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The Ecological Handicap of the Tropics

by Peter P. Waller, Berlin*

The long-forgotten subject of the ecological disadvantages of the tropics has been brought to the fore once again by the catastrophic droughts in the Sahel and in southern Africa. The naive belief that economic development is simply a matter of finding the right technology and of spreading scientific knowledge must give way to the acknowledgement that the "development threshold" of the tropical countries is very substantial and complex, and that surpassing it will be a long and wearisome business.

In the decade of "development euphoria" after the Second World War the effects of the natural environment on economic and social development in the Third World countries came to be pushed increasingly into the background in public debate. Everything was thought to be merely a problem of finding the right technology and the appropriate economic strategy.

It has taken the catastrophic drought in the Sahel countries and now in the countries of southern Africa to focus the attention of both the international development organizations and of scientific circles on the long-forgotten subject of the ecological handicap of the tropics.

For instance, in an analysis of the causes of the economic crisis in sub-saharan Africa, the World Bank points to the devastating periods of drought as a major reason for the crisis-ridden development there.¹ Nohlen and Nuscheler² also state that the ecological disadvantages of individual tropical regions are not difficult to identify, but they attribute the degradation of the ecosystem in the tropics primarily to human intervention. While this point is certainly true, it takes no account of the fact that the arid belts in the tropics are far less stable than the temperate zones and that therefore interference by humans leads to catastrophes that jeopardize the basis for existence. It is in this light that scientific circles now urge the preservation of the mobile lifestyle and economic structure of nomadic population groups which are adapted to the natural environment.³

The Humid Tropics

While few would dispute the ecological disadvantages of the dry tropical regions, there is still a widespread belief in the immense fertility of the humid

tropics.⁴ Natural geographical factors such as unfavourable climate and poor soil, characteristic of the humid tropics, are refuted by economists as a means of explaining underdevelopment, because the scientific findings of neighbouring disciplines are not known.

Thus Besters⁵ writes that all developed countries are located in the temperate zone while the underdeveloped countries are located in the tropics and the sub-tropics. Without any further reasoning, however, he then comes to the conclusion that it is not the underdeveloped countries which are handicapped in terms of nature but rather those which have been developed for a long time. He claims that in the tropical regions man has had little challenge to make nature serve his needs because it willingly provides him with means of sustenance.

Hemmer, in his standard work on economic problems in the developing countries, states that land suitable for agricultural production is exploited inefficiently because the traditional type of farming practised in the tropics, i.e. shifting cultivation, does not allow for the fallow periods needed to regenerate the soil.⁶ There is no mention of

¹ World Bank: Accelerated Development in Sub-Saharan Africa – An Agenda for Action, Washington D.C. 1981, pp. 12 ff.

² Nohlen, Nuscheler: Was heißt Unterentwicklung? in: Nohlen, Nuscheler (eds.): Handbuch der Dritten Welt, Band I, Hamburg 1981, pp. 33 ff.

³ Cf. F. Scholz: Nomadische Bevölkerungsgruppen als Forschungsproblem und Forschungsgegenstand in der Gegenwart, in: F. Scholz (ed.) Beduinen im Zeichen des Erdöls. Wiesbaden 1981, p. 7.

⁴ A climate is tropical if the coolest month of the year has a mean temperature of at least 18° C. The tropics are located north and south of the equator up to the tropic of cancer and the tropic of capricorn. An exact delimitation between tropics and subtropics as well as a delimitation of the humid tropics (tropical rainy climates) can be found in B. Andreae: Agrargeographie, Berlin, New York 1983 (2nd edition), diagram 34, p. 150.

⁵ H. Besters: Theorien zur wirtschaftlichen Entwicklung, in: Besters, Boesch (eds.): Entwicklungspolitik, Handbuch und Lexikon, Stuttgart 1966, p. 264

⁶ R. Hemmer: Wirtschaftsprobleme der Entwicklungsländer, München 1978, pp. 124-125.

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the fact that this has less to do with lack of knowledge than with population pressure.

Hemmer also baldly states that climatic conditions should not be seen as an obstacle to future development since the development agencies could opt for development structures which are adapted to the climatic conditions. No elaboration, however, is provided of the kind of "development structures" envisaged.

