaires. Teachers working in the classroom evaluate increases in knowledge and shifts in attitude.

Setting up an ELF programme requires commitment on the part of the school and the community. A good volunteer coordinator is needed to find volunteers and organize the programme. Many volunteers admit that they serve because they learn so much themselves. The programme brings community people into the schools, and gives children the important message that many adults care about them and their learning. It also conveys that nature and science are not confined to a classroom nor dependent on special equipment, experts, or far away field trips. It explores the wonders of the environment right nearby.

B. Primary School

Union of Soviet Socialist Republics-out-of-school environmental education (communicated by Dmitry Kavtaradze, Faculty of Biology, Moscow State University, USSR).

The town of Pushchino 120 km from Moscow is the site of a major biological research station, the Biological Center of the Soviet Academy of Science, Pushchino also the first town to experiment with the idea of a Soviet "ecopolis"-an urban settlement whose development is closely linked with its surrounding ecosystem.

With the help of local scientists, the municipal government, and scientists from Moscow State University, the citizens of Pushchino have learned a great deal about their nearby environment. They have studied and published a 700-year history of their region. They have put out books describing interesting hikes and nature traits near the city. They have mapped the flora and fauna, recorded the climate, and surveyed the population to discover how many people participate in outdoor activities like mushroom-gathering, skiing, and fishing. They have established nearby reserves.

All this was done with the help of children, through Pushchino's Children's Ecological Station. The Station occupies a few bright rooms on the first floor of an apartment building in Pushchino. Its walls are covered with colorful posters, maps, and drawings. Its rooms are tilled with work-tables and shelves with various kinds of scientific and outdoor equipment. There are barometers, anemometers, models of anthills, models of the historical fortress of Pushchino. There are children's nature books. There is an office for Anatoly Bukin, the only paid staff member of the center.

The center is open to all children of Pushchino after school and on school holidays. Attendance is voluntary, and the children can work on any projects they like. If there are enough interested in a particular subject, they organize a Circle with the help of Bukin and/or volunteer adults from the community. There are Circles studying geology, birds, the hydrology of the Oka River, ants, fish, pottery, architecture, computers.

Children's Circles have measured and mapped wind flows around Pushchino's buildings, and all the crow's nests in town, and all the anthills in the surrounding forest. They found and mapped the places where people had made picnic fires in the forest, concluded that there were too many, and then worked with the town to close down some of them and make others more attractive. The children put up feeding stations and nesting places for birds. They have brought to the town authorities proposals for reducing soil erosion, for protection of forest plants, and for setting up fish hatcheries. Every year they have a science fiction writing competition, and a special celebration of the coming of spring.

In the summer the Children's Ecological Station organizes camping expeditions for the children into the surrounding countryside. Adults accompany the expeditions to oversee the children's health and safety, but the young people themselves are responsible for planning the meals and cooking them, for water supply and sanitation, for firewood, and for cleaning up the campsite. They carry out research activities on these expeditions, the results of which are published in informational pamphlets for the townspeople.

Most of the education going on at the Children's Ecological Station is not in the form of lectures, but of active involvement. Exploration takes place at the children's own pace, in subjects of their own choice, and in a collective manner. Emphasis is placed not just on nature; not just on the town, but on the interconnections between the town and nature.

Publications and teaching aids developed from the experience of Pushchino are now available to other towns and to teachers in the USSR. About 15 other towns and cities have displayed interest in the Pushchino ecopolis programme and the Children's Ecological Station and are evolving similar programme of their own.

C. Secondary School

Federal Republic of Germany-field study of Rhenish Lignite Mining (paraphrased from a contribution by Lothar Geerling, secondary school teacher, Essen, FRG and Dr. Reinhold E. Lob, Director, Centre for Environmental Education, University of Essen, FRG, in Cowan and Staff, 1982, pp. 266-274).

The largest lignite deposits of Europe lie within the triangle formed by the cities of Aachen, Koln, and Dusseldorf. Much of the coal lies near the surface and is obtained through open-pit mining. 87 per cent of national lignite production comes from this area. Nearly all the coal mined goes to the production of electric power. It provides 26 per cent of the national electricity consumption. In the course of its production so far, 51 villages with a total of about 21,000 inhabitants have had to be resettled.

The coal is of obvious economic importance, and open-pit mining will be expanded in the future. Another 10,000 people will have to move before 1990, and 356 farms that are producing grain and sugar beets will be destroyed. The expansion will also engulf the Hambacher Forest, a natural oak-hornbeam-linden forest with many old trees and rare species. There is significant public criticism of this expansion, on both personal and environmental grounds.

Coal mining is a traditional part of the curriculum for Form 7 of Nordrhein-Westfalen's secondary schools. In the past the focus of the unit was generally on the methods used in mining, and on the ways of recovering and recultivating the land after a mine was exhausted. Little attention was paid to the problems caused by the complete stripping of the landscape, nor the social effects of resettling people, nor the lowering of the groundwater table, nor the public conflict about the expansion of the mines.

The curriculum was redesigned, not to condemn lignite mining, but to make obvious to the students that their daily and often unnecessary energy consumption promotes an activity that destroys landscapes and causes social dilemmas. Connecting the mining to the student's personal lives then allowed more general points to be made about the increasing consumption of industrial society and the resulting environmental stress.

The new curriculum begins with a unit on *energy as the basis of human existence.* The students learn what energy is, how it is consumed, how it is produced, the differences between primary energy, secondary energy, and available energy. They learn the history of increasing energy consumption in their country, and the varying levels of per capita energy consumption in different parts of the world. They learn the difference between nonrenewable and renewable sources of energy, and how the expected lifetime of nonrenewable energy sources can be estimated.

During this unit the students do an electricity account of their homes and their school. They see a film on energy and several charts and graphs on world energy consumption.

The second unit is about *deposits, exploitation, and use, of lignite.* The students see the link between their own personal energy use and the lignite mines. They learn how lignite is generated geologically, how it is mined, how it is converted to electricity, what that electricity is then used for in the cities of Nordrhein-Westfalen.

