AGRICULTURE IN ECONOMICALLY UNDERDEVELOPED COUNTRIES, ESPECIALLY IN EQUATORIAL AND SUBTROPICAL REGIONS [1])

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SUMMARY

People in equatorial and subtropical regions generally are poor. They are mainly depending on agriculture and productivity per head in local systems of farming is very low. This low productivity, expressed per family farm, is based on small farm size, low yields and low unit prices, especially for the products of food cropping. In an analysis the author distinguished between natural causes (leached soils, short day length, exuberant weed growth, etc.), causes related to the cultural pattern (shifting cultivation, no use of cattle, etc.) and causes which are a consequence of the retarded stage of development following out of natural and cultural circumstances. The paramount importance of a balanced development is stressed.

INTRODUCTION

Agriculture is the principal source of income in the underdeveloped regions of the equatorial and subtropical zones of the world. In general 70% to 80% and even more of the population live by agriculture in these regions, so that living standards are mainly governed by the local type of agriculture. The productivity of the latter is always very low, which is the chief reason why living standards are low in most parts of equatorial and many parts of the subtropical regions. At the same time it is the principal cause of their underdevelopment.

There can be no doubt about the income being low. Calculated in terms of money it averages U.S. $ 100 or less per capita per annum for most equatorial and subtropical regions, as against about U.S. $ 700–800 in temperate Western Europe and about U.S. $ 1800 in U.S.A. (27). But generally speaking, prices, especially of food, are also very low in these equatorial and subtropical regions. Hence in order to arrive at a true comparison of the real levels the incomes would have to be assessed but in any case the differences are so great that this is hardly necessary.

It might therefore be preferred to compare living standards by another method, e.g. by comparing the daily food consumption per capita calculated in calories and grams of protein, especially grams of animal protein (table 1). The result obtained is the same viz. low values for the equatorial and subtropical regions as well as deficiencies in vitamins, minerals, etc. Moreover, an abnormally high proportion of the income is used for food, and this is also an indication of poverty. According to the second law of ENGEL, the greater the expenses per family, the smaller the proportion spent on bare subsistence necessities, in this case food, and we can see that this proportion is generally very high. In Java, for instance, it reaches 70% to 80% (7, 10).

It might be maintained that the cost of clothing, housing and heating in the tropics is lower than in temperate regions, and that for this reason a lower income would not only be justified, but quietly accepted by the population,

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Table 1 Daily consumption levels per capita in various countries (28).

	Calories	Proteins	Which animal proteins		Calories	Proteins	Which animal proteins
Canada	3140	97	63	Brazil	2350	58	17
U.S.A.	3150	95	67	Japan	2050	62	14
Argentine	2990	102	66	China (25) ...	2030	63	6
N. Zealand	3190	97	64	*Peru*	2070	55	12
South Africa	3350	104	77	*Philippines* (25)	1960	44	10
United Kingdom .	3270	84	50	*Indo China* (25)	1560	36	4
France	2980	103	56	*Indonesia* (25) .	1880	42	4
Netherlands	2950	80	43	*India*	1880	51	6
Sweden	2970	79	50	*Pakistan*	1990	47	8
Italy	2570	50	24	*Ceylon*	1820	44	9
Portugal	2550	69	23	*B. Congo*	1930	42	5
Greece	2680	85	24	*Fr. W. Africa* .	2070	59	8
Turkey	2870	88	12	*Tanganyika* ...	1980	53	10
Egypt	2580	75	13	*Honduras*	2250	56	10
Fr. N. Africa ...	1920	65	16				

In italics : predominantly equatorial and subtropical regions.

so that there would be no incentive for improvement. This argument might also be logically applied to caloric intake, as there are indications for assuming lower caloric requirements, taking into account the lower bodyweight and height [2]) and higher temperatures. But food represents such a high proportion of the total expenses that the inadequacy of total income and the low living standards are sufficiently demonstrated thereby. Moreover, it is very probable that low bodyweight and height are a direct result of inadequate diets.

The low living standard is one cause of decreased vitality, bad hygienic conditions and numerous diseases and infection is also promoted by the warm humid environment. Such conditions decrease the energy output per capita and this in turn again decreases productivity.

Life in these regions chiefly depends on a few primitive systems of cropping, only supplemented by a certain amount of food gathering, hunting or fishing. Two or more of these systems of cropping together form a system of farming, and, for centuries some system of farming formed the precarious basis of subsistence. Thus in primitive societies where changes only occur very slowly, cultural and agricultural patterns became strongly correlated. New systems of agriculture and farming have been introduced in modern times but are far from general.

