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- TRADITIONAL PRACTICES OF AGRICULTURE IN NORTHEAST INDIA AND ITS OPTIONS FOR SUSTAINABLE MANAGEMENT
- DISPARITIES IN SOCIO-ECONOMIC DEVELOPMENT OF ARUNACHAL PRADESH: AN ANALYSIS WITH SELECT INDICATORS
- DETERMINANTS OF HYV PADDY ADOPTION IN ARUNACHAL AGRICULTURE
- IMPROVED RICE TECHNOLOGIES IN WEST BENGAL: WHAT PREVENT FARMERS FROM ACCEPTING THE RECOMMENDATIONS ?
- EXTERNAL CAPITAL INFLOWS IN POST-GLOBALISED INDIA
- TYPES OF ANCIENT INDIAN REPUBLIC
- AN EXPERIMENTAL EVALUATION OF KARANJA - BASED BIO-DIESEL AS A SUPPLEMENTARY DIESEL FUEL FOR RURAL APPLICATIONS.

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PREFACE

In keeping up with the time-honoured tradition of the RGURJ, this issue has included the papers which deal with a wide variety of subjects ranging from history to technology. The papers are the products of serious research and most of them are based on empirical studies. True that the papers are of high academic interest but some of them carry information which is of high practical value.

The paper by Majumder et al. is a study of the traditional agrarian practices of different communities of North East India. Its specific thrust is shedding light on the way how the traditional practices create an agro-environmental symbiosis which tends to preserve the environmental resources over time. All these symbiotic practices, the paper concludes, should be translated to the new technological regime in order to ensure agro-environmental sustainability. While the research concern of Majumder et al. spans the entire North East India, the papers by Neogi and Saikia have a specific focus being limited to Arunachal Pradesh. Neogi's study is the growing socio-economic inequality in the State. His approach is not structuro-aggregative, rather it is spatial with the district forming the unit of analysis. The study shows a growing inter-district inequality in most of the development indicators, something which is unprecedented in the State. Neogi suggests that the inter-district gap in development must be reduced in order for it to be sustainable.

Saikia's study is on the technological induction in Arunachal agriculture. He identifies the determinants of the adoption of high yielding variety paddy in the state. The paper by Ali complements Saikia's paper. While Saikia studies the factors determining the technological induction, Ali sheds light on the factors preventing the induction of new agricultural technology in West Bengal. Parida's paper is an attempt to show the status of inflow of foreign investment in India which is gradually getting more and more globalised. History comes alive in Singh's study of the different types of republics in ancient India. The paper by Lingfa carries technical information which has a high practical utility – it shows how the problem of rural energy can be solved by using non-edible vegetable oil.

Chief Editor

Traditional Practices of Agriculture in North East India and its Options for Sustainable Management

M. Majumder[1], A. Arunachalam[2], A. K. Shukla[3] and R. Sarmah[4]

Abstract

The tribal farmers of North East India since immemorial have been using thousands of locally adapted genotypes of major and minor crops in their various traditional agricultural practices. This region is the native home of about 160 domesticated and 325 wild relatives species of cultivated crops. The yield and efficiency of different agricultural practices vary greatly depending on crop composition and their management practices. The efficiency was found to vary between 1.7 to 75.2 and 0.7 to 8.8 respectively from ecological and economic view point. The maximum energy efficiency was recorded for Aji system practised by Apatani in Arunachal Pradesh whereas, the Homegarden system of Karbi was found most efficient economically.

Introduction

The North East India, covering an area of 255083 km² of hills, valleys and plateaus is ethnically and culturally very distinct from the rest of the country. The region comprises seven states of which Arunachal Pradesh is largest with an area of 83743 km² and Tripura is the smallest with an area of 10486 km² (Table 1). The North East India occupies 7.8 per cent of the total geographical area and is the homeland of 3.7 per cent of the total population of the country. The diversity among ethnic groups (100 major tribes with many sub-tribes, indigenous and immigrant communities), culture, topography (150 msl to 7300 msl) and environmental conditions (temperature varies from below freezing point to 37°C, monthly rainfall from 0 to 512.68 mm) has contributed to the rich and unique biodiversity of the region. The remoteness and inaccessibility has

contributed to the thinner population density (151 persons per sq km), which facilitates the local people to maintain their traditional agricultural practice, agrobiodiversity and knowledge. Shifting cultivation (slash and burn) is the traditional agricultural practices of most of the tribes of the region. In shifting cultivation and other agro-ecosystem the farmers maintain high species diversity, which contributes to the agro-ecosystem stability (Ramakrishnan, 1992). With high crop diversity it would be possible to combine the