In contrast, geographers, soil scientists and agricultural scientists have long pointed out that the humid tropics do have an ecological handicap. In the same edition of the "Handbuch und Lexikon der Entwicklungspolitik" in which Besters states that nature provides man in the tropics with what he needs, another author, the geographer Otremba clearly says: "Tropical soils receive their fertility from the quick transformation of the flush vegetation into humus. However, as soon as the natural forest is removed the production of humus ends and the soil soon loses all its productivity".⁷ Other authors have elaborated on the negative effects of tropical diseases on man and animals.⁸

More recent studies were able to demonstrate in detail the causes for the reduced fertility of tropical soils⁹ and to explain the reduced working capacity of peasants in the tropics on the basis of climatic conditions.¹⁰ Further ecological disadvantages in the humid tropics are the difficult task of prospecting for mineral resources and the increased maintenance costs for infrastructure, a point referred to in particular by the World Bank.¹¹

Before dealing in detail with individual aspects of the ecological handicap of the tropics, it is important to correct a misapprehension: the disadvantages of the tropical climate are not absolute obstacles to economic and social development. They constitute, however, an increased "development threshold". This means two things: historically, the hurdle to high civilization was too great for wide areas of the tropics, or in Toynbee's terms of "challenge and response", the challenge was too great to make an autochthonous response possible. In today's terms this means that, on the basis of scientific knowledge developed in the dynamic cultures outside

the tropics, most of the ecological problems of the tropics could be surmounted, but that this would require significantly greater capital input than was necessary in the temperate zones at a comparable historical period.

Also, it has to be pointed out that the ecological handicap of the tropics is only one factor in the explanation of underdevelopment. Other factors such as the dependency of tropical countries on the industrialized countries or the internal social and economic structures should by no means be underestimated. These factors have been the core of development theory and practice in the last twenty years. It is the aim of this paper to discuss some aspects of the ecological factor, which has largely been neglected.

Low-grade Soils

The plethora of plant life in the tropical forest has created a misconception among both amateurs and experts that these areas represent major potential reserves for agricultural exploitation. Indeed the gross production of biomass at approximately 32.5 t per ha is way above that of the other climatic zones such as the mixed forest zone at 13 t or the boreal coniferous forest zone at 7 t per ha.¹² On the other hand, the autochthonous form of land utilization adapted to the humid tropics, i.e. shifting cultivation, permits only a very low population density. The reason for this is that as soon as the forest is cleared, the soil very quickly loses its fertility and requires a long fallow period to be replenished.

This has long been known by scientists and yet quite a number of spectacular and costly failures of grandiose settlement schemes have been recorded.¹³ During the last 20 years scientific research has proved that shifting cultivation is not the result of human shortcomings but is in fact a method adapted to the natural environment. Without going into details of soil science, a few key aspects based on a study by Weischet will be explored here.¹⁴

The residual mineral and humus content, critical for plant growth, is very low in humid tropical soils. As a result of chemical weathering, roughly 100 times faster here than elsewhere, combined with advanced age, the

⁷ E. Otremba: Die Natur der Entwicklungsländer, in: Besters, Boesch, op. cit., p. 44

⁸ D. Lee: Climate and Economic Development in the Tropics, New York 1957; W. Manshard: Agrargeographie der Tropen, Mannheim 1968.

⁹ W. Weischet: Die ökologische Benachteiligung der Tropen, Stuttgart 1977.

¹⁰ H. Brandt: Peasant Work Capacity and Agricultural Development, Occasional Papers of the German Development Institute, No. 55, Berlin 1979.

¹¹ World Bank, op. cit., pp. 12, 15.

¹² W. Weischet, op. cit., p. 14

¹³ For example, the Tanganyika groundnut scheme (see A. Kolb: Entwicklungsplanung und geographische Forschung in Afrika, in: Die Erde, 1963, pp. 191-205) and more recently the Amazon settlement (see G. Kohlhepp: Brasiliens problematische Antithese zur Agrarreform: Agrarkolonisation in Amazonien, in: H. E. I. S. e. n. h. a. n. s. (ed.), Agrarreform in der Dritten Welt, Frankfurt 1979, pp. 471-504).