A variety of maps, worksheets, media, and discussions are used in this section of the course, to provoke student's own reactions to the lignite mines, and to compare the conventional wisdom the students have observed about the mines with the actual facts.

The third unit examines *the natural landscape destroyed by the mining* and the extent to which a planned, recultivated landscape after the mining can replace it. They learn about the. soils being removed, the effects of a lowered groundwater table on the surrounding area, the stages of recultivation and how long it takes, the archeological heritage of the area (which has been densely settled since Roman times).

The high point of this section is a day-long field trip. The students visit an open-pit mine and a recultivation site over a closed mine. They interview people in Konigshofen, a village about to be resettled, and they also see the slow renewal of social life in a resettled area. They learn from local officials about the expense of moving settlements and the difficulties of making fair agreements. with those who are moved. They walk through the Hambacher forest and talk with the local activist who are trying to save part of the forest.

In the final discussions after the field trip, the students can see the Rhenish lignite mines in all their complexity. They are not likely to take either the extreme view that energy production is an absolute priority whatever the social or environmental cost, or the other extreme view that any exploitation of energy should be rejected. They see their own role in the energy system and realize that some people are bearing a disproportionate amount of suffering to support the students' own energy consumption. They begin to ask questions about energy conservation and alternative energy sources, and about the proper social responsibility toward people who lose their water supplies or their health or homes in order that energy may be produced.

D. University

United States- Dartmouth College Environmental Studies 50 course (communicated by Dr. Donella Meadows, Environmental Studies Programme, Dartmouth College, USA).

In 1969 Dartmouth College established an inter-disciplinary programme offering students several courses in environmental studies. The courses included:

- basic environmental science,
- the role of the arts in environmental perception,
- the sociology and politics of environmental management,
- computer modeling of complex systems,
- environmental law,
- land-use planning;
- energy use and energy resources,
- International environmental issues,
- environmental ethics.

To allow advanced students to consolidate their learning, a final course called Environmental Studies 50 was created. In this course the students work as a group on some actual problem in the region- a problem that has been suggested by local citizens. They do whatever research, measurements, or surveying are necessary to quantify the problem. They come to understand its legal context, the political issues, the economic impact. At the end of the term they write a final report and make a public presentation, giving their suggestions about how to resolve the problem, usually with local officials and newspaper reporters present.

As an example, one year a large company was seeking to construct a wood-pulp mill on the region's major river. The company was trying to find the best site and to negotiate with towns for favourable tax concessions. Some citizens wanted to attract the mill to their town; others didn't want it to be built anywhere. There was great controversy and there were very few facts. The ES 50 class was assigned to study the proposed pulp mill and to prepare an environmental and economic impact assessment.

The students decided to keep their own opinions neutral until they learned more. Because of their serious neutral position, they were able to work with local citizens and experts of all opinions, including environmentalist, loggers and representatives of the company and of other competitive wood-products companies. The students learned how a pulp millworks and what the technology of this one would be. They visited similar mills already in operation and measured air and water effluents. They studied the impact of the forests, on the highways, on employment, and on the entire local economy. They made use of opinion surveys, soil maps, traffic counts, tax data, and computer models of the future economy of the region and of the international paper market.

Their final public presentation was attended by hundreds of people. They delivered a sober, factual impact. assessment for the plant and gave the local citizens advice, not on whether it should be built, but on how to minimize its negative impact and enhance its positive impact if it were built. They pointed out difficulties in the laws and points on which local vigilance would be necessary to be sure environmental regulations would be enforced. They also pointed out that the previous performance of this particular company in other locations had not been good, either in environmental compliance or in employee relations.

The students did not oppose the plant, they only presented facts, none of which were disputed by the pulp company. Later, in a public referendum the pulp mill was voted down. It was never built. Since then a number of smaller, locally-owned wood products firms have started to use the lumber resource that the pulp mill would have consumed.

Here are some other topics taken up by ES50 classes over the years:

- Should the use of salt to keep roads clear in the winter be reduced?
- Should a major hydroelectric dam on the river be built?
- How should a nearby town write its zoning and subdivision regulations to capture the value of the town's people, preserve the town's resources, and yet permit a reasonable rate of development?
- What is happening to discarded hazardous chemicals and radioactive materials in the region?
- How should Dartmouth College meet its energy requirements as the pace of fossil fuels increases?
- What will be the impact on the settlement patterns of the region if there is a major expansion of the College and its associated hospital?
- How can the region dispose of its trash after the local landfills are used to capacity?

E. Graduate Training

Thailand-Master's Degree in the Technology of Environmental Management (communicated by Dr. Chirapol Sintunawa, Assistant Professor, Faculty of Environment and Resource Studies, Mahidol University Bangkok, Thailand).

Thailand has long had an active environmental movement among its students and scientists. In the early 1970s this movement created considerable political uproar over two environmental scandals: the pollution of the Mae Klong River by sugar mills and the army hunting wildlife by helicopter at the Tung Yai Wildlife Reserve. As a result an article was written into the Thai Constitution on conservation of natural resources and the environment, a National Environment Quality Act was passed, and at Mahido University anew Environment Education and Research Project was established in 1973. The Project became a permanent Faculty of the University in 1978, now called the Faculty of Environment and Resource Studies. Its founder and initial director was one of Thailand's foremost environmentalists, Dr. Nart Tuntawiroon.

The guiding idea of the Faculty was to bring together experts in many disciplines to do research and teaching as interdisciplinary teams. As Dr. Tuntawiroon wrote: "Planning and management of resources and the environment for tomorrow's world are too complex to be left in the hands of specialists who have too narrow a view to be able to perceive the world in a holistic manner... A Thai economic planner, sitting in his air-conditioned room in Bangkok, juggling figures... would be pleased to endorse the policy of deforestation to increase available land for maize and cassava cultivation, as these crops show handsome figures in the list of annual export revenue. He does not realize that this is perhaps draw nutrients which have been accumulated in the soil by natural processes through thousands of years."