In the thinly populated regions one system of agriculture predominated. It is shifting cultivation (fig. 1), one of the oldest systems of agriculture, comprising the dibbling of millets, rice or maize (which was introduced later) in Africa and S.E. Asia. One also finds cassava cultivated with a dibble or a digging stick in Brazil ; tubers cultivated with a digging stick : yams, taro, bananas and fruit trees in Papua and also as a second-year crop in the dibble cultivation of rice, millet, maize, etc. in S.E. Asia ; the cultivation of millet in hoe culture in the Sudan and the cultivation of maize, beans, etc. with a

2) Caloric requirement at rest (basal metabolism) is determined by age, sex, height and bodyweight.

FIG. 1 FENCED TEMPORARY FIELDS, MOSTLY ABANDONED (NIKI-NIKI, TIMOR, E. INDONESIA).

digging stick in various parts of Central America. In none of these systems were cattle used.

In the more densely populated regions permanent systems of agriculture prevailed, mostly on rich volcanic or alluvial soils, e.g. the cultivation of tubers, etc. with a digging stick on permanent fields in Polynesia, or with a hoe in parts of Indonesia (Java, Minangkabau), in S.E. Asia in general, in Guinea and Uganda; the cultivation of maize and beans with a digging stick or a hoe in the highlands of the Andes, in Mexico and the Pueblo regions, often in combination with irrigation and manuring, but mostly without the use of cattle.

The most important present-day system seems to be the growing of wet rice with hoe or plough in South-East Asia, parts of Indonesia and the Philippines, with irrigation, manuring and the use of cattle. In India, as well as in Java, it is accompanied by permanent cultivation of crops on dry fields.

In combination with some supplementary systems of cropping, e.g. tree growing in dibbling or hoeing cultivation, some widely differing systems of farming originated which are typical of different regions and cultures (20).

The common farm unit is still the single family farm, or sometimes some modification due to such institutions as polygamous marriages, joint families, extended families, or greater genealogical or territorial units. The single family farm is always very small, varying from 1 to 4 acres, even in the most thinly populated regions. The other farm types vary in size according to the number of working members. It is only in the most densely populated regions that very small-sized family farms tend to predominate as a result of the pressure of population.

Thus there is no direct relation between population density and poverty in

the tropics, although conditions may be aggravated by the population pressure.

It should be stated that this poverty is not a new phenomenon. In the more densely populated regions, where the introduction of hygienic and medical measures led to a great increase in population, there is sufficient evidence to suppose that living conditions have worsened during the last century, but there is no reason at all to believe that in the less densely populated regions living conditions are now worse than they were 100, 200 or even soms 1000 years ago. These regions have remained stationary at the subsistence farming level or slightly above, whereas the temperate regions, with the exception of China, have shown a great development.

The difference is that nowadays the living conditions of the less prosperous peoples of the tropics and other underdeveloped regions are generally known, and these peoples are now acquainted with the wealth of the temperate regions and hope to attain the same level. Are general conditions in equatorial and subtropical regions such that the development of the temperate regions can be followed and repeated? This is the chief question to which an answer is required. Is the underdevelopment of these regions only due to a time lag, or are there certain factors in the tropical environment which constitute a handicap to such development? In this case, in addition to a time lag there will be a difference in the basic possibilities and it will be necessary to make the best use of the remaining possibilities.

Recently LEE (8) tried to summarize the general influence of climate on human productivity. The author and others tried to analyse the causes of low productivity in tropical agriculture (17, 19) as related to soil and climate (3, 14, 18), and also to the typical inherited peculiarities of the cultural and agricultural patterns (18, 20).

CONDITIONS IN EQUATORIAL REGIONS

For the purpose of analysing the real basic differences between agricultural production in equatorial countries and in the temperate western regions of the world, it will be useful to compare the size and productivity of family farms in regions where farm labour is still unmechanized, e.g. in Java and the Netherlands between 1930 and 1940 (17, 19).

A family farm in Holland was managed by one family, with the possible help of one farm hand when there were no grown-up sons, and had the use of one or two horses. Its area did not exceed 40–50 acres (16–20 ha) when mainly under cereals. Yield per ha was 3000–4000 kg of cereals (wheat or rye) and the price per 100 kg would have been about $ 3.–. This price is nowadays about $ 8.–, based on international import prices in 1955 (26).

A family farm in Java with the same manual labour and one buffalo or cow was not larger than 2–4 acres (0.8–1.6 ha). The average yield of hulled rice was about 1200 kg/ha and the local price about $ 2.– per 100 kg (26).