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need for increased harvestable food production with the need for maintaining high organic biomass content in the system as a whole. Without this high organic matter production it would become necessary to constantly input costly inorganic fertilizers, which are hard to come by and whose effectiveness in high temperature and heavy rainfall is questionable.

Population density of the region is lower than that of the country as a whole (324 persons per sq km), but the decadal growth rate of the northeast is much higher (31.18% during 1991-2001) than the national rate of 21.35% (1991-2001) (Figure 1). If this continues then serious threats may visit the rich agrobiodiversity and sustainability of the different agro-ecosystems of the risk-prone hilly region. Here an attempt is taken to focus on the diverse agricultural practices, their productive capability, strength of agrobiodiversity, their traditional management practices and the viable sustainable land use strategies for the region.

Natural resource utilization and their traditional management practices in NE

Different communities of Northeast are mainly dependent upon biodiversity-linked land use activities for their livelihood concerns. The forest is an indispensable component of the mountain societies of North East India, which provide supplementary food, fodder, medicine, fuel wood and other livelihood resources. For example, each household of people living in the adjoining areas of Namdapha national park collected in total, about 25 quintals of bamboo and timber, 52 quintals of fuel wood, one quintal of *Z. secunda* leaves for roofing and one quintal of wild vegetables and medicinal plants during the year 2002 (Arunachalam *et al.*, 2004).

Natural resource utilizations of the traditional societies are based on their traditional ecological knowledge (TEK). The mountain areas of Northeast have a variety of natural and human managed ecosystems, and even sacred groves or sacred landscapes protected for cultural and religious reasons. The sacred values of *Mesua ferra*, *Ficus religiosa*, *Alstonia scholaris* have been recorded among the Buddhists of Srilanka (Withanage, 1998). Local people believe that God will punish them if the natural habitat of those particular areas and trees (the temple areas) is disturbed. Concept of the sacred values and sacred groves is common in Meghalaya and Manipur and are widely studied (Tiwari *et al.*, 1998; Khumbongmayum, 2004). The people harvest the forest products mostly during the winter and no or a little harvesting made during the summer season. This process of harvesting shows the traditional conservation method. Most of the species naturally regenerate during the summer season and the young shoots will be destroyed if the harvesting is made during summer. Thus the indigenous people play rather unknowingly the conservation and natural regeneration practices traditionally.

The complexities of a variety of agro-ecosystems maintained by traditional societies are due to TEK-based biodiversity management, both in space and time. This forms the basis for their ability to cope up with uncertainties in the environment and maintain a sustained production level. The TEK of mountain societies also plays a vital role in conservation of crop diversity as well as soil fertility (Box 1). The spiritual beliefs and cosmologies are playing a vital role in cultural aspects of natural resource management. Indigenous knowledge of natural resource management about their environment and manipulation for better needs were studied by Richards (1985). It shows that this knowledge is not only a function of utility but also an intellectual process for the better management of environment. For example, the village council of Changki village in Mokokchung district of Nagaland has certain conservation-oriented measures to be followed by the community (Choudhury, 1998). Some of the important measures include:

- Conservation of land surrounding the village as Reserve Forest.
- A ban on the use of fish poison (both chemical and herbal).
- Not allowing the trapping of nesting birds.
- Prohibition of hunting during the breeding seasons of animals, or of female animals.
- Strictly prohibiting the cutting of edible, wild fruit trees.