¹⁴ W. Weischet: Ackerland aus Tropenwald – eine verhängnisvolle Illusion, in: Holz aktuell, No. 3, 1981, pp. 15-33

soils are poor in nutrients. Even graver, however, is the fact that the silicates have been leached out, with the result that the soil has virtually lost the ability to store new minerals (cation exchange capacity).

Mineral fertilizers therefore can be stored to only a limited extent in these soils; after a very short time they are leached out again and have only a short-term effect in increasing the fertility of the soil. On the other hand, there had long been a mystery as to why within catchment areas in rain forests which have not been disturbed by shifting cultivation, the water in the rivers contains virtually no mineral nutrients although leaching of the soils is taking place. It was not until after the Second World War that botanists and plant ecologists solved the mystery by the discovery of the action of "mycorrhizae" (root fungi). They surround the roots of trees in the form of a mesh and trap nutrients from the surface of the soil (nutrient gap), and pass these on directly to the roots.

In a virgin tropical forest biomass production functions on the basis of direct mineral cycling. Through the action of the rain and falling dead plant matter the mineral nutrients are brought to the soil via the decomposition of the tree litter. They are caught in the upper levels of the soil in the fungus trap and returned directly into the biomass. If the forest is then felled and burned, the cycle is broken at a vital point. The humus matter close to the surface is largely destroyed, the fungi soon die and minerals are increasingly lost through erosion.

Agricultural Supportive Capacity

Tropical soils are characterized by a great diversity. Some soils, notably alluvial soils and volcanic soils, are very fertile and in many tropical areas sustain high population densities (Java, Bangladesh). However, it is estimated that between 70 % and 80 % of the whole area of the humid tropics consists of highly leached soils with the described negative characteristics.¹⁵ Thus the question of the agricultural supportive capacity is particularly relevant in this region.

Generations of geographers have addressed themselves to the problem of the number of humans which can be supported in an area based on agriculture. Empirical studies have shown that the actual capacity of shifting cultivation ranges from 10 to 60 persons per

square kilometer.¹⁶ If the population density surpasses this limit, outmigration is the result.¹⁷

Of course it is possible to improve the agricultural supportive capacity of large areas of the humid tropics, despite the poor soil, by using better farming methods. However, there is limited scientific knowledge so far regarding the improvement of methods in this climatic zone. Exact quantitative forecasts on the supportive capacity of the humid tropical areas based on a high input level, as used by the Food and Agriculture Organization (FAO), must therefore be considered to be highly speculative.¹⁸

The two principle possibilities for intensive permanent cultivation and high supportive capacity in the humid tropics are tree-growing and rice cultivation. The former is heavily dependent on the world market (palm oil, coconut oil, bananas, etc.), and the latter is only possible in irrigable areas and especially on alluvial soil. Both options involve a very high level of capital expenditure. On the basis of information from German projects, Brandt estimates the average capital expenditure per hectare of tree cultivation to be 3,000 to 4,000 US dollars. The second possibility, rice cultivation, also involves heavy investment, probably in the region of 4,000 to 10,000 US dollars per hectare.¹⁹

Health

There is no disputing the fact that people in the tropics suffer far more from disease than those in the temperate zones. There are any number of empirical studies which prove that up to 90 % of the people investigated suffer from one or more endoparasitic diseases.²⁰

The disadvantage of the tropics in relation to other climatic zones is that the tropics have all the diseases which the temperate zones have, but also a whole series of diseases, particularly endoparasitic ones, which only exist in these regions (yellow fever, bilharzia, sleeping sickness, malaria etc.). Moreover the tropics provide much better conditions for diseases, particularly those involving "hosts", than the temperate zones, where the hosts are killed off in the winter or take

¹⁵ Calculation based on W. Weischet: Die Grundlagen des ernährungswirtschaftlichen Hauptgegensatzes auf der Erde, in: Wirth, Heinritz (eds.): 41. Deutscher Geographentag Mainz, Wiesbaden 1978, p. 281. These leached soils are mainly oxisols (latosols), ultisols and alfisols. A detailed map of the extent of these soils is found in: D. Stella: The Geography of Soils, Englewood Cliffs 1976, p. 72.