Hence the gross income of a Dutch family farm of this type was in the neighbourhood of $ 1900 and nowadays it would be about $ 5000. In reality most Dutch farms are smaller, being mixed farms with dairy cows, pigs and poultry, and growing potatoes, fodder and the like, i.e. crops which require much more labour but are more productive in gross income. The total production per farm would be about the same as that of the cereal farm.

The total prewar production of a Javanese family farm may be estimated

at between $ 20 and $ 40, based on local prices. On the basis of international prices it would now be between $ 125 and $ 250. On the one hand it should not be forgotten that in some fertile regions production is mich higher, that two irrigated rice crops are often possible in one year or even a third crop of soybeans or arachis (groundnuts). On the other hand, only a part of the farmland is irrigated riceland and most rice farms are very small and do not even reach 1 ha (2.5 acres), while the dry land is not very productive and usually only bears one crop a year.

Moreover, the price the Javanese peasant obtains for his rice amounts to a much lower percentage of the international import prices than that which the Dutch farmer obtains for his wheat or rye, one reason being the cost of milling. Real gross income of the Javanese peasant is therefore lower than that calculated above for today.

Before the war conditions were even worse. Generally speaking, rice prices have always been lower than wheat prices [3]) and the same trend is apparent today. A comparison of the prices of tropical foodstuffs in general (manioc, sweet potato, taro, soybean) with such comparable western foodstuffs as potatoes and beans, again shows that tropical foodstuffs are much cheaper.

Thus owing to size, productivity and prices, the gross income of an equatorial family farm is much smaller than that of a comparable one in western temperate regions. It should be born in mind that although the extremely small family farms in densely populated regions are a result of the population pressure, they are still not much larger when this pressure is absent.

On analysing the differences between tropical and temperate agriculture the following points emerge:

1 the family farm is much smaller in equatorial regions,
2 productivity per ha is much lower in equatorial regions,
3 except in the case of rice after World War II prices per unit for comparable foodstuffs are much lower in equatorial regions.

If we could discover the cause of these differences we might be able to find a means of eliminating them. It would then be seen that some differences are actually determined by the typical natural conditions of equatorial regions, especially of the wet tropics so that it would be very difficult if not impossible to eliminate them, whereas others result from the inherited cultural and agricultural pattern, i.e. the local systems of cropping and farming, and the consequent difficulties of an undeveloped economy.

Most equatorial farmers are subsistency farmers who mainly cultivate *food-crops*. This affects their normal farm systems in the following ways:

a *Farm sizes* are definitely restricted by the difficulty of *controlling weeds*. In most equatorial regions rain falls throughout the year, or there may be one or two short dry seasons (these, however, often occur very irregularly). Most food crops are grown during the rainy season, but during this period weeds grow very fast and there are very few opportunities of controlling them

[3]) Before World War I an Indian farmer received 3 Rs per maund (82 lbs) of wheat, but only 1 Rs per maund (82 lbs) of paddy (= 57.5 lbs of rice), i.e. about 1.40 Rs for 82 lbs of ordinary husked rice and less than double the price for high quality rice, which was an exceptionally high price (9). If the farmer decorticates the paddy himself, 1 maund of ordinary rice was worth about 2 Rs to him.

by the frequent weeding, hoeing, etc., which has to be carried out during a dry spell. The result is that when the crop area per family is too large, weed growth will be so extensive that it cannot be checked and either productivity will be very low or only a small area can be cropped. Theoretically the maximum area per family farm for annual food crops would be 2–3 ha – if all cultural practices hitherto known were to be applied (16).

One of the best crops would be wet rice, because weed growth is often very limited in the case of this permanently inundated crop and weeding is always possible. Hence it is easy to understand why the largest family farms are to be found where wet rice is grown, despite the fact that wet rice may need a great deal of extra labour for irrigation. In Thailand family farms of up to 12 acres (4.8 ha) are found with an extensive type of wet rice growing with buffaloes for ploughing (23).

Conditions are just as unfavourable in shifting cultivation as in permanent agriculture. One reason why new land is annually opened up for shifting cultivation is the vast increase in weed growth after the first year of cultivation, while the size of the annual plots is restricted by the difficulties of clearing and burning.

Sometimes the *soil* can only be worked (ploughed etc.) for very limited periods, e.g. just after the first rains or while it is drying after the wet season. In addition to the difficulty of weeding this may be another factor limiting the size of family units. Moreover, shallow ploughing, often extended over a long period in the beginning of the rainy season, may produce very foul land, causing increased difficulties in weed control.