Agricultural Practices

The northeast India falls under the agro-climatic zone-II (Eastern Himalayan Agro-climatic region, as identified by the Planning commission, Government of India, in 1989) with five different agro-climatic zones, viz. Alpine (>3500 m), Temperate subalpine (1500-3500 m), Sub-temperate (1000-1500 m), Mid tropical hill (200-1000 m) and Mid tropical plain (<200 m). The agro-climatic and socio-cultural variations have diversified the agricultural system of the region. Jhum is the predominant form of agricultural practice among the farmers of upland communities of northeast India and over four lakh families comprising almost all the major communities practise jhuming. Average land holding under jhum cultivation varies from 0.16 ha to 1.29 ha per family and covers about 3,86,900 ha annually under this practice throughout the region (Choudhury and Sundriyal, 2003). Mixed cropping with a fallow period of 3-10 years is the main characteristic features of the system. However, fallow length of up to 60 years has been reported in remote areas and less than 3 years in the densely populated areas of the region. As a result of increasing population pressure there has been a shift from more extensive to more intensive systems of landuse. Under shorter fallow agriculture (1-2 years) the weed biomass is slashed in January and organized in parallel rows covered by thin layer of soil and allowed to decompose. The crops are sown on these

ridges in March. Double cropping is done in a year, one between March and June and another between August and November (Mishra and Ramakrishnan, 1981). The composition of crop mixture varies from communities to communities and from place to place.

Among different settled cultivation systems wet rice cultivation is predominantly practised throughout the hill terrain, both at low and high elevations. Apatanis of Arunachal Pradesh are well-known practitioners of modified version of wet rice cultivation locally known as 'Aji'. The 'Aji' system with a combination of rice and fish together with millet on the bunds separating each plot has been referred to as one of the most productive and efficient agricultural systems of the region (Ramakrishnan, 1994). The Apatanis also practise upland dry farming, growing millets, maize and vegetables and some extant of jhuming (Maikhuri and Ramakrishnan, 1990). The Monpas and Sherdukpens of Arunachal Pradesh, plain tribes and communities of Assam, Tripura and Imphal valley exclusively depend on wet rice cultivation. In the valley areas lacking water storage facilities mono-cropping as well as mixed cropping of seasonal crops are practised, where seeds are directly broadcast instead of plantation as in wet rice cultivation. The indigenous people residing in the adjoining villages of Namdapha national park in Arunachal Pradesh practise double cropping in this system. The first cropping is from May to August using paddy and maize, and the second from October to January with monocropping of mustard or any of the winter vegetables.

Terrace cultivation was introduced in the region by Government agencies in order to discourage farmers from jhuming. However, due to higher input in the form of labour (2478 MJ ha^{-1} in the first year and 984 MJ ha^{-1} during subsequent years) and inorganic fertilizers (60 kg ha^{-1} yr^{-1} N, 30 kg ha^{-1} yr^{-1} P and 30 kg ha^{-1} yr^{-1} K) this system could not get wide acceptability among the farmers (Ramakrishnan, 1992). In Arunachal Pradesh this system was practised in small scale in Lower Subansiri district (Gangwar and Ramakrishnan, 1987) and in some parts (Burnihat, Shillong and Nayabuglow) of Meghalaya.

Along with jhum and valley cultivation systems some secondary forms such as home gardens, and plantation crop cultivation are also practised by the farmers of the region. Through these the farmer has linked his family to forest ecosystem and also effectively incorporated animal husbandry. Thus agriculture, animal husbandry and domestic sub-systems of the village are all closely linked with the forest ecosystem, providing food, fodder, fuelwood, timber, medicine and other day-to-day requirements. Home gardens are complex and highly diversified systems, an interesting agro-ecosystem

from the point of view of resource management for sustainable agriculture (Gliessman, 1989). The home gardens have rich plant species diversity, dominated by woody perennials and are stratified forming a multistoried structure and resemble natural forest. In some of the areas with continued shortening of the jhum cycle, a shift to plantation of cash crops has evolved. Broom grass (*Thysanolaena maxima*) and bamboo (*Dendrocalamus hamiltonii*) have been harvested from the wild or from cultivated areas. *Citrus* species and *Cinnamomum obtusifolium* have been established frequently with understorey of ginger (*Zingiber officinale*), banana (*Musa* sp.) or pincapple (*Ananas comosus*). Other crops recently introduced by the government agencies on an experimental basis include tea (*Camellia sinensis*), coffee (*Coffea* sp), rubber (*Hevea* sp) and cashew-nuts (*Anacardium occidentale*), etc.