¹⁶ W. Manshard: Bevölkerungswachstum und Ernährungsspielraum, in: Geographische Rundschau, 1978, No. 2, p. 43

¹⁷ P. Waller, R. Hofmeier: Methoden zur Bestimmung der Tragfähigkeit ländlicher Gebiete in Entwicklungsländern, dargestellt am Beispiel Kenias, in: Die Erde, 1968, No. 4, p. 342.

¹⁸ Cf. Food and Agriculture Organization of the United Nations (FAO): Land, Food and Population, Rome, 11 August 1983. The assumptions made on the basis of the FAO calculations, for example that forest is confined to lands unsuitable for agriculture, are at least ecologically highly debatable.

¹⁹ Brandt, op. cit., p. 133. Brandt estimates the capital coefficient (capital input per unit of annual production increase) at between 2 and 4, a value comparable with industrial production.

²⁰ A. Kamarck: The Tropics and Economic Development, Baltimore 1976, p. 59.

significantly longer to multiply. For instance, the common house fly, which is host for various intestinal diseases, takes 44 days at a mean temperature of 16° C to hatch out of the egg. At 25° C this period is reduced to 16 days and at 30° C to 10 days.²¹

The higher incidence of disease in the tropics, which still pertains today, has a serious effect on the quantity and quality of work produced and therefore on economic and social development. Modern medicine has enabled great strides to be made in combatting tropical diseases, although the fight has certainly not been won yet, as the increase in malaria shows. Yet once again the costs of fighting disease in the tropics are far greater than in other climatic zones.

In emphasizing the ecological handicaps of the tropics in the field of health there is no intention of overlooking the close connection between health and other aspects of society. The poor health of people in the tropics can also be attributed to a great extent to poor food, unhygienic living conditions or faulty government health policy.²² This does not alter the fact that, historically, the high incidence of disease in the tropics has been a significant factor in impeding development, and that the aim of satisfying basic health requirements in the tropics requires disproportionate capital expenditure.

²¹ Ibid., p. 81.

Climate and Work Capacity

Probably the most serious ecological handicap of the tropics lies in the reduced work capacity of the people because of daily and seasonal high temperatures, humidity and insolation. While this has always been obvious to anyone who has had to live permanently in the tropics or has even had to spend just a short time there, this key problem for development in the tropics has been largely neglected in scientific circles for the past 30 years. One simply assumed that the "natives" were accustomed to the climate and that their working capacity was not really reduced. This, however, is definitely incorrect.

On the basis of quite a number of empirical studies in Africa and Asia, Brandt comes to the conclusion that the mean work output per male worker in tropical agriculture fluctuates between 700 and 1,500 hours per annum, whereas the figure for comparable historical periods in Europe, the USA, the Soviet Union and China was up to 4,000 hours per annum.²³ In the European countries the increase in real wages and the decline in high work output did not begin until a relatively advanced phase of economic development. Thus development was made

²² G. L a c h e n m a n n : Primary Health Care and Basic Needs Orientation in Developing Countries, Occasional Papers of the German Development Institute, No. 69, Berlin 1982, p. 24 ff.

²³ H. B r a n d t , op. cit., p. 84.

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Dieter Lösch

MARKT ODER STAAT FÜR DIE DRITTE WELT?

Wirtschaftssystem und Wirtschaftspolitik in Entwicklungsländern, illustriert am Beispiel der Republik Malawi

(The Market or the State for the Third World?)

The economic system and economic policy in developing countries, illustrated by the example of the Republic of Malawi)

A necessary prerequisite for a successful development policy is an economic system atune to the needs of the developing countries. This study shows where the causes of the – empirically proven – higher stage of development of those developing countries with a market economy are to be found and offers practical guiding principles for action for an economic policy based on the market in the poorest developing countries. (In German.)

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V E R L A G W E L T A R C H I V · G M B H – H A M B U R G

possible by the sweat of generations of peasants or, to be more precise, "enforced overtime" in the order of 1,500 working hours per year.²⁴

This "enforced overtime" is not possible in a tropical climate. The reason for this is the reduced physical working capacity under hot conditions. Various scientific investigations in work physiology indicate that for a healthy, heat-trained worker continuous work of 300 kcal/h (bush-clearing, hoeing, heavy weeding) is only permissible up to a temperature of 27° C.²⁵ Exceeding this temperature leads to fast overheating of the body, physical performance declines rapidly and several hours of rest are necessary to restore the thermal equilibrium of the body. In the case of full insolation or of a worker who is undernourished or ill, the critical heat value is significantly below 25° C.