"This same economist will quite likely, with all good intention, approve of a plan for building a reservoir for irrigation, power generation, or industrial consumption. He will not be aware that the money invested may be entirely wasted, as there will be no water to fill the reservoir, since the watershed feeding it has already been destroyed. It is most unlikely that he will understand the secondary and tertiary effects of some development projects on the environment, such as why dam building should create salinization, affect fish population, or spread schistosomiasis."

To avoid this kind of narrow-mindedness, the Faculty of Environment and Resource Studies advocates training people to act in "an interdisciplinary team, each member of which must be quite competent in his own field and yet be able to work with others in harmony towards a unified objective. This is of course much easier said than done, and training manpower for such a purpose cannot be easily accomplished. It can perhaps be likened to an orchestra, each member of which must not only have a complete mastery of his own individual instrument, but must also be able to perform with others in perfect harmony to produce a symphony.

About 35 students each year are admitted to the 2-year Master's programme in the Technology of Environmental Management. It is by far the most popular and highly competitive postgraduate course in Thailand-an average of 800 candidates take its entrance examination. The entrants already have bachelor's degrees and usually several years' working experience in fields such as public health, soil science, engineering, fisheries, economics, biology, forestry; geology, or agronomy. They spend their first year in intensive course work, as follows:

Semester One

- Ecological Systems Analysis.
- Systems Approach and Cybernetics.
- Pollution Problems and Control I.
- Population Studies.
- Sociology and the Human Environment.
- Introduction to Mathematics and Science (for those with backgrounds in social science).
- Introduction to Economics and Management (for those with backgrounds in science),

Semester Two.

- Environmental Conservation and Resource Management.
- Mathematics Applied to Environmental Systems. Pollution Problems and Control II.
- Economic Analysis of the Environment.
- Administrative Systems for the Environment.

An important part of the first year is the five field trips the students take to study Thai environment and development problems firsthand. Their first trip is a general introduction to Thailand's varied bioregions and cultures, from the hills of the northeast to the fertile central plain. on the second trip the students visit the faculty's ecological field station in the south. They study the ecology of a mangrove/fishery/coastal region and the coffee growing hills above it. The third trip involves practice with research tools such as surveys and physical sampling. The students spend 12-17 days in a single village, usually one that is far distant and hard to reach, sometimes only approachable by bamboo raft or by elephant. They collect data on the population and the economy and they analyze soils and waters with the Faculty's mobile laboratory. A different village is visited each year, and thus over the years a valuable data base is being assembled on Thailand's rural areas.

On the fourth field trip the students develop a conservation or resource management plan for a wildlife area or national forest, usually at the request of a government agency. The fifth trip draws together all the expertise and knowledge the students have acquired during the first year. They spend 4 weeks on site researching a detailed environmental impact assessment for a proposed development, such as the Nam Choan Dam near the Burmese border on tin-mining on Phuket Island. After returning from the site the students have two months to prepare together their written analysis, which is delivered to the proper government authorities.

These field trips not only give students a chance to use all the tools and concepts they have learned in the classroom, they also acquaint the students directly with the resources, the environment, and the people of their country. Four to six faculty members go along on each trip, so the students also get to watch the faculty work together as an interdisciplinary group and solve problems on-site. And through the trips the students already, in their first year, are supplying information and analysis directly useful to their country.

Second-year students work with the 20 faculty members on research projects, which are written up as individual master's thesis. Much of this research is commissioned by the Thai government. Examples of thesis topics are:

> A field study of agricultural energy use for the major crops of Thailand.
>
> Effects of sediment from mining activities on the coastal aquatic ecosystems of southern Thailand.
>
> A socio-economic impact analysis on the use of biogas in Thai rural households.
>
> An economic evaluation of land degradation through crop nutrient removal by cassava, sugarcane, and maize.
>
> A forecast of the saturation point for the expansion of Bangkok International Airport.
>
> An integrated approach to wastewater treatment in the tapioca starch industry.
>
> An investigation of pesticide content in human tissue in Thailand.
>
> The relationship between socio-economic environmental factors and the performance of pupils from slum and non-slum districts of Bangkok.

More than 200 students have now graduated from the Faculty of Environment and Resource Studies. They have not lost their disciplinary identities as engineers, lawyers, educators, etc., but they have gained the additional ability to understand, communicate with and work with people of other disciplines, and they have learned to see some of the long-term environmental and social consequences of short-term decisions. They now work at the National Environment Board, the National Energy Authority, the Ministries of Agriculture, Industry, Education, and Defense, the Office of the Prime Minister, the Departments of Forestry and Mineral Resources, and in the private sector and journalism. Some have stayed on to teach in the Faculty, many continue to work with the Faculty as consulting experts or as sponsors of research studies.

The cost of this Master's Programme is paid partly by student's fees and research grants, but mostly by the government of Thailand. As Mahidol University's Rector, Prof. Natth Bhamarapravati says, "We are a country with an average income of $900 per capita. But we support our university and train our students as if we had $2,000 or even $4,000 per capita- in order that some day we *will* have that much."

F. Advanced Training

Costa Rica- CATIE and the training of national park managers (excerpted from a paper by Craig MacFarland, James R. Barborak arid Roger Morales, Wildlands and Watershed Programme, Tropical Agricultural Research and Training Center (CATIE), Turrialba, Costa Rica).

In 1969 there were only 25 protected natural areas in Central America, covering less than 3.2 per cent of the land area of the region. Only 8 of these were actively managed in the field. The others were "paper parks" only. By 1981 the number of protected areas had risen to 149; covering 11.6 per cent of the land area, and 127 were receiving at least minimal field protection through stationing of rangers; naturalists, and park staff. Among the protected areas are three existing and four planned Biosphere Reserves, and six World Heritage Sites, with two more planned.

This growth could never have happened without a tremendous increase in the number of trained and motivated professionals in the field of wildlife management at all levels, from senior policymakers through planners and area managers to basic technicians, rangers, guides, and extension agents. A major factor in training those professionals was CATIE. the Centro Agronomico Tropical de Investigacion y Ensenanza (Tropical Agriculture Research and Training Centre).