With the help of Government and different development organizations the traditional system and agroforestry has been modified recently. Land with 80-90% slope and with soil depth greater than one metre has been brought under mixed cropping system (e.g. agri-horti-silvipastoral system). The system comprises agricultural use of the foot-hills, horticulture in the mid portion and silvipastoral crops in the top portion of hill slopes. Counter bunds, bench terraces, half moon terraces and grassed ways are the major conservation measures. But this system is slightly labour intensive. For instance, about 190 man days per hectare is required (Verma *et al.*, 2001).

Status of agrobiodiversity and management practices

Agrobiodiversity is a fundamental basis for agricultural production and food security, as well as a valuable ingredient of environmental conservation. The wide variation in geo-climatic conditions and variations of agricultural and management practices within the region have contributed to rich diversity of agricultural crops. This region is also rich in diversity of wild relatives of cultivated crops. Out of 355 wild relatives of cultivated crops reported from all over India, 132 (37.18%) occur in this region (Table 2), which indicates the richness of the area in terms of agrobiodiversity. The northeastern Indian Himalayas is the centre of origin of more than 20 major agricultural and horticultural crops (Vavilov 1950). This region is the native home of about 160 domesticated and 325 wild relatives species of cultivated crops (Upadhayay and Sundriyal, 1998). The wild relatives of rice (e.g. *Oryza granulata, O. rufipogon, O. jeyporensis, O. malampuzhaensis*, and *O. sativa var spontanea*), *Digitaria*, *Coix*, *Panicum*, *Setaria*, *Elusine*, *Zingiber*, *Circuma*, *Cinnamomum*, *Elettaria*, *Gossypium* and of legumes (such as pigeon pea, rice beans, green gram, winged beans, broad beans, Dolichos, and sword beans) are available in this region (Borthakur 1992). According to an estimate of NBPGR about 50000 land races of paddy exist in India of

which 5000 in the northeastern Indian Himalayas. The genetic diversity of rice is found in our survey of tribal inhabiting in the far remote area of Arunachal Pradesh, where they are cultivating 41 different varieties in their diverse agricultural systems of which 22 were upland varieties and 18 were wetland varieties. One variety of rice locally known as "Begun bichi" can be grown in both conditions. There is wide variability in the rice germplasm collected from different parts of northeastern region, but glutinous and japonica forms dominate the endemic types. Out of 37 reported citrus species of India 17 (with 52 varieties) are in Assam (Bhattacharya and Dutta, 1951). This region is also home to many sub-tropical fruits such as *Garcinia*, *Artocarpus*, *Phylanthus*, *Anona*, *Averrhoea*, *Persia*, *Aegale*, *Flacourtica*, *Passiflora*, *Avocado*, *Actinidia*, *Dillenia laeocarpus*, *Eugenia*, *Ficus*, *Juglans*, *Vitis*, *Spondias*, and *Syzygium*. A number of species belonging to the genera *Malus, Prunus, Pyrus, Sorbus, Docynia, Rubus, Cotoneaster, Ribes, Fragaria*, and *Actinidia* grow in the wild. The wild relatives of *Abelmoschus, Alocasia, Alpinia, Amomum, Brassica, Camellia, Canavalia, Citrus, Colocasia, Corchorus, Cucumis, Curcuma, Digitaria, Dioscorea, Docynia, Erianthus, Eurya, Hedychium, Hibiscus, Mangifera, Momordica, Morus, Mucuna, Musa, Oryza, Prunus, Rubus, Setaria, Sorbus, Trichosanthes* and *Vitis* are endemic to the northeastern India (Upadhyay and Sundriyal, 1998).

Until recently, the immense agro-biodiversity of the region was safe as people used to practise mixed cropping of wide indigenous crop cultivars in their traditional shifting cultivation system and in home gardens. In jhum cultivation system 5-45 species of traditional crops are mixed together, where the number of species decline drastically with the shortening of the jhum cycle. A total of 59 edible plant species have been documented from different agricultural systems of Chakmas in Arunachal Pradesh. Almost all the species (51) are grown in home gardens, thirty-three species in different jhum fields and fifteen in valley cultivation system. The selection of crop species under different jhum cycles is based on the traditional ecological knowledge of the farmers (Ramakrishnan, 2001). Different traditional practices also play an important role in the conservation of agrobiodiversity and soil nutrients (Thurston *et al.*, 1999) (Box 1).

