APATANI WET RICE CULTIVATION: AN EXAMPLE OF A HIGHLY EVOLVED TRADITIONAL AGROECOSYSTEM

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Abstract

The tribal societies of north-eastern India have wet rice cultivation as a land use activity, along with shifting agriculture (locally called `*Jhum*'), and the *'home gardens'*, which is an imitation of a forest but with economically important species. Wet rice cultivation is done at valley bottoms and sometimes on small terraces constructed at the base of the hill slopes all around; this results in a whole set of plots forming a sancer-shaped structure. The structure, organization and function of these agroecosystem types differ significantly depending upon social, cultural, economic and ecological setting in which this land use system is practiced. The Apatani version of wet rice cultivation is one of the most advanced. Even this offers opportunities for redevelopment, with additional scientific inputs. This paper considers the possibilities.

Introduction

Half of the world population is engaged in agriculture, the vast majority being in the tropics and the sub-tropics. Their agricultural practices are diverse, ranging from a variety of shifting agriculture systems, fallow systems, home gardens and sedentary systems such as wet rice cultivation (Ramakrishnan, 1992; Swift *et. al*. 1996). Small farmers in the wet tropics largely do rice cultivation to obtain their basic needs, because rice, like sugarcane, maize and others have a high calorific value (Finck, 1970). These traditional systems based on technology developed over many generations are often energy efficient, at the same time providing high economic returns to the farmer, as shown through many studies done by us in north-eastern India and subsequently synthesized in a UNESCO-MAB volume (Ramakrishnan, 1992). It is in this context that there is a renewed interest in these traditional agroecosystems. Though shifting agriculture (locally called *jhum*) is the predominant land use system in the north-eastern hill region of India (Ramakrishnan, 1992), the tribals here have other important agroecosystem types. Home gardens and wet rice cultivation are two other land use systems. The present paper looks at one of the most advanced traditional wet rice cultivation done by the Apatanis in Arunachal Pradesh in north-eastern India, in the context of valley cultivation as a land use system in the region.

Arising from this, the paper also examines at possible redevelopment strategies of wet rice cultivation so that it would meet certain basic criteria for sustainability, namely, that: (i) it should be possible to maintain them without major input of energy from outside the region,

(ii) it should be compatible with environmental quality on short- and long-term basis, (ii) it should have the flexibility to meet not only present needs of the society but also the long-term demands through adaptive innovations and (iv) finally it should ensure equity with justice.

Rice Agroecosystem in North-east India

Like jhum, valley agriculture is practised through out the hill terrain, both at low and high elevations of north-eastern region of India. It is a sedentary form of wet rice (*Oryza sativa*) cultivation and is a complementary system to jhum. It is done wherever the terrain permits, on flat lands between hill slopes. However, small terraces may also be built by some tribal communities all around the flat valley land extending into the foot of the hill slopes. This results in a saucer-shaped structure in which rice plots are organized. Obviously, this cropping system is restricted due to topography. The soil in valley lands is fertile due to nutrient wash-out from the hill slopes and therefore does not need added fertilizers. The main advantage is that the land gives sustained yield year after year, unlike the jhum system that is under cropping only once in a few years of fallow interval depending upon the jhum cycle.

The yield from valley cultivation of rice varies considerably depending upon the socio-ecological context in which it is done (Ramakrishnan, 1992). The ecological/economic efficiency of rice cultivation varies significantly. The Nepali migrants into the tribal areas, who are traditional rice growers often show a high efficiency in production. Differences between tribes are also to be found. Khasis and Garos often get economic yield comparable to a 5-yr jhum cycle where as the Karbis are able to obtain yield comparable to a 60-yr cycle; this is because Karbis take a winter crop of mustard which is highly yielding and thus a more efficient use of the land. From an energy efficiency point of view, these traditional systems, are generally better than most western agricultural systems, which yield only 1 or 2 units of food energy per unit of energy input (Spedding, 1975; Leach, 1976; Pimental and Pimental, 1979), compared to more than 10 units of energy harvested per unit energy input.

Wet Rice Cultivation by the Apatanis of Arunachal Pradesh

The Apatanis with a highly developed valley cultivation of rice perfected over centuries has often been suggested to be one of the relatively advanced tribal societies in the north-eastern region of India (Furer-Haimendorf, 1962, 1985). Wet rice land agroecosystems of the Apatanis, like those of other tribes, is also dependant upon nutrient wash-out from the hill slopes. With crop harvest, considerable quantities of nutrients are lost through economic yield and must be replaced for sustainable land use. Recycling crop residues and use of organic wastes of the village for sustaining soil fertility, as also done by the Apatanis is an effective way of restoring soil fertility.