CATIE is a non-profit research and training center formed and supported by the Central American nations, the Dominican Republic, and the Organization of American States. Its central campus in Turrialba, Costa Rica, includes classrooms and laboratories, field experimental plots; and an excellent library on tropical agriculture, animal husbandry, and renewable resource management. Among CATIE's educational programmes is an active Wildlife and Watershed Programme (WWP). Besides training, this programme also does technical assistance, research, documentation and information services, and experimental or demonstration projects in the countries of the region. The projects and activities of the programme are chosen jointly with the key resource management institutions in the member countries.

Since 1977 WWP has sponsored more than 60 regional and national short-term training activities of 10 major types concerning wildlife management, and has created a M.Sc. post-graduate study programme in wildlife management at CATIE. More than 760 individuals have been trained (some have participated in more than one activity). Of those, 710 are now working actively in wildlands management somewhere in the region-- many of those not doing so have been promoted to areas of even greater responsibility. About 85 per cent of the directors of wildlands agencies and parks in Central America and 60 per cent of the junior professional staff have received at least 2-3 weeks of training in CATIE programmes; some have received much more. Over 40 different publications have been produced, including manuals on training methodologies, techniques,- and sample management plans.

Here are some of the types of training devised by the CATIE WWP programme.

In-service training

Personnel in need,- of specific training are matched with trained individuals working in similar situations in another country to serve as apprentices or assistants and thereby to learn on the job. For example, when Nicaragua set up its pilot national park Volcan Masaya, it needed to train rangers. WWP with the Costa Rican National Park Service set up an on-the-job training programme at Volcan Poas National Park in Costa Rica, an established and well-maintained park. The training was inexpensive, the Nicaraguans traveled by bus to and within Costa Rica, and required only living expenses while they were there.

Mobile seminars

These 2-3 week excursions provide a broad basic introduction and first-hand exposure to management problems, tools, and approaches. Around 30 participants with 7 instructors visit manage watersheds, national forests, recreation areas, national parks, and cultural monuments. There are intensive lectures and readings, plus site visits, with practical field exercises in small groups at each site. The main purpose of the mobile seminars is consciousness-raising and preliminary familiarity with the principles and purposes of wildlife management.

Short courses

These courses last only a week and are used primarily for training in operational (short-term) planning. Each one places heavy emphasis on practical exercises that produce a real and useful product for a specific wildland area in which the course is held.

Major thematic workshops

These intensive 3-4 week events spend about 25 per cent of the time on an introduction to concepts, principles, methods, and techniques, and 75 per cent on projects in which the participants work in groups, guided by instructors, to prepare a real product such as a management plan, environmental education programme in the field, or set of interpretive designs. They are held in wildland areas, and they produce a useful byproduct for those areas at no extra cost. The plans produced by the participants are in draft form and need revision, but they are always of high quality and are generally put directly to use by the park or forest for which they are designed.

Master's training at CATIE

The Master's Degree in Wildlife and Watershed Management takes two years, four trimesters of coursework and four of thesis work. Courses include fundamentals of tropical forestry, tropical soils, elementary hydrology, statistics land use inventory, natural resource economics, and watershed and wildlife management. Thesis students are treated as "associate staff members" and their research deals with real field projects being undertaken by the WWP staff.

In addition to the degree candidates, a number of special students come to CATIE for one year of coursework and field work, including working with national counterparts in Costa Rica on two in-depth practical exercises, such as the preparation of a management and development plan for one protected wildland and an environmental education plan for another. There is emphasis on how to work with local people and with local, regional, and national agencies and how to involve them in the planning process. The result is not only training of each student, but also two excellent plans per year for Costa Rican wildlands.

All programmes are multi-disciplinary and field oriented with practical, hands-on experience to supplement the theoretical and conceptual base. All involve working with local people and local institutions. Instructors come not only from the CATIE staff but from national agencies, from the wildlife preserves, and sometimes from international conservation organizations.

G. Teacher Training and Curriculum Development

Sudan-the University of Khartoum's environmental education workshops (communicated by Dr. William Stapp, School of Natural Resources, University of Michigan, USA and Dr Yaqoub Abdulla Mohamed, Institute of Environmental Studies, Khartoum, Sudan).

Sudan's environmental education programme was given a great thrust forward by three workshops held between 1983 and 1985. They were attended by governmental officials, educational administrators, and classroom teachers, and sponsored by the University of Khartoum's Institute of Environmental Studies, Clark University's International Development Programme, the University of Michigan's School of Natural Resources and USAID.

The first workshop was designed for high-level administrators in the Ministries of the Environment, Health and Education. The workshop focused on the philosophy of environmental education, its methodologies, strategies for the development of an environmental education curriculum and teacher training.

The second workshop was for school administrators and trainers of teachers. It focused on increasing awareness and knowledge about critical problems of the Sudanese environment, and strategies for integrating environmental education into existing educational programmes.

The third workshop developed an environmental education curriculum. It was held at Bakht-Er-Ruda Institute of Education in Ed Duiesn, Sudan, which is a community of over 4,000 teachers, teachers-in-training, and elementary and secondary students.

The participants in this third workshop, were 20 selected trainers of teachers and administrators, representing elementary, intermediate, and secondary education. They came from a variety of educational disciplines: science, history, math, Arabic language, English language, Islamic religion, geography, music and art. Their task was to design a curriculum in environmental education for Bakht-Er-Ruda itself, using the recommendations of the first two workshops about goals and objectives, guiding principles, and concepts.

The participants decided to organize the curriculum around three critical environmental issues of Sudan: desertification, famine, and health. They agreed that elementary schools should concentrate on the learner's *home and school area,* the intermediate levels on the learner's *community,* and the secondary schools on the *region and the country* of Sudan.

At each level, elementary, intermediate, and secondary, three interdisciplinary teams were formed, one for each topic area. Each team then decided on the level of understanding of each issue to be achieved at each educational level, with the work integrated so that each level built on the understanding achieved at the one below.

Then each team worked out a relatively comprehensive and detailed unit of classroom activities that would occupy one to several weeks of classroom time.