Another reason for the smallness of the farm is the *very limited use of cattle* in agriculture. Shifting cultivation depends solely on manual labour and is unsuitable for the introduction of cattle into agriculture. In permanent agriculture cattle is practically only used for ploughing, but not for sowing, weeding etc. Often it is not employed at all.

The region between India and Java is practically the only agricultural area of the equator, where the use of cattle for ploughing here and there forms part of the old agricultural pattern, viz. with the Indians, Ceylonese, Burmese, Mons, Thais, Khmer, Chams, Tonkinese, Minangkabau and Javanese. Nowadays cattle are also employed in this way by some other peoples, but in this case it appears mostly to be a fairly recent acculturation.

As already stated, the farm size is and always has been small in both thinly and densely populated regions and in both permanent agriculture and shifting cultivation. In shifting cultivation family farm units seldom extend beyond 1 ha: Papua (1), Philippines (4), Africa (5, 12), South America (11). Where there is permanent agriculture, family units in densely populated regions may even be less than 1 ha: Peru, Haiti (11), Tonkin (5), Java (10,22), South India and Ceylon (15), Melanesia and Polynesia (1), but in such cases there is often more than one cropping period per annum.

However, even in ancient times family units were generally limited to less than 1 ha. According to DE VRIES (22), in the Middle Ages the land shared out per family in Java was limited to less than 1 ha. SLATER (13) states that in India in former times, before excessive population growth, in Trichinopoly a Brahman family possessed as little as five acres of paddy land of medium

quality and lived in idleness on the produce, the land being cultivated by servants. In the specially rich valley of the river Tambraparni three acres were enough to support a family in idleness.

Thus the smallness of the farm is partly due to unfavourable natural conditions and partly determined by the cultural and agricultural patterns.

b There are various reasons for the *low yields*. Most *equatorial soils* are very poor (lateritic and sandy soils). Exceptions are recent volcanic soils and recent alluvial flats and it is on these that we find the regions with high population densities (S. Burma, Cochin-China, Tonkin, Java).

Normally the equatorial soils are extensively leached, very poor in organic matter and all constituents needed for maintaining fertility, i.e. retaining available water and nutrients for plantgrowth. Moreover, most of these soils are very sensitive to periodic drought. Most annual crops are grown in the rainy season, but the *day length* during growth is only 12 hours, as against 16 and more hours in temperate countries. This limits productivity. The use of chemical fertilisers and green manure was practically unknown, and even where cattle is present dung was seldom used. Moreover, the soils are permanently leached out and their organic matter disappears rapidly.

Hence the soils are underdeveloped. It is only in certain densely populated regions that irrigation and terracing, and occansionally also many years of manuring, have had some favourable effect on its productive capacity (fig. 2).

Furthermore, production has remained low owing to the lack of selection, weeding, disease and pest control, as well as such effective cultural practices as the regular use of dung, fertilizers and green manure, improvements in the soil structure and profiles, drainage, soil reaction and salinity.

The production of food crops in equatorial regions is not only inferior in weight, but in calories and kg of proteins. Af few comporisons follow (17):

	Temperate (Netherlands)				Equatorial (Java)			
	per ha weight	calories	kg of protein		per ha weight	calories	kg of protein
Rye	22.5 q.	7.200.000	250	Rice	12 q.	4.280.000	90
Beans	22.5 q.	6.620.000	495	Soybeans	7 q.	2.340.000	250
Potatoes	200 q.	14.000.000	340	Sweet pot.	70 q.	7.000.000	75
				Cassava	80 q.	9.000.000	90

Hence it is certain that yield will be low; this is partly due to such natural conditions as poor soils and short daylength and partly to factors resulting from social and economic conditions.

c *Prices* for tropical food crops, with the temporary (?) exception of rice, are very low. This is partly due to the fact that these food crops are either not in use for human consumption in most temperate countries (maize, sorghum, millets) or are very perishable (sweet potatoes, yams, taro, manioc, etc.).

Moreover, they are often of low quality. With the exception of rice, all predominantly equatorial and subtropical crops are cheaper than those of temperate regions: compare various millets with wheat, rye, barley and oats, tubers such as sweet potatoes, taro and yams with Irish potatoes, various kinds of temperate beans with soybeans and peanuts which are even much richer in fats and proteins.

In most cases these prices are formed in a sellers' market with a minimum price determined by the low general income of the producer who, moreover,

FIG. 2 PRIMITIVE TERRACES PROTECTED WITH BANANAS (MERAPI SLOPE ABOVE DJATINOM, M. JAVA).

works without knowing the significant and definite costs in terms of money.