Geographic Determinism

Taken together the three main ecological handicaps of the humid tropics – infertile soils, disease and reduced work capacity – constitute such an enormous development threshold that one has to come back to the question referred to at the beginning of this article: "Why have economists so far taken so little notice of this fact?"²⁶ Kamarck attributes this to an overreaction to the old ideas of "geographic determinism" propounded at the beginning of the century, particularly by the American geographers Ellen Churchill Semple and Ellsworth Huntington. Semple²⁷ stated: "The debilitating effects of heat and humidity, aided by tropical diseases, soon reduce intruding peoples to the dead level of economic inefficiency characteristic of the native races." Huntington maintained that the various climatic zones simply determined various levels of civilization.²⁸

Economists later overreacted to geographic determinism by believing rather naively that modern science could soon overcome the ecological handicaps

of the tropics. For instance Higgins²⁹ concludes his chapter on geographic determinism with the sentence: "Thus the disadvantages of the tropics are steadily disappearing with the growth of scientific knowledge and improvements in techniques with respect to control of disease, seed selection, use of fertilizer, transport, and industrial production."

Today we know that we are only beginning to understand the special problems of tropical agriculture, that the eradication of tropical diseases still has a long way to go, and that the significant reduction of the work capacity of an agricultural worker in a tropical climate cannot be overcome by reference to the discovery of air conditioning. What then are the consequences of the ecological handicap of the tropics for development policy? There are basically two: that it is not possible to press capital out of agriculture for the development of industry, and that much more scientific research is needed to develop appropriate land use systems for the humid tropics.

Traditional Development Model

The traditional development model – sustained increase of work output in agriculture, transfer of surplus from agriculture to the urban sectors³⁰ – is not feasible under the climatic conditions of the tropics and given the increasing scarcity of land. By contrast, in many countries the rural areas will have to become net receivers of capital if these countries are to have a chance of survival.

In the last twenty years, however, many governments, in particular those of African countries, have pursued a policy of discrimination against rural areas to the benefit of the urban areas and the industrial sector.³¹ This policy has led these countries into an economic crisis that threatens their very basis of existence.³² The only way out of this catastrophe is recognition of the failure of the traditional development model under tropical conditions and a fundamental reorientation of the allocation of public funds towards the rural areas.

²⁴ Ibid., p. 14.

²⁵ Ibid., p. 101; relative humidity of over 75 % and low insolation.

²⁶ An exception to this general neglect of the climatic factor is a recent study by Hesse, who tries to establish a connection between tropical climate and industrialization. He argues that the complete stop of agricultural work for part of the year forced the population in Western Europe to engage in non-farm work and thus led to industrialization. On the other hand the most highly developed cultures in the tropics, which were based on intensive rice irrigation, had their population engaged in agricultural work all year round with little pressure for non-agricultural work and therefore little inducement to industrialization. Cf. G. Hesse. *Die Entstehung industrialisierter Volkswirtschaften*, Tübingen 1982.

²⁷ E. Semple: *Influences of Geographic Environment*, New York 1911, p. 10.

²⁸ E. Huntington: *Civilization and Climate*, New Haven 1915.

²⁹ B. Higgins: *Economic Development*, New York 1959, p. 273.

³⁰ Besides countries in Western Europe, Japan (an extra-tropical country) also followed the traditional development model. In the early phase of development, the Meiji-Period, a high increase in agricultural productivity was achieved with little capital through an increased utilization of the factors labour and land. Cf. K. Okawa: *Japan's Development – A Model for Less Developed Countries?* in: *Asian Development Review*, Vol. 1, 1983, No. 2, p. 50.

³¹ W. Zehender: *Entwicklungskrise – Krise der Entwicklungsplanung?* in: *Arme Länder Afrikas*, Occasional Papers of the German Development Institute, No. 71, Berlin 1982, p. 182.

³² P. Waller: *Die Wirtschaftskrise Schwarzafrikas und die Strategien zu ihrer Überwindung*, in: *Europa-Archiv*, 1984, No. 6, pp. 187-194.