For example, in the area of desertification the elementary it could discuss soils and wind erosion and involve students in the planting and care of trees for a shelterbelt around the Bakht-Er-Ruda school grounds: At the intermediate level the students could establish and maintain a tree nursery for the community of Ed Duiem. At the secondary level, they could work with the District in the implementation of a total forestry programme.

In the area of famine the elementary students could learn about basic nutrition and the effect of under-nutrition on the growth of children. They could review the Bakht-Er-Ruda school lunch programme for its nutritional content and make recommendations for improvement. At the intermediate level, they could develop a student volunteer programme for the Famine Relief Center of Ed Duiem. At the secondary level they could study the causes of famine in the Gezira District and assist in the development of programmes to reduce the District's vulnerability to drought.

In the area of health at the elementary level the students, in collaboration with the school nurse, could develop a children's preventive health care booklet. The intermediate students could study community health problems and volunteer to work in community health clinics. The secondary students could study water-borne diseases associated with the Gezira irrigation system and work with the Blue Nile Health Project to prepare and disseminate educational material on schistosomiasis and malaria.

On the final day of the workshop, each team presented its suggested curriculum and activities to the whole group for comments and evaluation.

H. Adult Education

Zimbabwe-district conservation workshops (communicated by Mrs. Soneni Ncube, Department of Natural Resources, Harare, Zimbabwe).

In 1984 the Department of Natural Resources of the Government of Zimbabwe, with assistance from UNEP, organised a National Workshop on the Role, of Women in Conservation.

Women constitute the majority in the population of Zimbabwe's rural areas. They utilize natural resources more than men, who often live in towns and only come home over weekends. It is women who suffer most when natural resources such as firewood, water, and thatching grass are depleted through mismanagement. It was for these reasons that the workshop was planned for women.

The workshop was attended by influential women delegates from all eight provinces in the country. They discussed the environmental problems they saw in their areas, identified the causes of those problems, and suggested possible solutions. During the course of the workshop, the women also heard lectures on soil erosion and soil conservation, wildlife preservation, water conservation, forests, and the relationships among these various resources.

At the end of the meeting the women made several resolutions, the first of which called for more such workshops, to be held out in the districts and the provinces. The women said that a lot of people in rural areas were not sufficiently aware of the interactions among the natural resources, and therefore did not understand why it was necessary to conserve.

The Department responded by holding eight similar workshops, one in each province. In each of these women participants again requested more workshops, at the level of district councils (in Zimbabwe the smallest local administrative units). They also requested that men and youth be allowed to attend the workshops along with the women.

So the Department put on 55 more workshops, one in each district. The participants included local chiefs, political leaders, and district council officials. The workshops took place in district halls or office buildings, or in government training centers. These centers have electricity, kitchen facilities. and overnight accommodations for people who have come some distance, as well as meeting halls with blackboards and projection screens. The Department of Natural Resources supplied projectors and films.

The workshops were held just before the rainy season, when there is little work in the fields, so that people can stay for the whole 3-5 day period. Each was attended by 30-60 people. Participants came from as far as 150 km away, and they were fed and housed for free. Bus fares were also reimbursed. Each district was given a budget of Z$600 (about $US360) for all the workshop expenses.

The schedule and content of each workshop was different, because each district's resources and environmental problems are different. Each programme was drawn up by Department of Natural Resources field officers, in conjunction with field workers in forestry, agriculture, wildlife, and various non-government development organizations. This co-operation of agencies was important, because it let the rural people see that conservation of resources is not a secondary issue, but is interlinked with economic development.

Here is the schedule for one workshop, held in Cheziya/Gokwe District in June 1985 (films are shown in the evenings):

Day 1

Morning:

- Welcome and introduction.
- Opening address (by the Secretary or Natural Resources and Tourism).
- Remarks on resource conservation by the District Council by a Women's Leader and by a Youth Leader.

Afternoon:

- Group discussion on conservation.

Day 2

Morning:

- Tour to problem areas: a silted river behind a dam, overgrazed areas, unprotected and eroding arable land.

Afternoon:

- Group discussion.

Day 3

Morning:

- Lectures on possible solutions to the problems, given by field workers in agricultural extension, national parks, and forestry:
- Soil management.
- Wildlife management.
- Pasture management.
- Water management.
- Management of indigenous trees and establishments of woodlots.

Afternoon

- Discussion and evaluation.

The Department discovered that the discussions were much freer when the participants could use their own local language. Government officials were kept away from the discussions, so the participants could express their own ideas their own way. It also proved important to include influential local leaders, as people tend to listen to what they say, and they can lend authority when the participants go back to educate others about what they have learned.

At all the workshops the participants agreed to the set of resolutions originally put forward by the women at the first meeting. These resolutions are:

1. That there should be more provincial and district workshops.
2. That women should consult with political leaders at provincial, district, branch, and cell level in their districts, to arrange meetings to educate more people on the importance of natural resource conservation.
3. That women should be further educated in conservation and agriculture and should be further represented in natural resource committees.
4. That more efficient methods of distributing resource information be explored.
5. That women be trained and employed as extension officers by the Department of Resources.
6. That district council should be urged to make laws in order to control the misuse of natural resources.
7. That communal areas be reorganised in order to make planning and development easier.
8. That councilors be urged to remove people who have settled in areas designed for grazing.
9. That District Council allocate more land for raising fuelwood and poles and that land be fenced.
10. That women should form tree-planting groups and that the Forestry Commission should teach women's clubs how to raise tree seedlings.
11. That Youth Brigades be trained to make simple bricks that could replace poles in the of homes.
12. That fuel-saving stoves be introduced in rural areas and people trained in their construction, and that electricity should be provided to those who can afford it.
13. That people cultivating within 30 metres of streambanks be made to stop.
14. That co-operative gardens be formed to eliminate the problem of streambank cultivation.
15. That land allocation in communal areas be the responsibility of the chief (at present this is the district council's function).

