

E. H. HARTMANS (*)

Tropical Ecosystems ()**

Although most if not all of the participants in this meeting are students of the tropics or even have lived and worked in the tropics, I would like to start my introduction by giving some rather elementary and basic information. I do this with the belief that it may help to guide us in the coming discussions and deliberations.

The tropical zone is a vast region of the earth surface immediately north and south of the equator. It extends to 23 1/2°C north to the Tropic of Cancer and 23 1/2°C south to the Tropic of Capricorn.

In Latin America the tropics include among others all of Brazil, Colombia, Venezuela, the Caribbean and the southern half of Mexico. In Africa all countries south of the Sahara belong to the tropical region except the Republic of South Africa, Lesotho, Swaziland, Botswana and Namibia. In Asia included among others are the southern part of India, all of Thailand, the Philippines, Indonesia, the Pacific Islands and the northern one-third of Australia.

It is the warmest region on earth with average temperatures ranging between 20° and 35°C. Close to the equator even the nights remain warm but in Africa, north of the equator, close to the desert, night temperature may fall to below zero while day temperatures may be as high as 45° to 50°C.

The seasons are more defined by differences in rainfall than by temperature. Precipitation is as high as 4000 mm in the rain forests close to the equator and as low as 100 mm in the Sahel.

Roughly 80% of the soils are of the latosolic type, naturally supporting forests and savannahs. They are located all over the zone where rainfall is from 400 to 4000 mm. Another 15% of the tropical area is desert, growing some shrubs

(*) Former Director General International Institute of Tropical Agriculture (1980-85) Ibadan.

(**) To the International Meeting "Towards a Second Green Revolution: from Chemical to New Biological Technologies in Agriculture in the Tropics" (Rome, 8-10 September 1986).

and grasses grazed by herds of nomadic tribes. Finally some 5% are mid- or high altitude areas, ranging from 1000 to 4000 meters with moderate climatic conditions and with some rich volcanic soils.

With this great diversity of physical and climatic conditions, it is not surprising that there are many different ecologies and many different ecosystems.

Before discussing some of the general aspects of tropical ecosystems, let us first define the meaning of the word ecosystem. In this paper an ecosystem refers to all components of a certain environment, be they biological or physical, all of which are interdependent and regularly interacting with each other. There is no size limit implied in this definition. It may be part of a country, a square kilometer of jungle or as small as a fish pond or wood lot. Men, and the agricultural systems they developed, usually are part and parcel of the ecosystem. For instance, the nomads with their cattle and their grazing grounds and their social tribal structure form an ecosystem. The farmer with his 2 ha. of cultivated land, utilized under the traditional bush fallow system, represents another ecosystem.

Before the industrial revolution and the application of chemical and physical sciences, men developed agricultural systems which were generally well in harmony with the natural biosphere. The small compound farm unit in the tropics is a beautiful example of such a harmony with the extreme conditions of the tropical rain forests and is a stable tropical ecosystem. However, man with his actions may change the environment in which he lives and thereby cause disturbance in the existing life support system and equilibrium of nature and so cause a change in the ecosystem. While industrial activities have been generally pointed at for their polluting effect on the environment, agricultural enterprises are in no small way guilty of the same crime. Only in the last two decades an increasingly greater concern has been expressed in words and writing about the ecological consequences of man's actions in his striving to increase production and higher living standards through industrial and agricultural activities. Recently the World Bank was severely criticized by environmental groups for financing projects without studying their environmental impact (e.g., Brazil).

Agriculture has many different biological and physical aspects. There is soil and water management, pest control, livestock and wildlife management, crop production, forest and fish management, etc. The application of scientific innovations usually relates to one or more components of the production process but each of the components is usually considered as an independent acting force with little regard to management of the whole unified system. *There is a general disregard of the need for ecosystem management.*

Far more attention needs to be given to the effect of new technological introductions on the stability of nature and to possible negative effects on certain parts of the ecosystems. Also much more consideration needs to be given to the sustainability of such new introductions without constant demand for additional inputs.

As stated before, the tropics have many different ecosystems; however, for the purpose of this meeting it may be useful to give most of our attention to three

major ecological zones, i.e., the tropical rain forest, the savannah zone and the semi-arid and desert zone. In these zones the topsoils are in general very shallow with little organic matter and, when not covered and protected, quickly lose their fertility and under the tropical rain storms and high temperatures become subject to erosion and degradation. Because of these soil and climatic conditions the tropical ecosystems are naturally very fragile.

Deforestation in the higher rainfall part of the zone may cause major changes in the micro-climate, but also in the hydrological cycle, the energy balance and the soil physical and biological values. In the long run it might affect the world's macro-climate (Dr. Lal). It causes significant changes in air and soil temperature and relative humidity. Without special protective measures it will lead to rapid soil degradation and thus loss of all capacity for sustaining life. Due to inappropriate land clearing and subsequent cultivation methods, it is estimated that some 2 million ha. of land are destroyed each year in the tropics. It may take up to 20 years to regenerate this land, if ever.