Irrigation farming such as wet cultivation of rice require communal work to maintain it, and to improve the water delivery system. In the absence of a disciplined schedule and scale of water distribution among the beneficiaries, very often economic returns could decline drastically. The Apatanis with cooperative effort under the overall supervision of the village headman, have optimized water use along with nutrient use in their rice field. Therefore, an understanding of the valley land agroecosystem function of the Apatanis becomes significant.

Cropping and yield patterns:

Hari is an Apatani village in Arunachal Pradesh at an altitude of 1570 m. and has 418 families and total population of 2021. The average size of a family is about five, living in a large bamboo hut of 15x4 m. floor area. Wet rice cultivation is their only agricultural land use.

Apatanis, at Hari, make effective use of their irrigated land by planting early and late ripening varieties of rice. Early variety is sown farther away from the village where disturbance by animals and poorer irrigation facilities could be major constraints (Kumar and Ramakrishnan, 1990). Lower nutrient status on plots farther away from the village is another consideration. Thus rice plots closer to the village are nutritionally richer than those farther away. Closer to the village, where conditions are more favourable, late variety is preferred. Fish culture done here synchronises well with late ripening rice variety. Further, rice is supplemented with *Eleusine coracana* cultivated on elevated partition bunds between the rice plots.

The early variety of rice had higher density but with reduced basal area compared to the late variety. Economic yield per plant and per unit area of the early variety was significantly lower compared to the late variety. The yield per hectare of *Eleusine coracana* grown on partition bunds of rice plots was higher in plots with early variety than in those with the late variety. Fish production done only along with late-variety rice was substantial.

With human labour as the major input (both men and women participating), the Apatanis obtain a high energy output. Labour input for rice/rice + millet where early variety of rice is grown was higher than for the late variety of rice. The Apatanis do not use draft animal power. The output from the system and the net return to the farmer was higher under late variety grown alone or with millet/fish, than under early variety of rice. The economic and energy efficiencies, and output per unit labour hour were also higher under the agroecosystem with the late variety of rice.

The exceptionally high energy efficiency of this valley land agroecosystem (60 to 80 units per unit energy input) is markedly different from the values discussed for other rice systems discussed earlier for other tribes in this region, with an output/input ratio of 4-18 (Ramakrishnan, 1992). The high energy efficiency shown here also contrasts with that recorded for jhum in north-east India, which does not exceed 50. It is far superior to the traditional wet cultivation of rice of the Indian plains with an efficiency value of just about 9 (Mitchell, 1979) and that done elsewhere in the Phillippines (Nguu and Palis, 1977). With 27-35 MJ units of energy output per labour hour, this system compares favourably with similar systems of China (32.8 MJ) (Dazhong and Pimentel, 1984) and more modern agriculture of industrialized societies (Leach, 1976), such as the United Kingdom, with an output of 40 MJ units. In the present context, it is significant that human labour is a free input being largely obtained from within the family itself, and for specific tasks alone through cooperative efforts.

With a highly developed wet rice cultivation, the Apatni economy is largely based upon agriculture alone (Kumar and Ramakrishnan, 1990). Widening plots by digging adjacent higher ground down to an irrigable level seems to be successful responses to population increase and new market opportunities. The net per capita monetary return through agriculture is high. As much as 40% of the rice produced is sold to the economically weaker neighboring tribes such as the Nishis and the hill Miris. However, the agroecosystem of the Apatanis could be improved through appropriate crop rotation and productive utilization of the land during the winter season. Inspite of these possibilities, the Apatani village ecosystem is a good example of economic self-sufficiency of a traditional agricultural society that practices ecologically sound sedentary agriculture in the north-eastern hill region of India.

Incremental Pathway for Agricultural Development

Many traditional agricultural systems need to be redeveloped through incremental, rather than quantum change, based on traditional ecological knowledge; anything drastic may not find acceptance by the local communities. Apatanis like other traditional societies in the north-east India, have a rich traditional ecological knowledge (TEK), as much as what the traditional jhum farmers have, on which their valley rice cultivation operates (Box 1). Capturing this traditional ecological knowledge can be done through an 'incremental pathway' for agricultural development, building upon the TEK, in a step by step fashion.Thus, one may have to consider a short-term compromise that may be constrained because of ecological, economic, social and/or cultural reasons, apart from a more ideal and perhaps desirable long-term strategy.

The most comprehensive application-oriented study on the 'incremental pathway', as a route for agricultural development is available through the case study on the shifting agricultural system from north-eastern India (Ramakrishnan, 1992), the conclusions of which have wider applications for this widely practiced land use system prevalent all over Asia, Africa and Latin America.

