Nature and Agriculture in Monsoon Asia

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Abstract: Monsoon Asia encompasses East, Southeast and South Asia. It is characterized by an extremely high population density and, as a corollary, by a high land use intensity. Thus, the region has no more land for further expansion of cultivation and has to focus its effort on intensification of agriculture.

Another distinctive feature of monsoon Asia is very high shares of the area and production of rice in the world. Some 90% of the total acreage as well as annual output of rice are concentrated in the region, making it rightly deserve the name "rice granary" of the world.

Climate and landforms of the region were reviewed with regard to a widespread use of the land for rice cultivation. A high rainfall and/or a high concentration of rainfall in the rainy season, on the one hand, and the occurrence of extensive lowlands, on the other, are the two determining factors for the dominance of rice cultivation in Monsoon Asia. Particularly, a vast expanse of lowlands is a unique feature of the region, resulting from a combination of geological instability and high rainfall of the region.

Rice cultivation emerged as an adaptation to extensively inundated lowlands, but with time it was expanded even to the land that could support rice only with irrigation. High productivity and high sustainability are the outstanding merits of rice cultivation, while upland cultivation in Monsoon Asia for dry footed crops has been handicapped by low soil fertility and high susceptibility to soil erosion.

In the future, rice would remain as the most important crop in Monsoon Asia and further intensification of rice cultivation should be attained. To nourish the region's increasing population, upland cultivation must also be intensified with adequate measures for soil amendment and conservation
Keywords: monsoon rains, extensive lowlands, rice cultivation, upland and slopeland utilization, soil conservation.

1. Introduction

The word monsoon, derived from Arabic 'mausim' meaning the season, is used to denote a seasonal wind, whose prevailing direction varies with the season. A monsoon climate has seasonal winds that change their direction by nearly 180° through a year. For example, most of South and Southeast Asia have southwesterly winds during the summer months, while northwesterly winds prevail during the winter months. Southwesterly winds blowing across the Indian Ocean are charged with a full of moisture and bring a rainy season to most of tropical Asian countries Whereas northwesterly winds are blocked by the Himalayan and Annamese ranges, so that the greater part of South and Southeast Asia experiences a dry season. In this way, monsoons also govern the rainfall pattern, exerting a profound influence on human life, particularly on agriculture and food production.

East, Southeast and South Asia are often collectively called Monsoon Asia, but it is not easy to delineate the extent of monsoon East Asia on a map. According to a map of soil regions of China [1], the whole territory is divided into the 3 regions: 1) Southeast humid soil region (41.6% in area), 2) Central dry and humid soil region (22.7%), and 3) Northwestern dry soil region (35.7%). Relying on this information, the author of this paper postulates that the humid regions of China, which make up about 50% of the country, may be included in Monsoon Asia. Delineation of South and Southeast Asia or tropical Asia follows the ordinary geographical concept; the countries of the Indian subcontinent, including Sri Lanka, and those of continental as well as insular Southeast Asia.

Defining the realms of Monsoon Asia as above, the statistics of population, land area and the cultivated area of Monsoon Asia were obtained and compared with those of the world and Asia as a whole, as shown in Table 1, using the database of Food and Agriculture Organization of the United Nations (FAO) [2]. In this calculation, 50% of the land area and 90% of both the population and the cultivated area of China were assumed to be in Monsoon Asia.

Table 1. Population, Land area, and Cultivated Area of the World, Asia, Monsoon Asia and Tropical Asia [2]

	Population	Land Area (A)	Cultivated Area (B)	B/A
	$\times 10^6$ (%)	$\times 10^6$ ha (%)	$\times 10^6$ ha (%)	%
World	6,378 (100)	13,004 (100)	1,541 (100)	11.8
Asia	3,871 (60.7)	3,099 (23.8)	571 (37.1)	18.4
Monsoon Asia	3,374 (52.9)	1,374 (10.6)	446 (29.0)	32.5
Tropical Asia	1,986 (31.1)	849 (6.5)	298 (19.4)	35.1

From Table 1 it is at once clear that Monsoon Asia is a region with an extremely high population density, with some 3.4 billion people or 53% of the world population in only a little more than 10% of the world total land area. As a corollary, the ratio of the cultivated to the total land area is as high as 32.5% for the whole Monsoon Asia, and

35.1% for tropical Asia, where there are lesser constraints, climatic or topographical, for human inhabitation. The high land use intensity would indicate that practically no more land is available for further expansion of cultivation and thus intensification of agriculture would be the only choice for increasing food production in Monsoon Asia.

Another prominent feature of Monsoon Asia is the predominance of rice cultivation in agriculture. Rice is by far the most important food staple for most of the people in the region and the acreage of rice often exceeds 50% of the total cultivated land in most of the countries. Table 2 endorses this observation, showing that some 90% of both the harvested area and production of rice in the world are concentrated in Monsoon Asia that has only a little more than 10% of the world’s land area.