VII. CONCLUSION

> I think it is necessary to emphasize this fact: No one need wait for anyone else to adopt a human and enlightened course of action. Men generally hesitate to make a beginning if they feel that the objective cannot be achieved in its entirety. It is precisely this attitude of mind that is the greatest obstacle to progress-an obstacle that each man, if he only will it, can clear away himself, and so influence others. *M. K. Gandhi*

Anyone who has been paying attention to the global environmental situation is bound to be worried. The ozone layer that protects all life from dangerous ultraviolet radiation is being depleted by chloride pollutants. Because of carbon dioxide generation from fossil-fuel burning, the global climate may be changing. Hundreds of millions of people live in poverty. The world's population is still growing rapidly. Tropical forests are disappearing. Soil is eroding.

When you look at all these problems all at once, they can seem overwhelming. When you compile in one place all the concepts, all the knowledge that must be transmitted in the education that will help the world's people deal with those problems, that can seem overwhelming too. The job that needs to be done is doable, but it is enormous.

In his address to the "Tbilisi Plus Ten" conference, the international gathering that assessed the ten-year progress of the International Environmental Education Programme, William H. Mansfield, Deputy Executive Director of UNEP, pointed out that environmental education is not a luxury, not something to be worked at gradually, and not easy. It is, he said, "a staggering education challenge and a desperately urgent one. Traditionally our formal education systems have played a central role in bringing about change by shaping new perceptions and values. But with so little time to accomplish so much, the leisurely route is no longer open. We must find ways rapidly to educate a generation of teachers to the new realities so they can educate students who will be the next generation's decision makers. And we must also re-school many mature adults and educate some who have not been schooled earlier, to deal with the mounting and new problems on the horizon."

The job is urgent and enormous, but it is also well underway. There are many partners in doing it. And virtually every person who is involved in environmental education has proceeded one concept at a time, one class at a time, one book at a time, one exercise at a time. Environmental education, like the job of managing the earth's environment wisely, will have to be done by millions of people. Each of those people will be working separately and appropriately to his or her special circumstances, but all will be united by a common planet, common concepts, common dreams of an earth that is fruitful, diverse, and managed in a way that provided sustainably for the needs of all.

VIII. GLOSSARY

Atmosphere- the envelope of air around the earth.

Carrying Capacity- the maximum population that can be sustained indefinitely from a given resource base, with a given lifestyle, economic system, and set of technologies.

Conservation- the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations, while maintaining its potential to meet the needs and aspirations of future generations.

Development- the modification of the biosphere and the application of human, financial, living, and non-living resources to satisfy human needs and improve the quality of human life.

Ecology- the study of the interrelationships of living organisms and their environment.

Ecosystem- an interrelated group of living species and the physical environment in which they live.

Education- the process of learning knowledge, skills, and attitudes to live successfully in the world. When it takes place as part of a course in an organization such as a school or college, it is formal education. When it takes place through media, on the job, through community action, through word-of-mouth it is informal education.

Entropy- unavailable energy, a measure of the disorder of a system.

Environment- the total surroundings in which all living things exist and from which they draw their sustenance.

Environmental Education- programmes and activities that increase the level of awareness, understanding, and appreciation of the environment as a totality and its interactions with human activities.

Hydrosphere- the earth's waters, whether in liquid form in the oceans, seas, lakes and groundwater, in gaseous form in the atmosphere, or in solid form in the ice caps and glaciers.

IUCN- the International Union for the Conservation of Nature and Natural Resources.

Lithosphere- the soil and rock that comprise the earth's crust and outer mantle.

Sociosphere- the man-made system of institutions, rules, ideas, information, culture, economics, and politics.

System- any interrelated set of elements organized around a purpose.

Technosphere- the manmade system of structures, machines, factories, roads, and other physical objects that reflect the prevailing technological ideas.

Training- higher-level educational programmes designed to develop knowledge and skills for the solution of practical, and usually specialized, problems.

UNEP- the United Nations Environment Programme.

UNESCO- the United Nations Educational, Scientific, and Cultural Organization.

WWF- the World Wildlife Fund.

IX. READING LIST

1. United Nations Environmental Education Conferences and Reports

Caduto, Michael J., *A Guide on Environmental Values Education, UNESCO,* Paris, France, 1985.

Connect, an international newsletter of UNEP and UNESCO on environmental education (printed on recycled paper), distributed free in six languages (English, French, Spanish, Arabic Russian and Chinese).

IUCN, *World Conservation Strategy,* (prepared with UNEP and the World Wildlife Fund), 1196 Gland, Switzerland, 1980.

Stapp, William B. and James E. Crowfoot, *Developing a National Strategy for Environmental Education-A Planning and Management Process, UNESCO,* Paris, France, 1978.

UNESCO, *The International Workshop on Environmental Education.* Belgrade, Yugoslavia, 13-22 October 1975, Final Report, Paris, France, The International Environmental Education Programme, UNESCO-UNEP, ED-76/WS/95, 1975.

UNESCO, *Intergovernmental Conference on Environmental Education,* Tbilisi, 14-26 October, 1977, Final Report, Paris April 1978.

UNESCO, *Environmental Education in the Light of the Tbilisi Conference,* Paris, 1980.

UNESCO, *Trends, Needs and Priorities of Environmental Education since the Tbilisi Conference,* (Preliminary report of a world survey) Paris, 1983.

UNESCO -UNEP's "*International Strategy for action in the field of Environmental Education and Training for the 1990's*," Nairobi, Paris 1988.

UNESCO -UNEP International Environmental Education Programme, numerous environmental education modules, on simulation and gaming, environmental problems in cities, energy, conservation and management of natural resources, pre-service training of teachers, and many other topics. Information about availability and procurement at no cost can be obtained by writing to *Connect* at the UNESCO address given on page 54.

2. On the Theory and Practice of Environmental Education

Bakshi, Trilochan, S. and Zev Navch, *Environmental Education Principles, Methods, and Applications,* Plenum Press, New York and London, 1980.

McInnis, Noel and Don Albrecht, *What Makes Education Environmental?,* Data-Courier Inc., Louisville KY, 1975.

Silver, Michael and Eva Mekler, *Bringing Up a Moral Child: A New Approach for Teaching Your child to be Kind, Just, and Responsible,* Addison-Wesley Publishing Co., Inc., 1985.