Yield patterns of different agro-ecosystems

The crop yield differs markedly in different agricultural practices depending upon the crop components, number of crops mixed and mode of practices. The crop yield from different jhum cultivation systems has been estimated between 986 - 3745 kg ha^{-1} yr^{-1} of jhum cycle length between 5 to 60 years (Maikhuri and Ramakrishnan, 1990; Ramakrishnan, 1992). In case of 3 year jhum cycle of Chakmas the yield is 2915 kg ha^{-1} yr^{-1}, (Table 3) which is higher than that of 5 year cycle of other communities. This may be due to emphasizing more on seed and fruit crops (paddy, maize and chillies) and out of that about 62% of total yield is obtained from paddy, 28% from maize, 6% from chillies and the remaining 4% from other crops. Different studies show that the yield from jhum system gradually declines with the shortening of the cycle length; however, exceptional cases were also recorded. The terrace cultivation of Solungs in Arunachal Pradesh is the lowest productive system with an annual yield of only 1172 kg ha^{-1} (Gangwar and Ramakrishnan, 1987).

The Aji system (paddy + millet + fish) is highly productive in comparison with jhum and other valley system of the region, where the production is recorded as 3456 kg per hectare with early varieties of rice and 4046 kg ha^{-1} yr^{-1} with late varieties of rice (Table 4). The yield from wet rice cultivation system of Chakmas is estimated 2932 kg per hectare. The Agro-ecological Research Centre at Jorhat, Assam reported an average paddy yield in the hill region of northeast as 800-900 kg per hectare. Mishra and Ramakrishnan (1981) also reported 900 kg per hectare yield of paddy from valley cultivation system in Meghayala. However, Aurora *et al.* (1977) have reported about 1200 kg per hectare paddy yield from Tripura. The paddy production in different agricultural systems of Chakmas was higher than that of other communities in the region, however, the overall production of the systems was lower in comparison with the jhum system under longer fallow periods (10- 60 years).

From paddy + maize mixed cropping system of Chakmas in the valley, the yield was estimated as 2468 kg per hectare and during second cropping (i.e mono-cropping of mustard) only 597 kg per hectare yield was obtained. The yield in home gardens of Apatanis in Arunachal Pradesh was estimated 5811 kg per hectare (Kumar and Ramakrishnan, 1990), which is the most productive in the northeast. However, the yield from homegardens of Mikirs in Meghalaya was estimated only 2590 kg per hectare (Maikhuri and Ramakrishnan, 1990). The total output from the home gardens of Chakmas is 3454 kg per hectare that includes 1116 kg ginger, 1550 kg vegetables, 480 kg fruits and 25 kg tobacco.

The yield from different cash crop systems varies greatly depending upon the crop components. The yield from pure cultivation of broom grass of Khasis from Meghalaya was reported 620 kg per hectare, 1095 kg per hectare and 1500 kg per hectare respectively from first, second and third year cultivation, whereas in mixed cropping system the yield of broom grass was estimated 390 kg per hectare, 660 kg per hectare and 660 kg per hectare respectively for first, second and third year cultivation. In case of thatch grass and bamboo of the same community the estimated yield was

4133 kg per hectare and 3695 kg per hectare respectively.

Energy and economic efficiencies of different agricultural practices

The efficiencies of the jhum cultivation gradually increase with the reduction of the jhum cycle period up to ten years and start declining with shortening of the cycle (Maikhuri and Ramakrishnan, 1990). The net return under a ten-year cycle was higher than all other jhum cycles, because of reduced labour costs involved in slash-and-burn operations under this cycle than under longer cycles on one hand, and the poor crop yield due to reduced soil fertility under shorter cycles. The energy and economic efficiencies of 3 year jhum cycle system of Chakma were 5.5 and 1.6 respectively. The efficiencies of jhum system of different tribes with varied fallow length are summarized in table 3.