Table 2. Area and Production of Rice in the World, Asia, Monsoon Asia and Tropical Asia [2]

	Harvested Area	Production	Yield
	$\times 10^6$ ha (%)	$\times 10^6$ t (%)	t paddy ha^{-1}
World	150 (100)	606 (100)	4.04
Asia	133 (88.3)	547 (90.2)	4.13
Monsoon Asia	131 (87.5)	542 (89.4)	4.12
Tropical Asia	100 (66.3)	341 (56.3)	3.43

Three distinctive features, that is, an extremely high population density, a very high intensity of land use and an extraordinarily high concentration of rice acreage and production, have been pointed out for Monsoon Asia. As discussed below, physical elements of the region appear to be conducive to the making of these features.

2. Natural Settings of Monsoon Asia

1) Climate

A greater part of Monsoon Asia is governed by humid to subhumid climate. Much of East Asia and equatorial tropical Asia rarely experience severe drought. The regions at a distance from the equator in South and Southeast Asia have a long dry season during the winter months. However, even these regions have quite a high annual rainfall, say well over 1000mm, brought about by the monsoon during the summer months.

According to Kyuma’s water balance study [3] for the conditions of rainfed rice, a greater part of insular Southeast Asia can grow one crop of rice even without supplementary irrigations, but large areas of continental Southeast Asia and the Indian Subcontinent can hardly grow a crop of rice under rainfed conditions. This latter result, however, contradicts with the reality, as most of these areas are being utilized for growing rice even without supplementary irrigations. What is overlooked in this study is the landform conditions. Rice is grown mostly in lowlands and many of these lowlands are naturally inundated during the rainy season by the runoff from uplands. As a matter of fact, a vast expanse of lowlands is an even more prominent physical characteristic of Monsoon Asia than is her climate.

2) Geology and Landforms

In the map of Monsoon Asia it is readily noted that many gigantic rivers flow down from the Himalayas and Tibetan highlands, such as the Yangtze, Zhujiang, Songkoi, Mekong, Salween, Irrawaddy, Brahmaputra, Ganges, and the Indus. The occurrence of these huge rivers and of the extensive alluvial lowlands along their middle and lower reaches is a remarkable characteristic of the landforms of Monsoon Asia.

Data are available on the extent of alluvial lowlands in the world, Asia and the Tropics [4], as shown in Table 3. Alluvial soils occupy less than 1/20 of the world total land area, whereas they do extend to 1/6 of the land area of tropical Asia. Furthermore, only 1/10 of the total potentially arable land of the world is located in alluvial soils or in lowlands, while the ratio is as high as 1/3 for Asia and tropical Asia.

Table 3. Importance of Lowlands in Asia (in Mha) [4]

	Land Area		Alluvial Soil Area	
	Total	Potentially Arable	Total	Potentially Arable
World	13,000	3,152	588	316
Asia*	2,704	620	—	192
Tropics	4,893	1,652	365	172
Tropical Asia	987	344	168	114

* Excluding former USSR

The exceptionally large expanse of lowlands in Monsoon Asia is considered to have resulted from geological instability of the region in conjunction with heavy monsoon rains. The orogenic movements of the Himalayas and their associated mountain ranges in the continental part of Monsoon Asia and the active volcanism along the Circum Pacific Volcanic Zone in the insular part are providing a huge amount of erodible sediments under the influence of downpour of monsoon rains. Many gigantic rivers draining the continental Monsoon Asia carry down the sediments and form large floodplains and extensive deltas before discharging their heavy load into the sea. Fig. 1 [5] shows an annual discharge of suspended sediments from various drainage basins of Eurasia, Africa and Australia. It is clear from the figure that Monsoon Asia is discharging by far the largest quantity, amounting to as much as 9.2Gt, of sediments into the sea even after depositing a tremendous quantity of sediments in the floodplains and deltas.