Livestocking and overgrazing in the semi-arid and desert zone has led to a breakdown of the sparse vegetation system and the further advance of the desert.

The colonial powers, well aware of the fragility of land resources in the tropics, kept their production pattern as close as possible to the natural vocation of the zone, i.e., they replaced the natural forests with forests of improved timber varieties, or with commercial trees like rubber, cacao, coffee, tea, oilpalm, cashew nuts and coconuts, thus maintaining the protective cover of leaves and branches. They generally did not attempt to grow annual crops on a large scale. One such attempt to grow ground nuts on a large scale in the early 50's in the savannah zone of the then Tanganyika, now Tanzania, became one of the best known large scale failures in history. Savannah land was put into production which advanced western technology turned into a dust bowl in a few years' time.

Degradation of natural resources is not a unique feature for the tropics. It is happening in various forms all over the world, especially the pollution of land and water through chemicals and the disturbance in the biological equilibrium of nature through the intervention and control of plant and animal life with biological, chemical and mechanical means at man's disposal. The dust bowls in the southern United States are one example. The expansion of the deserts is another.

Perhaps the most dramatic pollution of nature ever recorded was caused by the nuclear disaster at Chernobyl in the U.S.S.R. It, more than any other event, affected plant, animal and human life over a very wide area. It, more than any other event, caught the attention of the world in illustrating the difficulties and dangers of controlling man's own inventions. After Chernobyl the perception of science and technology, its development and application have obtained new dimensions in the minds of scientists, politicians and the man in the street, not only in the production of energy, but also in all other segments of the economy and especially in agriculture.

Indigenous populations over the ages developed systems of agriculture which were well adapted to the conditions of nature. On the good deep soils of the tropics, mostly of volcanic origin, they used an intensive system of cultivation with rice as the principal food crop whenever irrigation was possible or rainfall was adequate.

On the predominantly shallow soils of the tropics the traditional system of bush fallow and shifting cultivation was and is practiced to cope with the fragility of the soils and the rapid decline in the life-supporting biophysical processes.

In the rice based ecosystems dramatic changes have taken place during the 60's and 70's, normally referred to as the green revolution. The introduction of new high yielding rice varieties developed by the International Rice Research Institute (IRRI) has been a major factor in improving the welfare of the people.

No such dramatic change has yet taken place in the zone where shifting cultivation and bush fallow is practiced. Although this system is fairly stable, it is low in productivity of labor and low in output per unit of land area and therefore no longer capable of feeding a rapidly expanding population.

Research at the International Institute of Tropical Agriculture (IITA) in Nigeria, has now identified the components of appropriate new technologies which offer great hope for the future. They consist of low input systems, which minimize soil erosion, nutrient leaching and weed growth and maximize biological fixation of nitrogen and nutrient recycling and at the same time increase labour productivity and crop yields. They allow the farmer to practice a stable permanent agriculture thus eliminating the need for bush fallow and shifting cultivation.

I refer here to an agroforestry system, called alley cropping, in which crops are grown in alleys between hedgerows of trees and shrubs. In this system, minimum or zero tillage and the use of prunings of shrubs and trees and crop residues greatly decrease rainfall run off, soil erosion and soil temperature, while improving the soil's permeability, its fertility and its physical structure for root growth. In addition the deeply rooted trees and shrubs recycle nutrients from deep soil layers. The new technology is basically a modification of the bush fallow system with great emphasis on the establishment of a sound, harmonious, biologically based system.

One of the participants at a recently held alley farming workshop at IITA, attended by some 100 researchers, government representation and others from some 15 African countries and from Indonesia, Fed. Rep. of Germany, United States, India and Australia, stated "Alley farming has come to stay and is going to be a very useful system. If properly handled it will revolutionize agriculture as far as the peasant farmer is concerned".

Of course, while appropriate land and soil management practices lie at the heart of future strategies for increased food production in the tropical belt, they must go hand in hand with the production, efficient distribution and adoption of new crop varieties. Such new varieties, with resistance to a number of

previously destructive pests and pathogens and with adaptation to a wide range of ecologies are now becoming available through the efforts of national and international research organizations for all major food crops.

Sustainability of the ecosystems of the tropics with low risk and low input requirements, while making full use of nature's ability to create a stable equilibrium, is the basic characteristic of these new technologies.

The great task ahead is now the transfer of these technologies to the millions of small farms. This will require large scale demonstrations on farms but also changes in agricultural policies so as to make agriculture financially more attractive.

The organizers of this workshop are giving us the opportunity to explore the many existing and potential means at man's disposal for raising the level of food production in the tropics. A dominating thought throughout the presentations and deliberations must be the sustainability of the developmental actions among populations with very little means and under physical conditions of extreme vulnerability.

I am most happy and grateful to be part of this important event.