These three factors combined, result in a low remuneration per hour of labour. In Indonesia before World War II some 10 published and many unpublished farm analyses showed a reward of about 1 kg of husked rice per hour of labour in agriculture (21). DUMONT (5), who gives figures for various parts of the world, arrives at 1.5 kg of husked rice for Tonkin, 1.25–5 kg of maize in most parts of Asia and Africa, 9 kg of millet for the Chad regions, as against 16 kg of maize for Western France (cattle in agriculture) and more than 200 kg of maize in the Corn Belt of U.S.A. (mechanized agriculture).

CONDITIONS IN SUBTROPICAL REGIONS

In subtropical regions shifting cultivation is rare and the situation as to farm sizes is more favourable. When crops are grown in the hot rainy season (India), weed growth is as troublesome as in equatorial regions, but winter crops are less exacting because temperatures are lower and the weather is often dry. Thus in many parts of Northern India a farm may be as much as

FIG. 3 EVERY FARMER OPERATES HIS OWN IRRIGATION SYSTEM, FROM A CANAL OR RIVER OR FROM HIS OWN WELL (RIVER BHADAR, SAURASHTRA, INDIA).

10 acres in size for partly irrigated soils and more than 25 acres for dry soils. Where the soil is heavy it may still be difficult to work it during the short periods before or after the rains [4]). Generally, however, at least in the Old World, cattle are used for ploughing and sometimes even for sowing, harrowing, weeding, etc. Hence the agricultural regions are usually more densely populated than agricultural regions of the equator. Productivity is also on a higher level because the soils are generally richer than in equatorial regions and day length in summer is much longer than 12 hours. But the irregularity of rainfall decreases productivity and may lead to severe crop failures. Thus irrigation is often necessary but constitutes a further handicap. Although it promotes larger and more reliable crops, it is very labour consuming as water is normally too scarce to enable the easiest method to be applied, i.e. a free flow of water as in use for wet paddy. It is said that one man and two oxen are required to irrigate four acres from a well, and that when distributing water on a wheatfield one man does not normally handle more than 1.5 acres per day [5]). Thus if the water used is supplementary and the crops are properly chosen, an irrigated farm of a size of 8–10 acres can be managed by a family with older sons or a farmhand (figs. 3 and 4).

Production is also kept low by the low level of manuring, selection, pest and disease control, but often also by salinity damages.

Exept in the case of rice and wheat prices are also low. Sorghum and millets are low-priced, as are also various beans and tubers.

HUMAN LABOUR IN AGRICULTURE

The general situation is therefore, that in equatorial regions in particular

4) These are the regions where mechanisation, at least partly, might be a help.

5) When the supply of water is limited not more than 0.5 acres per day can be handled. Water is applied every ten days.

FIG. 4 LAND, DIVIDED INTO SMALL BASINS, DESTINED FOR IRRIGATED WHEAT (DRY REGIONS OF NORTHERN INDIA).

agriculture, and more especially food growing, does not pay as high a price per hour of labour as in the temperate zones. This was already suspected by SMITS (14) who drew attention to the small size of farm units and to the small reward, calculated in kind, per hour of labour. VINK (21) was able to confirm his figures.

Of equatorial regions it was also stated by BROEK (3) that: "The leached soils of the tropical rain forest on the whole give low yields. This may be counterbalanced by obtaining two harvests a year, but that is not everywhere possible. Furthermore, there is reason to believe that cultivation requires more labour per acre of cropland than in the Temperate Zone, chiefly because of the need for frequent weeding (24). If these observations are correct, it means that the productivity of labour in the tropics is low. This might be one explanation why the white man usually has found small-scale farming unprofitable. His remarks contain a justified warning agains white-farmer emigration to the tropics, based not on social or medical, but on economic indications."

More data have gradually become available on the quantity of human labour [6]) required for various systems of cropping in equatorial regions, the subtropics and temperate regions.

Some figures can be given for the opening up of land in shifting cultivation and supplementary figures for the dibbling of rice and of other crops.

For opening up land CONKLIN (4) gives for the Philippines in climax forest per ha 75 man days and in secondary forest 40 to 50 man days, for fencing, protecting and quarding in climax forest about 93 man days and in secondary forest 55 man days, and for weeding about 40 man days in climax forest and 75 man days in secondary forest.

If harvesting other crops, cleaning and storing is included, the total number of man days per ha becomes almost 400.

The following man days are spent per ha on the burning stage of shifting cultivation: in the Congo (5): 15 man days for slashing and cutting undergrowth, 35 man days for

cutting the big trees, 40 man days for collecting the branches and 30 man days for the burning itself, in all 120 man days.