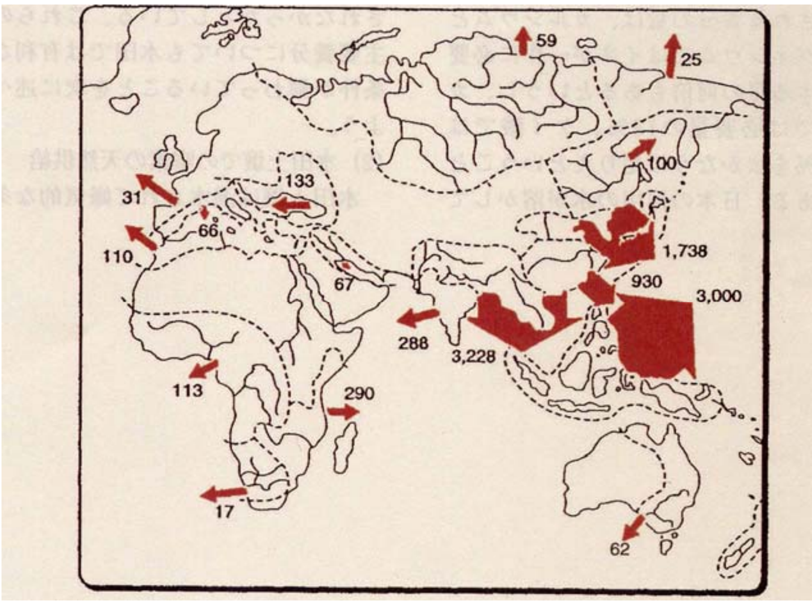

Fig. 1. Annual Discharge of Suspended Sediments from Various Drainage Basins of the world. Numbers Refer to Annual Input of Sediments in Mt [5]

3. Utilization of Lowlands

1) Rice Cultivation as an Adaptive Technology for Lowlands

Monsoon Asia has a very large share of potentially arable lands in her lowlands, as is seen from Table 3, and it was indispensable that these lowlands were to be utilized for food production as the population of the region had increased. An element that favored this process was the occurrence, among the native vegetation, of *Oryza Sativa*, a plant species that tolerates wet and inundated conditions of lowlands caused by the concentration of monsoon rains during the summer months.

Rice cultivation is considered to have originated somewhere in southern China. The oldest, so far known, archaeological remains of cultivated rice were found at Pengtoushyan, Hunan Province, in the central Yangtze valley. The carbonized rice grains excavated from the remains were carbon-dated to 7,500-8,500 years BP [6]. The second oldest, ca. 7,000 years BP, at Hemudu, near Hangzhou to the south of the lower Yangtze Plain, was situated in marshy land readily subjected to floods during the rainy season [6], clearly indicating that rice cultivated there was wetland rice or paddy rice.

It is possible to say that paddy rice cultivation began as an adaptation to the natural conditions of Monsoon Asia. As such, it should not have disturbed the ambient environment greatly and, as time elapsed, should have created what we may call the second nature, which accommodated natural and man-made elements in perfect harmony. High stability or sustainability of paddy rice cultivation is a characteristic naturally derived from this setting. Furthermore, location of paddy farming in lowlands would have assured its high productivity, because rice is nourished by rich alluvial soils and plenty of water.

2) Advantages and Disadvantages of Paddy Rice Cultivation

In addition to general richness of alluvial soils, paddy rice cultivation is endowed with several other merits, as itemized below [7]. High productivity and high sustainability of paddy rice cultivation are resulted from these merits.
1. High Natural Supply of Nutrients: Irrigation water, high N fixation, P solubilization.

2. Resistance to Soil Erosion: Leveling and bund construction, terracing in sloping lands.
3. Detoxification of Excessive Nutrients: Denitrification, P fixation by subsoil.
4. Detoxification of Agrochemicals: Hydrolysis, reductive deactivation, dechlorination.
5. Tolerance to Monoculture: Alternation of oxidation and reduction.
6. Relative Indifference to Soil Tilth: Minor importance of soil structure and consistency.
7. Relative Ease of Weeding: Exclusion of terrestrial weeds, easier uprooting.
8. Carbon Sequestration: Submergence retards organic matter decomposition.

To be fare, disadvantages associated with paddy rice farming must also be mentioned. Paddy field under submergence is one of the most important artificial sources of methane emission. It is possible to reduce methane emission through elaborate water management in rice farming, but the irrigation-drainage system for effective water control is costly to develop and has not as yet been set up in the greater part of paddy lands in Monsoon Asia. Risks of water pollution in intensified rice farming and excessive water use under the limited water resource situation are other obvious disadvantages. By and large, however, the advantages clearly outweigh the disadvantages.

4. Utilization of Uplands and Slopelands

1) Upland

Upland is the term here, used in contrast to slopeland, to denote relatively level land that is utilized for cultivation of various field crops. In Monsoon Asia upland is covered extensively by Ultisols (Udults and Ustults) or Acrisols that are characterized by acidic reaction and the dominance of variable charge clays (or low activity clays) [8]. Generally they have high erodibility and are susceptible to soil loss under rainfalls with high erosivity. According to Takahashi *et al.* [9] who studied soil erosion and rainfall characteristics in northeast Thailand, often 70%~80% of rainfall in a single rain event during the rainy season pour as “critical rains” with intensities higher than 3 mm every 10 min, a threshold intensity at which surface run-off occurs.