The Aji system of Apatanis was the most efficient with energy efficiency values of 75.2 and 61.8 respectively for late and early varieties of rice and the respective monetary efficiencies were 3.65 and 2.79. In case of wet rice cultivation system of Chakmas the respective energy and economic efficiencies were 5.6 and 2.0. From several studies the energy efficiency of valley cultivation among different communities like Garos, Karbi, Nepalis and Khasis in Meghalaya, and Nyishi and Apatanis in Arunachal Pradesh was reported in between 2.7 to 17.8, whereas for the same system of these communities the monetary efficiency was reported in between 1.14 to 3.4 (Gangwar and Ramakrishnan, 1989; Patnaik and Ramakrishnan, 1989; Maikhuri and Ramakrishna, 1990, 1991; Kumar and Ramakrishnan, 1990). In case of rice and maize mixed cropping system of Chakmas the total energy invested was 7416 MJ ha^{-1} which is less than that of both wet rice cultivation and the jhum cultivation systems. The total energy output was 36634 MJ ha^{-1}. The energy output - input ratio of the system was 4.9 and the monetary efficiency for this system was 1.42. During second cropping (with mono-cropping of mustard) total energy investment was around 3219 MJ ha^{-1}. The energy output was about 14806 MJ ha^{-1} and the energy output-input ratio was 4.6, which is higher than any other cropping system practised by them. Here the economic output was found to be Rs. 5376 per hectare in return of the total input of Rs. 3259 per hectare i.e. the monetary efficiency is 1.7.

The energy and monetary efficiencies of home gardens of Apatanis were recorded respectively as 33.2 and 3.3 (Kumar and Ramakrishnan, 1990). Though the home gardens are less efficient than Aji system and 10 year jhum cycle systems of different

communities of the state, yet they provide a variety of food items meeting their day-to-day requirements. From view point of energetics, the homegarden system of Apatanis is more efficient than that of Karbi (23.5), whereas from monetary point of view Karbi system (8.8) is much more efficient. The economic efficiency of homegardens of Khasis was estimated 1.8.

The terrace cultivation system has the lowest efficiency among the different existing systems of the region. In terrace cultivation, the energy and monetary efficiency was recorded respectively 22.5 and 1.39 of the Solungs' system (Ramakrishnan, 1992). The energy efficiencies for terrace cultivation systems from Meghalaya were estimated between 1.7 and 21, whereas the monetary efficiencies were found in between 1.4 and 2.1.

The economic efficiency of broom grass cash crop system as estimated by Karki (2001) shows a gradual increase upto 4th year of plantation and then starts declining as the plants grow older (Table 5). The total monetary return upto 6th year was estimated at Rs. 35600 per hectare in return for investment of Rs. 9450 per hectare with an efficiency value of 3.8. Gangwar and Ramakrishnan (1989) estimated the economic efficiencies for pure cultivation of broom grass as 0.7, 1.5 and 2.1 respectively for 1st, 2nd and 3-7th year and from mixed cropping with *Cinnamomum obtusifolium*, the respective values were 1.3, 2.0 and 2.8. In the same study the economic efficiency for thatch and bamboo based cash crop system was estimated 2.2 and 1.9 respectively. For tea, coffee, pineapple (mixed cropping) and ginger based cash crop systems the economic efficiencies were estimated between 1.7 (coffee) and 3.9 (pineapple) and energy values between 1(coffee) and 43.5 (ginger).

Soil nutrients in different agricultural practices

Nutrient losses are greater in the agricultural fields than in the forest ecosystem and that their replenishment is very low, which reduces soil fertility (Sarmah *et al.*, 2001). The major cause of depletion of soil fertility in agricultural system is the removal of plant cover. The depletion through run-off water and leaching processes could be substantial under situations of uneven topography and poor physical qualities of soil in northeast. In slash-and-burn agriculture the burning of slashed plant materials is done in order to release the plant nutrients in a single flush after fire (Table 6) and to capitalize on the nutrients released by growing mixture of crop species for a year or two after which the land is reverted to its natural vegetation so as to restore soil chemical fertility and to