Stapp, William B., "An Instructional Model for Environmental Education," *Prospects, Vol.* VIII, No. 4, 1978, pp. 495-507. Studies from the Clearinghouse for Science, Mathematics, and Environmental Education, Ohio State University, College of Education and School of Natural Resources, 1200 Chambers Road, Third Floor, Columbus, Ohio, 43212, USA.

Schoenfeld, Clay, and John Disinger, *Environmental Education in Action P Case Studies of Selected Public School and Public Action programmes,* January 1977.

Schoenfeld, Clay and John Disinger, *Environmental Education in Action ll: Case Studies of Environmental Studies Programmes in College and Universities,* February 1978.

Schoenfeld, Clay and John Disinger, *Environmental Education in Action III: Case Studies of Public Involvement in Environmental* Policy, December 1978.

Bowman, Mary Lynne and John F. Disinger, *Environmental Education in Action IV. Case Studies of Teacher Education Programmes for Environmental Education,* December 1980.

Cowan, Margaret E. and William B. Stapp, *Environmental Education in Action V International Case Studies in Environmental Education,* December 1982.

Sytnik, K.M. (ed.), *Living in the Environment: A Sourcebook for Environmental Education,* UNESCO/UNEP, 1985. (Translated from Russian.)

3. **On the Planet and on Sustainable Development: the Substance of Environmental Education**

Brown, Lester, The *State of the World 1986,* 1987, etc., Worldwatch Institute, Washington DC USA. (Analysis, published annually, of global resource, population, and environmental problems and possible solutions.)

Centre for Science and Environment, *The State of India's Environment 1984-85,* Centre for Science and Environment, New Delhi, 1985. (A readable, fascinating, and very critical assembly of facts and stories about land, energy, resources, environment, health, food, and poverty in India. Interesting in itself, also a good model that could be adapted to other nations.)

Our Common Future, OUP-Oxford 1987. Report of the World Commission on Environment and Development to UN General Assembly and UNEP's Governing Council.

Council on Environmental Quality, *The Global 2,000 Report to the President, U.S.* Government Printing Office, Washington D.C.,1979. (A comprehensive summary of information from many U.S. executive agencies on the state of the world's population, resources, and environment.)

Ehrlich, Paul, Anne H. Ehrlich, and John Holdren, *Ecoscience,* W.H. Freeman and Company, San Francisco, 1977 (new edition due out soon). (The most massive, scholarly, and complete college-level textbook on environmental science and policy issues, also an excellent reference book.)

Georgescu-Roegen, Nicholas, "The Entropy Law and the Economic Problem", in Herman Daly, *Toward a Steady-State Economy, W.* H. Freeman and Company, San Francisco, 1973, pp. 37-49. (The significance of the law of entropy to economic development.)

Harrison, Paul, *land, Food, and People,* FAO, 1984. (A non-technical description of the findings of a major FAO/IIASA study of the soil and water resources of the ultimate food production capacity of the Third World.)

Holdgate, Martin, Mohammed Kassas, and Gilbert White, *The World Environment 1971-1982,* A Report by the United National environment Programme, Tycooly, Dublin, 1982. (An excellent sourcebook on the state of the world environment.)

Illich, Ivan, Tools *for Conviviality,* Harper & Row, New York, 1973. (On people-oriented development.)

Lovelock, James E., *Gaia: A New Look at Life on Earth,* Oxford University press, Oxford, U.K., 1979. (The theory of the earth as a self regulating system.)

Macy, Joanna Rogers, *Dharma and Development,* (The story of the Sarvodaya Shramadana peoples' movement in Sri Lanka.)

Meadows, Donella H. et al., *The Limits to Growth,* Universe Books, New York, 1972. (A computer model of the world population, industry, resource system and its potential for supporting all human needs.)

Myers, Norman, *Gaia: an Atlas of Planet Management,* Anchor Press/Doubleday and Company, Inc., Garden City, New York USA. 1984. (A colourful, comprehensive sourcebook of data, graphs, and charts about the earth, its resources, and its human economy.)

Repetto, Robert led.), *The Global Possible,* Yale University Press, New Haven and London, 1985. (Expert papers from a global conference on the state of resources and the possibilities for good management.)

Tolba, M.K., Development without Destruction, UNEP-Tycooly Press, 1982.

4. **A History of Research on Concepts for Environmental Education** (taken from Ph.D thesis by Michael Atchia at Salford University, U.K.,1978).

Craig, G.S., Certain techniques used in developing a course of study for the Horace Mann Elementary School. Bureau of publications, Teachers' College, Columbia University, New York, 1927.

Robertson, M.L., The selection of science principles suitable as goals of instruction in the elementary school. Science Education, 19, 1935, p. 65-71.

Martin, W.E., A determination of the principles of the biological sciences of importance for general education. Unpublished. Ph.D dissertation, University of Michigan, Ann Arbor, 1944.

Glidden, H.F., The identification and evaluation of principles of soil and water conservation for inclusion in the secondary school curriculum. Unpublished Ph.D. dissertation, University of Nebraska, 1953.

Irish, E.E., *A* determination of materials dealing with soil conservation and suitable for integration into courses of high school science for general education. Science Education, 37, 1953, p. 84-99.

Caldwell, L.T., Determination of earth science principles. Science Education, 39(3),1955, p. 196-213.

Visher, H.H., A determination of conservation principles and concepts desirable for use in the secondary schools. Unpublished Ph.D. dissertation, University of Indiana, 1960.

Hanselman, D.L., Inter-departmental teaching of conservation at the Ohio State University. The Natural Resources Institute, Ohio State University, Columbus, 1963.

Trainor, V.F., A determination of science concepts that should be taught in the junior high school. Unpublished Ph.D dissertation, University of Connecticut, 1964.

Ronfeldt, L.L., A determination of Basic Urban Environmental Understandings important for inclusion in the Elementary School Curriculum. Unpublished doctoral dissertation, 180 pages, University of South Dakota, 1969.

Roth, R.E., Fundamental Concepts for environmental management education (K-16) Doctoral thesis, University of Wisconsin, 1969.