Soil fertility is invariably low, with low contents of organic matter and available phosphorus, not to speak of low CEC and low exchangeable bases. Soil physical properties are not favorable either. Soil structure is not stable and water holding capacity is low. Hard setting and crusting of surface soils are frequent problems related to high erodibility. Thus, not only soil fertility management, but also soil tilth and surface managements are of prime importance, in addition to soil conservation.

Monsoon Asia in 2004 harvested cereals other than rice from about 119.3Mha of upland fields and their total production amounted to 351.3 Mt [2]. Thus, the mean yield was calculated to be 2.95 t ha^{-1}. In the same year rice was harvested from 131.4 Mha of land and its production amounted to 541.8 Mt (see Table 2), resulting in the mean yield of 4.12 t ha^{-1}. Upland cereals yielded only about 72% that of rice. This difference might have come from various causes; along with unstable water conditions, poor soil fertility and poor soil physical conditions in the upland would explain no small part of the difference.

2) Slopeland

In contrast to level to gently sloping/undulating uplands, hilly and mountainous lands with steeper slopes are called here slopelands. In more humid part of Monsoon Asia these slopelands have long been protected by forest vegetation and so their soils, if not truncated by erosion, are generally younger and richer than upland soils developed on level, stable landforms. Therefore, utilization of slopelands could be advantageous only if proper management were practiced to avoid soil erosion and fertility deterioration.

In fact, considerable areas of slopeland have been utilized by shifting cultivators. Traditionally in Monsoon Asia shifting cultivators had been paying careful attention to soil resilience by practicing short cultivation/long fallow system with minimum of disturbance to the surface soil to avoid soil erosion and to help facilitate forest regeneration [10]. Moreover, some limited areas of slopeland have also been under sedentary cultivation of perennial fruit trees, tea, mulberry, *etc.* with or without terracing. One remarkable example of sedentary slopeland utilization for paddy rice is the Banaue terraces in the Philippines. The same type of terraced paddy fields can be seen in many other places in Monsoon Asia, the most notable being those of Yunnan Province in China. But up till today in many countries slopes steeper than 30% or 17º are considered unsuitable for crop cultivation in their respective land capability classification systems.

Land scarcity in Monsoon Asia is now compelling people to cultivate steep slopelands more and more intensively. In Taiwan, a report [11] says that 50% of slopeland crops were grown on slopes steeper than 30%. As a matter of fact, in some of the countries in Monsoon tropical Asia more than 45% of the land area are slopelands with slopes steeper than 30%: Laos 74%, Malaysia 48%, Burma 45% and Vietnam 45% [12]. Therefore, for the people in these countries it would be an inevitable choice to utilize even steep slopes for cultivation if population pressure has been elevated.

As mentioned above, shifting cultivation as a means of slopeland utilization has traditionally been quite sustainable. But today the fallow period is becoming shorter and shorter, hardly enabling soil nutrient status, particularly that of phosphorus, to recover. Thus, cultivators have to spend more labor for weeding, undergoing more risks of pests and diseases and soil erosion, and yet their effort ends up with less production. Shifting cultivation in many cases is now in a vicious circle destined for total collapse of the system and for land degradation.

Agroforestry, particularly alley cropping and SALT (Sloping Agricultural Land Technology) [13] systems, appears to be a promising alternative for sustainable slopeland utilization. But in reality cultivators do not necessarily respond positively to these seemingly sound alternatives in spite of strong recommendations by researchers and extension workers. It seems necessary just not to prove technically sound alternatives but to have more insight into the psychology and behavioral patterns of slopeland cultivators.

5. Conclusions

An extremely high density of human population in Monsoon Asia has been supported by paddy rice cultivation developed on exceptionally extensive lowlands that have resulted from erosions of uplifting Himalayas and erupting volcanoes under heavy monsoon rains. A native grass, *Oryza Sativa*, has many outstanding merits when cultivated in submerged soil, thus making paddy rice/soil system highly productive and, at the same time, highly sustainable. On the contrary, upland cultivation of dry footed crops in Monsoon Asia has been handicapped by low soil fertility and high soil erodibility. Slopelands that have traditionally been utilized by shifting cultivators are now being more intensively managed, but not without high risks of soil erosion and land degradation.

To meet the pressing need for food by the increasing population in Monsoon Asia, paddy rice cultivation in the lowland should, first of all, be further intensified, particularly in the tropical Asian countries where infrastructure for irrigation and drainage has not been fully developed. Upland cultivation should be developed with full awareness of low fertility, poor tilth and high erodibility of Ultisols prevalent in the region. Slopeland should be utilized for crop cultivation only when good soil conservation measures like terracing can be provided. Otherwise, mountains and hills should better be conserved as watersheds that would secure stable water supply to lowlands for successful intensification.

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