To elaborate one of the components in this developmental pathway, a keystone species such as the Nepalese alder (*Alnus nepalensis*), a socially selected and ecologically important 'keystone species', performing key functions in the natural and agricultural ecosystems, is extensively used by tribal societies for soil fertility management. This early successional tree species in the north-eastern hill region, which is traditionally conserved in the slash and burn plots conserve up to about 120 kg. nitrogen ha^{1} yr^{1}. We have shown that under one cropping cycle, the system loses something like 600 kg. of nitrogen per ha. in one year of cropping. Under short agricultural cycles of 5 to 6 years, not more than 300 kg. ha^{2} of soil nitrogen alone is put back into the system during the 5-year period. Introduction of Nepalese alder into the plot could recover all the 600 kg. N during a five year period. Recovery of all the 600 kg. would otherwise require a minimum of 10 years of recovery period through natural processes of forest succession. In other words, introduction of Nepalese alder into the system under a 5-year agricultural cycle could stabilize the system, with adequate nutrient recovery. Apart from nitrogen fixation, the production of nitrogen-rich litter and mineralization also contributes to biological build-up of soil fertility. Thus, this species could be used for fallow management with community participation, since the people can identify themselves with a value system that they understand and appreciate, and therefore participate in the process of development. Similarly, the bamboo species that the Apatanis use around their agricultural plots is also a socially selected and ecologically significant keystone species.

Therefore it is not surprising that these considerations formed the basis for a decentralized village development plan in one of the north-eastern hill States of India. Over a thousand villages in the state of Nagaland has been organized into Village Development Boards (VDBs), with the specific purpose of rural development in mind. The VDBs were established taking into consideration the traditional village organization of the given cultural group; however, all of the VDBs had the same function, namely rural development. Using this institutional mechanism, the highly distorted shifting agricultural systems, which indeed is basically an agroforestry system, but now operating at subsistence or below subsistence level, is now being redeveloped, by strengthening the tree component that has been weakened due to extreme deforestation in the region. The entire basis for this incremental build up is the rich traditional ecological knowledge base of these hill societies (Box 1). The project implementation by the Nagaland Government officials through Village Development Boards created by the Government of Nagaland and being implemented now aims at augumenting the traditional system of agriculture, rather than attempting to radically change it. The Nepalese alder based agroforestry systems, with planting of trees done both in space and time (during the cropping and fallow phases of shifting agriculture) and maintained for hundreds of years, by some of the local tribes like the 'Angamis' formed the impetus for this initiative.

Reliance being placed on participatory testing rather than being transplanted into the field site by the extension agents, about a dozen tree species are being tested in over 200 test plots. Currently it is estimated that the agroforestry technology is being tested in 5500 ha. of replicated test plots. Farmers have adopted this, for local-based testing in 870 villages, covering a total area of 33,000 ha (38 ha per villages x 870 villages); in these plots, local adaptations and innovations for activities such as soil and water management are emphasized.

Similar possibilities exist for redeveloping the Apatani wet rice cultivation in their valley lands. A variety of rice agroecosystem types exist in the north-eastern hill areas of India, and this is indicative of the developmental possibilities. Many of them represent under-utilization of land and are inefficient. Traditional wet land cultivators of rice such as the local Apatanis of Arunachal Pradesh and the immigrant Nepalis provide are examples of a high degree of ecologic and economic efficiency for this system. In all these case, however, valley land cultivation is constrained by the availability of water for cultivation during the relatively dry winter months. Where tribes like the Garos at Lailad take two crops in a year, they essentially restrict their activity to the monsoon period.

A few possibilities exist for redeveloping this system so that the farmer is able to obtain better returns : (a) mere transfer of technology from one tribe to another could be helpful. The Apatani system of farming is one of the most evolved and highly organized system of wet cultivation of rice, (b) introduction of early maturing and improved varieties of rice would help in obtaining two or even three harvests in a year, (c) water is a major constraint outside the monsoon period. Rain water harvesting and storage in tanks offers immense possibilities for irrigation. The run-off water from hill slopes could be collected in 70 to 80 m3 tanks lined with heavy duty polythene sheets. They are cheap, easy to maintain and have a life span of 20-25 years (Kothyari, *et. al*. 1991). By harvesting surface run-off water of the rainy season and by diverting sub-surface seepage water through cheap rainwater harvesting tanks

(Kothyari *et. al*., 1991), we were able to link it with a verity of ecosystem rehabilitation efforts, which elicited enthusiastic community participation. This is only just the beginning towards an understanding Indian agroecosystem types and for their redevelopment on a sustainable basis.