Thereafter 75 man days are needed for a maize crop (3 months), for a dry rice crop interplanted with bananas, cassave, etc., 75 man days.

In all this means 270 man days for a year, including opening up. Every year a new field has to be burnt and cleared.

Much labour is also required in permanent tropical and subtropical agriculture. According to DUMONT (5), who gives no figures for cattle, labour requirements are:

Tonkin: wet rice, 225 man days per crop per ha.
Tonkin: wet rice, 435 man days per year per ha, of which 60 man days for weeding.
Morocco: dry wheat, 45 man days per ha.
Morocco: irrigated fields, 250 man days per ha.
Spain (Valencia): horticulture, 325 man days per ha, all irrigated.
Spain (Cordoba): cereals, 50–60 man days per ha.
Italy (Comacchio): wheat, 72.5 man days per ha, harvested by scythe.
Italy (Pegola) : wet rice, 230 man days per ha.

VINK (21) gives figures for Indonesia, divided among human labour and cattle (mandays and cattle days respectively):

Dry rice	: till harvest	30	+	19,	harvest 30,	total	60	+ 19,
„ „	: „ „	87	+	15,	„ 14,	„	101	+ 15,
„ „	: „ „	120	+	38,	„ 28,	„	148	+ 38,
Tobacco (dry)	: „ „	41	+	28,	„ 13,	„	54	+ 28,
„ (wet)	: „ „	37	+	13,	„ 28,	„	65	+ 13,
„ (wet)	: „ „	73	+	14,	„ 15,	„	88	+ 14,
Groundnuts	: „ „	17	+	17,	„ 37,	„	54	+ 17,
Sugar cane	: „ „	55	+	37,	„ 37,	„	82	+ 37.

Both the tropical crops of the rainy periods and the kharif crops of India grow during the hot moist season when weeding is the principal bottleneck in crop growing. As DUMONT (5) says: "The bane of tropical agriculture is weeding" [7]).

MUKERJEE (9) gives some figures for India which enable a distinction to be drawn between labour for ploughing and working the field, for weeding and for such other activities as manuring, earthing, sowing, etc., for summer crops:

		Ploughing	Irrigation	Weeding	Total without harvesting	Total with harvesting
Irrigated kharif:	patal :	6 + 12	24	24	86 + 12	?
„ „ :	brinjal :	31 + 10	52	99	268 + 10	316 + 10
„ „ :	chillies :	30 + 12	13	56	147 + 12	174 + 12
Dry „ :	jute :	6 + 12	–	40	59 + 12	135 + 12
Perennial:	sugar cane :	3 + 6	48	18	185 + 6	293 + 6
„ :	mulberry :	246 + 72	(60)	24	466 + 98	?

If wet rice is grown, the fields being permanently inundated, irrigation does not require much labour and is not even counted. Weeding is often only carried out very extensively (21):

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6) All rounded off to mandays of 8 hours or cattledays of 8 hours.

7) Even in a cool climate rainfall may be so high and continuous that timely weeding becomes almost impossible, e.g. in the Puerto Monte and Chiloë region in Southern Chile which have abundant rainfall throughout the growing period animal husbandry is predominant here (11). On the other hand in some cool, dry climates of equatorial and subtropical regions weed growth may be limited (Meseta of Costa Rica, Highlands of Kenya and Tanganyika).

Celebes : wet rice (ext.)	7 + 8	–	3	17 + 8	37 + 8
India : „ „ (ext.)	6 + 12	–	15	29 + 12	50 + 12
Java : „ „ (int.)	13 + 24	–	54	92 + 24	122 + 24

The rabi (winter) crops of India, when not grown with irrigation, resemble more the normal crops of temperate regions. When irrigated they require more labour (9):

Bengal, dry rabi, wheat	4½+ 9	(13)	16	34 + 9	48 + 9
„ , „ „ , cotton [8])	6 + 12	(23)	11	37 + 16	116 + 16
„ , wet „ , opium	15 + 28	50	42	108 + 28	228 + 28
„ , „ „ , potatoes	15 + 30	64	32	190 + 30	222 + 30

We may compare these dry rabi crops with the crops of temperate regions (2, 6):