Bringham, A.L., The frequency and significance of environmental concepts as found in literature for primary grade school children. D.Ed thesis, University of Wyoming, Laramie, 1971.

Allman, S.A., Identification of environmental education concepts for inclusion in an elementary school curriculum. Ed. D thesis in Environmental Sciences, University of Nebraska, 1972.

Marlett, B., The development and field test of an instrument to measure secondary student's attitudes towards selected environmental education concepts. Ed.D. Texas Technical University, 1972.

Lucas, A.M., Environment and Environmental Education: conceptual issues and curriculum implications. Ph.D. thesis, Ohio State University, 1972.

Conceptual-Medel, P., A conceptual framework for environmental education, adapted to the Philippine environment. Ph.D. dissertation, Michigan State University, 1974.

Howett, G., Twelve major environmental concepts categories and their rationale. Project I-C-E (Instruction Curriculum Environment), Green bay, Wisconsin, U.S.A., 1977.

Atchia, M., Concepts and Dynamics of Environmental Education with particular Reference to Britain, Africa and Mauritius. Ph.D thesis at Salford University, U.K.,1978.

X. ENVIRONMENTAL EDUCATION IN THE UNITED NATIONS: A SHORT HISTORY

In the 1970's concern for the environment reached a global level for the first time in human history. One of the responses to that concern was the 1972 United Nations Conference on the Human Environment in Stockholm, Sweden. This conference established UNEP, the United Nations Environment Programme, the first organization ever authorized by the world's governments to monitor and protect the global environment, and to make information about it available to all the world's people.

The Stockholm conference also emphasized the need for environmental education. Recommendation 96 called for education that could link academic disciplines, deal with actual and urgent problems, and prepare the citizens of an interdependent world to live and prosper in harmony with the laws of their planet. The Recommendation stated that:

> organizations of the United Nations system... should establish an international programme in environmental education, interdisciplinary in approach, in-school and out-of-school, encompassing all levels of education and directed toward the general public, in particular the ordinary citizen living in rural and urban areas, youth and adult alike, with a view to educating people as to simple steps one might take to manage and control one's environment.

UNESCO in particular was asked to work with all appropriate United Nations agencies, nongovernmental organizations, and. member nations to develop a framework for furthering international education.

By 1975 UNESCO and UNEP had established an ongoing International Environmental Education Programme (IEEP). It assembled an international bibliography and a computerized world directory of individuals and organizations involved in environmental education. It surveyed the UNESCO member states (136 of them at the time) to assess their environmental education needs, and it called together experts to begin articulating the principles and procedures for environmental education. A workshop in Belgrade, Yugoslavia, in 1975, brought together a group of twenty experts from each of the five UNESCO regions to provide a framework for environmental education.

The Belgrade meeting was followed in 1976 by regional meeting in Latin America, Africa, Europe, the Middle East, and Asia, to assess the regional status of environmental education and to form networks of interested people within the regions. These meetings paved the way for a worldwide meeting in 1977-the Intergovernmental, Conference on Environmental Education, held in Tbilisi, USSR.

Delegates from 70 countries attended the Tbilisi meeting. They drew up 41 recommendations setting goals, targets and strategies for implementation of environmental education. These recommendations were ultimately endorsed by 150 nations.

At Tbilisi enthusiasm for environmental education produced a remarkable degree of agreement, which transcended the common differences between North and South, East and West. As a result, those interested in environmental education can now derive support from colleagues all over the world, from an international movement and a growing network for the exchange of ideas and information.

Five years after the Tbilisi conference, the IEEP conducted a second worldwide survey to evaluate the progress of environmental education and to determine new trends. The member states surveyed reported that environmental education was an increasing priority, reflecting a growing concern for the threatened environment.

The IEEP's international newsletter *Connect* is distributed free in six languages to 16,500. individuals and institutions throughout the world who are actively involved in environmental concerns: IEEP now maintains a data base with information on 900 environmental education institutions and 300 projects. It has put out many brochures and books, prototype modules for education and for teacher training, guides on environmental education methodologies, and audiovisual material..

Thirty-one pilot, experimental, and research projects have been undertaken, aimed at helping member states to incorporate environmental education into their national education plans. Regional and sub-regional workshops have been organized; and 37 national teacher training workshops. Over 140 countries have been directly involved in the UNEP/UNESCO International Environmental Education Programme, more than 260,000 primary and secondary school students, about 10,00 teachers and administrators- and the number reached indirectly are much greater.

At the same time, UNEP, together with the International Union for the Conservation of Nature and Natural Resources (IUCN) and the World Wildlife Fund (WWF) developed a World Conservation Strategy, first published in 1981. The purpose of the Strategy is to stimulate improved management of living resources and to provide policy guidance on how this can be done. It outlines three primary objectives:

- to maintain essential ecological processes and life-support systems,
- to preserve genetic diversity,
- to ensure the sustainable utilization of species and ecosystems.

The World Conservation Strategy strongly endorses the need for environmental education, in order to foster anew ethic that encompasses plants and animals as well as human beings, and that allows people to live in harmony with the natural world on which they depend for survival and wellbeing.

In 1987 on the tenth anniversary of the Tbilisi Conference, UNESCO and UNEP jointly organized a second International. Congress on Environmental Education and Training, held in Moscow, and widely known as "Tbilisi Plus Ten". The Congress reviewed progress since Tbilisi, reported on the state of the environment and its implications for education, and produced an "International Strategy for Action in the field of Environmental Education and Training for the 1990s."

The IEEP continues to work with countries to incorporate the environmental dimension into their educational systems. Many countries have responded with official statements stating the importance of such education, and with complementary legislation, institutional arrangements, and ministerial or inter-institutional committees to implement environmental education at all levels of their educational systems.

The International Environmental Education Programme foresees no closing date: there is no end to efforts to preserve and improve the environment for generations to come.

For more information on the International Environmental Education Programme, contact:

The Environmental Education Section. Division of Science, Technical and Environmental Education,

UNESCO,

7, place de Fontenoy,

75700, Paris, France

or:

Environmental Education and Training Unit

UNEP

P.O. Box 30552,

Nairobi, Kenya.