Integrated Landscape Management

Agroforestry is an important and traditional land use system in the tropics, with large variations in terms of organization of crop-tree mixtures, and serving a variety of functions. With many tree species including bamboo around the plots, Apatanis also, in a sense, practice agroforesty. This option is attractive in that it combines improved food production, harvestable wood by the local poor, and in the process carbon sequestration through the forestry component, all within the same system. We have already seen the significance of redeveloping traditional agroforestry systems, as an option for agricultural and overall rural development too. In the context of global change - with a number of components to it such as climate change, biological invasion, biodiversity depletion, and land use and cover change which may ultimately lead to site desertification - and with all the uncertainties associated with the impact of global change (Walker *et. al*., 1999) on agroecosystem functioning, agroforestry acts as a buffer and provides resilience to the system at the landscape level (Ramakrishnan, 2000). A more holistic approach to forest management in the tropics and agriculture redevelopment with emphasis on landscape management is crucial for sustainable management of resources, providing developmental benefits to local communities, based on equity and social justice.

With greater accessibility to external energy subsidies, the developed world may be able to maintain assured levels of production, at least in the short-run. Even here in the developed world and in the developing world too, modern agriculture needs to be buffered through landscape level heterogeneity, to counter undesirable impacts. Viewed in the above context, what we often have now in a landscape model, are small patches of pristine, often unmanaged, conservation areas (nature reserves) set in a sea of intensively managed monocropping agroecosystems.

There are many lessons that one could learn from traditional societies, in terms of effective agroecosystem/landscape management itself. Learning from adaptive social evolution of land use practices of these societies could be an important lesson one could learn to cope with global change related uncertainties. Realizing that biodiversity and ecosystem complexity do contribute in a variety of ways to ecosystem functions and that agroecosystems do harbour a great deal of biodiversity valuable for general human welfare, it is reasonable that we go in for a mosaic of natural ecosystems coexisting with a wide variety of agroecosystem models derived through all the three pathways. The relative area apportioned for each of these land use units would of course be determined by ecological and social location-specificities. In a landscape mosaic, agroecosystems form one, though important, of the components of a wide variety of ecosystem types: natural systems such as forest, grassland and fresh water pond or lake, interspersed with human-managed agricultural monocropping systems such as rice, wheat or maize fields, village woodlots, etc.. A highly diversified landscape unit is likely to have a wide range of ecological niches conducive to enhancing biodiversity, and at the same time ensuring sustainability of the managed landscape itself.

The more recently evolved *'biosphere reserve'* concept of UNESCO, indeed, a rediscovery of the concept of the *'sacred landscape'* of traditional societies (cf.Chapter 3), dating back to antiquity, is an attempt towards such an integrated management strategy to conserve natural resources for sustainable use, with inter-generational equity concerns.

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Box 1. Biodiversity linked traditional ecological knowledge for soil fertility management (from Ramakrishnan, P.S. 1992)

- Traditional tribal societies in north-eastern India organize nutrient-use efficient crop species on the top of the slope and less efficient species along the bottom to match with the soil fertility gradient on a steep slope.

- With shortening of shifting agricultural cycle the farmer tends to emphasize more on tuber and vegetable crops, as compared to their emphasis on cereals under longer cycles.

- Operating under a mixed cropping system, where the species are sown at the same time soon after the first rain during the monsoon, the farmer harvests crops sequentially as and when the crop matures over a period of a few months; after harvesting the economically useful component, he recycles the biomass into his agricultural plot, which decomposes rapidly.

- Weed biomass pulled out of his plots are put back into the system for similar reasons; about 20% biomass of weeds which he leaves *in situ* without being pulled out serves important nutrient conservation role on a hill slope, which otherwise could be lost through erosive/leaching processes.

- Earthworms form an important component of many traditional agricultural systems. Under the Tropical Soil Biology & Fertility (TSBF) programme, some of our collaborators have designed an eco-technology for *in situ* management of earthworms for sustainable management of soil fertility, with reduced input of inorganic fertilizers in tea gardens of southern India; this technology is now patented by the investigators.

- Socially selected and/or valued species of traditional agricultural systems and those from natural systems often have ecologically significant keystone value; these keystone species often play a key role in nutrient enrichment of the soil; such species helps in redeveloped land use systems with community participation.

- Traditional eco-technologies, such as water harvesting systems and their use have been shown by us to be of value in altering soil biological processes and thus improving soil fertility, under a monsoonic climate.

- Apatanis manipulated sub-specific crop biodiversity (rice varieties) to capture nutrient differentials in the soil and optimize production from the agroecosystem

- Elaborate water management and nutrient recylcing strategies represent a highly complex form of traditional ecological knowledge and technology linkages