Holland : rye (sand)	5 + 7½	–	½+ ½	11½+ 10	27½+10
„ : wheat (clay)	3½+ 7	–	3 + ½	8 + 9	16½+ 9
„ : peas (clay)	3½+ 7	–	8	13 + 8½	20½+ 8½
„ : sugarbeet (clay)	3½+ 7	–	30	35 + 8½	47½+ 8½
„ : mangold (sand)	3 + 5½	–	37½	58 + 12½	89½+23
„ : potatoes (sand)	2½+ 5	–	15 + 1½	33½+ 8	116 +11
„ : potatoes (clay)	3½+ 7	–	7½+ 2½	23½+ 9½	54½+ 9½
Germany : cereals	3½+ 6½	–	1½+ 1½	8 + 9	15 +13
„ : potatoes	9 + 7½	–	5½+ 5½	18 + 14½	49½+23
„ : sugarbeets	6½+ 12½	–	24½+ 3	34 + 17	62½+44
„ : mangolds	6½+ 12½	–	24½+ 3	34 + 17	74 +43

These figures show that opening up the land in shifting cultivation requires a vast amount of labour, and guarding, fencing and protecting also take a great deal of time. It may be added that in many grassy regions where cattle keeping is customary, fencing requires more labour than opening up and planting together (fig. 5).

In equatorial regions much time is spent on weeding and on weeding and irrigation in subtropical regions in the wet season or under irrigation. The least exacting crop is wet rice, since once the irrigation system has been completed, water regulation by flooding the fields is almost automatic. The requirements of rabi crops of subtropical regions resemble those of the temperate crops, although they require more weeding.

In densely populated regions much more labour is often spent on a crop than is strictly necessary. The size of the farm is determined by the critical periods when much labour is required. In other periods there is generally disguised unemployment, although everybody tries to make his time productive. This is why in Indonesia the total number of man days required for wet rice varies from 75 to 200. It stands to reason that the productivity of labour in man days above 100–150 is very small (21).

Increasing productivity, food crops as against cash crops

Farm size is kept small by weed growth, workability of the soil, no or insufficient use of cattle, and insufficient use of implements.

In the case of food crops the soil has to be worked, sown and kept free of weeds every year. All measures facilitating weeding, working of the soil and other tasks will tend to increase farm size, especially those which eliminate the bottlenecks.

8) Cotton is often sown late at the end of the rainy season.

FIG. 5 STRONG FENCES ARE NECESSARY FOR PROTECTION AGAINST ROVING CATTLE (NJAMPLONG, TIMOR, E. INDONESIA).

Chemical weed control by herbicides or hormones (if possible such as are not adversely affected by rain), better implements for working the soil, weeding, etc., introduction of cattle to replace human labour and speed up the work of weeding, ploughing, etc. may all be advisable. Even mechanisation, though generally expensive, may be advisable on very heavy land, workable only during short periods on to ensure clean land requiring less weeding.

Increase in farm size by introducing a second or even a third crop per annum is a further possibility. Hence irrigation will normally be required.

After the installation of an irrigation system it is not very difficult to irrigate wet rice because the water levels in the fields are maintained almost automatically. Irrigation of dry crops, i.e. without inundation, e.q. in rows, small basins etc. requires much more labour.

Any measure which obviates the need of fencing and quarding will often also increase farm size as it can release labour for other work.

One of the best crops for increasing farm size is wet rice as it does not require much tillage after sowing and weed growth is limited, while weeding is possible at all times.

But there are other ways of improving farm size, i.e. by trying to escape the drawbacks of having to weed and work the soil. In addition to many other advantages all perennials furnish a permanent shade and protection for the soil, thus preventing weed growth, and it is only necessary to till the soil before planting and in the first period after planting. This is both true of such perennials as bananas and of treesand shrubs, forest and grassland. It is unfortunate, that only a few foodplants, such as bananas, belong to this group. Most plants of this type are cash crops, e.q. cacao, rubber, sugarcane (ratoons), cola, coffee, oil palm, coconut palm, tea, cinchona, tung, clove, nutmeg, pepper, cinnamon, citrus, kapok, date palm, sisal. Some cash crops, such as cotton, tobacco, groundnuts, chillies, ginger, etc., have the same draw backs as food crops, while cassava (manive) often can be used to subdue weed growth.

Productivity is kept low by poor soils, weed competition, short day length, poor varieties, etc. It can be increased by soil improvement e.g. better drain-

age and watering, provision of dung (cattle), artificial fertilisers and green manures, better implements for weeding and ploughing so as to extirpate the weeds, better varieties and better methods of pest and disease control.

An important advantage of perennial crops is that in wet regions, they grow and may even produce throughout the year, they enrich the topsoil with inorganic material from deeper layers and with organic material (foliage, small branches). This keeps the topsoil covered and protects it from erosion and excessively high temperatures caused by direct sunlight. Moreover, the disadvantage of a short growing period and a short day length, typical of most food crops, is more than compensated by the continuous growth throughout the year. This is equally true of trees and shrubs etc., forests and grasslands.