A continuation of modern industrialization will only be possible in countries which can generate capital out of mining activities or which can attract foreign private capital. In countries where these conditions are not met – i. e. the poor countries of Africa – industrialization will be limited to small-scale industry mainly in the rural areas – as was the case in the early phase of industrialization in Western Europe, too.³³ In these poor countries the modernization of agriculture cannot be financed by other sectors of the economy but only from outside. Thus the necessary reorientation in the allocation of funds by the respective governments must be supported by increased development aid from the industrialized countries.

Towards Appropriate Land Use Systems

Traditional shifting cultivation can be regarded as an ecologically stable system on condition that the fallow periods are long enough for a complete regeneration of the soils. With increasing population densities, however, fallow periods are reduced, soils are continuously deteriorating and the subsistence of the population is no longer guaranteed.

Two possible solutions to this problem have been mentioned above, i.e. irrigated rice cultivation and tree cultures. The latter have been tried very successfully by developing countries such as the Ivory Coast (cocoa and coffee). However, the vision of the humid tropical region as an exporter of the products of tree cultivation and an importer of food³⁴ is not very realistic since world demand for tropical agricultural products is stagnant, the outlook for prices is very poor and the reserves of land with a good infrastructure for exports are dwindling. In any case even the countries which do earn considerable amounts of foreign currency through the export of tropical agricultural products need these export earnings for other important imports and cannot afford to use them for food imports. They are thus forced to become self-sufficient in food production.

Because of this food crisis, especially in Africa, appropriate forms of land use (ecofarming) which do not destroy the environment and at the same time can feed more people are becoming more and more important. One appropriate form of land use for the humid tropics is agro-forestry, a synthesis between food production, wood production and conservation of the environment.³⁵ It is an almost closed system which

means that it works without costly (and energy-intensive) inputs like chemical fertilizer and pesticides.

The introduction of these "low external input" systems in areas where they were not traditionally practised meets, however, with a number of difficulties which can only be overcome in the longer term.³⁶ The greatest weakness of these new systems is the virtual lack of implementable packages of measures for specific locations. Thus the most important bottleneck in the development of appropriate land use systems for the humid tropics is scientific research.³⁷ Although a few research institutes of high standard exist, they are not nearly enough for applied research geared to the immensely varied natural conditions typical for the humid tropics. To give this type of applied research highest priority is the most important consequence for national governments as well as for bilateral or multilateral donor organizations considering the appalling food crisis and the natural handicap the tropical countries face in solving it.

For the humid tropics one could envisage a dual land use system. In locations with good soils or with good infrastructure, land use could be dominated by modern high input systems (irrigated rice, tree cultures) which on the basis of high capital investments produce an agricultural surplus to feed the cities and can earn foreign currency. The vast majority of the areas with low quality soils could be stabilized through various ecofarming systems, notably agro-forestry. They would produce only small surpluses and require few inputs, but would certainly be able to fulfil the basic needs of the rural population and sustain the environment.

The outlook may sound very modest. However, its realization would require an immense effort by the people and the governments of the tropical countries as well as by the industrialized countries. After the decades of euphoria over the achievements of science and technology it is time to realize that the ecological handicap of the tropics is still there. This is not to say that other obstacles to development – national as well as international ones – are of little significance. It is only to say that the "development threshold" of the tropical countries is very substantial and complex. To surpass it will require the combined efforts of generations.

³³ G Hesse, op cit p. 62.

³⁴ B. Andrae, op. cit., p. 164.

³⁵ A good survey of the elements and problems of agro-forestry can be found in: C. H. MacDonald, *Agro-forestry in the African Humid Tropics*, Tokyo 1982, The United Nations University.

³⁶ Some of the difficulties in the implementation of these systems are, benefits are only obtained after several years during which work input is, however, substantially increased; also, they require a change in the work organization of the family which quite often meets with resistance. Cf. D. Prinz: *Zwei Konzepte zur Steigerung der landwirtschaftlichen Produktivität – die „Yurimaguas Technologie“ und das „Ecofarming Modell“*, in: *Der Tropenlandwirt*, Oktober 1983, p. 196.

³⁷ A. G. Seifeldin: *Agro-forestry research for the humid tropics*, in: C. H. MacDonald, op. cit., pp. 22-26.