Price levels will depend on the development of a local market and on changes in world-market prices. Solong as there is production in subsistency farming there will be no real cost price in money for the products and production will continue even at very low prices. But as soon as production causes visible losses, e.g. in a developing money economy, it will be reduced to producing sufficient food for subsistence, at any rate in the case of food crops. Before then surplus production will be sold at any price.

If there is a combined production of food crops for own use and cash crops for the market, production of cash crops will cease at prices which are considered too low, with all the possible consequences to the price level.

If cash crops are principally produced, low prices may result in increased production as was the case with rubber before World War II, since in that case money is essential for purchasing food.

Development

As was demonstrated above, there are many possibilities of increased productivity. Increase in per capita area may be promoted by better weeding methods, better methods of ploughing, etc., double cropping, introduction of animal labour and better inplements, and also by introducing other types of crops, e.g. perennials, wet rice, grasslands. Better yields may be obtained by selection, disease and pest control, fertilization and green manuring, soil improvement, drainage and watering, and also by better working and weeding and better adapted choice of crops. Better prices may result from the development of a local market.

Since by our present knowledge farm size can be increased to 2–3 ha, not including perennial crops, and yields may be increased by 50–100 % [9]) farm-production levels could be reached which in many regions would be five to ten times that achieved at present.

In this case, however, there must be a market for these products, viz. both food and other crops. In most of these regions a family at present only barely produces enough food for one other family and sometimes even hardly enough for its own subsistence. If more is produced there will be no market available for surplus production, as most of the population produces its own food and a marked increase in production would have to go to other markets. Most cash crops always have to be exported.

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9) In Holland yields since 1880 increased 50–100 %.

A higher production per family farm will mean in the first place a higher level of food consumption both in quality and quantity. But a proportionate part of the higher production of the farm units will be available for others.

If after an increase in production a farm unit produces enough for, say, three other families, these families must have the means of obtaining this surplus. Now in most underdeveloped regions the normal development has been to start producing materials for the world market, thereby introducing a money economy into their subsistency farming.

The most natural development should be that in which the farmer produces more than his own needs in food and other materials and sells his surplus to people in local industry, mining, commerce and trade and other production groups in exchange for the products of their activities. Hence it becomes essential for production outside agriculture to be increased on a large scale. If one farmer family produces a surplus great enough to sustain three other families in food and other materials, these three families should produce enough goods and services for exchange with the farmers and for mutual exchange, but in any case they should produce enough to obtain the means of securing the farmers' surplus in food which they need for their subsistence.

This may be combined with production for export, but the development of local society with a differentiation in industry, trade, transport, etc. will provide a more balanced structure than in regions dependent on export only.

In this society with larger family-farm units and higher yields, agriculture can be developed, capital can be formed and local initiative can promote further development.

But this is a difficult problem in densely populated regions where land is scarce. Farm size can only be increased when farmers can be transferred to industry, commerce etc. Such a development can only be gradual and balanced. Buyers on the local market have to be found for every increase in farm production, which is unsuitable for export and these future buyers should be the landless persons and the many farmers with too small farm units who will have to leave agriculture. For this development capital and know-how are indispensable, and at the moment neither are locally available.

The problems of densely populated regions are much more urgent than those of the thinly populated regions. They not only need capital for those who will in future increase production outside agriculture in order to offer goods in exchange for the increased agricultural production. They will also need capital for those leaving agriculture in the process of increasing the size of the farm units, while at the same time those remaining in agriculture have to increase the former total production.

Development should be balanced and price fluctuations should be avoided. If only agricultural production is increased, prices of agricultural products will develop a tendency to drop at the moment the local market is satisfied, i.e. when there are not enough other producers capable of offering goods or services in exchange. Migration will be of not much advantage in this case. Generally speaking this was the situation obtaining in Indonesia.

Where agriculture remains stagnant, as in Chile, and industry, mining etc. are developing on a large scale, a shortage of agricultural products will be a cause of inflation and it will become necessary to import foodstuffs.

A balanced development of agriculture and other means of production seems to be the intention in India. It is a policy beset with many difficulties but if kept will in hand, it would appear to be a promising long-term policy.

It should not be forgotten that if the underdeveloped regions are capable of improving their production level and increasing the total world income, partly locally, partly by exporting, they will be able to buy goods and services on the world market and this will be to the benefit of the entire world.

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