improve its physical properties. However, during the process of cultivation a number of perturbations take place due to slash, fire, hoeing and ploughing, introduction of crop species, weeding and crop harvest, which causes rapid depletion of nutrients and this process continues through the early and secondary successional phases. The major physical causes of loss of nutrients from jhum fields of northeastern region are blown off, run-off and percolation (Table 6). The burning also causes loss of carbon and nitrogen due to volatilization (Ramakrishnan, 1992). The decrease of organic carbon content on burning is more pronounced particularly when the temperature exceeds 150°C during burning. The pH, K and exchangeable calcium and magnesium content of the soil increases after burning (Table 7). However, the available phosphorus content does not change appreciably (Chauhan, 2000). The data on the loss of organic carbon, phosphate and potash in jhum cultivation showed that the loss of these nutrients in the first year cropping was 84.70, 0.08 and 1.60 kg ha^{-1}, respectively (Table 8). During second year cropping the loss of these nutrients was found to be 1321.00, 0.21 and 12.50 kg per hectare, respectively (Chauhan, 2000). The loss of these nutrients from jhum cultivation suggests that the practice is detrimental to soil fertility, particularly in case of shorter jhum cycle. During the cropping phase the nutrients are taken up by crops and weeds, some of which are recycled back into the system as plant residues and substantial quantities are removed through crop harvest and weed removal from the plots. The net consequence of these input/output events is often a net loss from the system and a decline in soil fertility at the end of the cropping period. The recovery of the loss would take place during the fallow phase and the extent of recovery depends on the length of the fallow phases.

Our studies on different agricultural practices of tribal in the adjoining villages of Namdapha national park indicated that the field soil under wet rice cultivation had rich nutrient as compared to other systems including the jhum field. The C/N ratio varied between a narrow range of 12.9 to 15.7 (Table 9). The highest C/N ratio during mustard cultivation could be due to greater rates of microbial immobilization of soil nitrogen due to increasing surface area for microbial colonization by the incorporation of residues of the previously harvested crops (paddy + maize).

Option for sustainable land-use development: Recommendations

Overall, for improving the land use and sustainable management of natural resources, the following strategies have been prescribed by different workers and can

be implemented.

- With wide variations in cropping and yield patterns under jhum practised in diverse ecological situations, the transfer of technology from one area to another could improve jhum, valley land and home-garden ecosystems. Thus, for example emphasis on potato at higher elevations has led to a manifold increase in monetary efficiency (Ramakrishnan, 1992).

- When the jhum cycle length cannot be increased beyond five-year period, redesigning and strengthening the agro-forestry system by incorporating ecological insights on tree architecture should be done. During fallow period the regeneration could be accelerated by introducing fast growing native plants such as *Alnus nepalensis*, *Flemingia vestita*, *Clarodendrum collebrookenum*, *Albizia lebbeck*, *Cassia stipulate*, etc. and suitable fodder grasses having social and ecological values.

- Arunachalam *et al.* (2002) compared shifting cultivation with agroforestry based on few socio-biological principles which suggest better acceptance of balanced agroforestry both ecologically and economically.

- The Sloping Agricultural Land Technology (SALTs) developed in Philippines can also be a viable alternative to jhuming in the northeasten India, where cropping, livestock, horticulture and forestry can be incorporated on farmers' will as SALT-1 (Sloping Agricultural Land Technology), SALT-2 (Simple Agro-livestock Technology), SALT-3 (Simple Agro-Forest Land Technology) and SALT-4 (Small Agro-fruit Livestock Technology). SALT can be established on farmland with slopes between 5-25% or more (Caleda and Esteban, 1981). The salient features in terms of design of different SALTs are summarized in table 10.

- Since citrus, pineapple and banana are the major fruit crops of the region, pure horticultural land use can be developed with plantation of mandarin orange at a distance of 5m and pineapple (semi-shady species) may be planted in between the orange plants in the same row and the space between the rows can be used for vegetable cultivation. Here various tree species can be grown as wind breaks, shelterbelts or fillers in this system to protect the orange plants from the high velocity winds (Verma *et al.*, 2001). *Salix* sp., *Populus* sp. and *Anlus nepalensis* have been proved successful around the fruit farms without any adverse effect on the fruit production.

- Improving the nitrogen economy of jhum in the cropping and fallow phase by the introduction of nitrogen fixing leguminous and non-legumes. The farmers have already adopted

the *Alnus nepalensis* and *Albizia* species in the agricultural systems based on their traditional knowledge to meet modern needs. Another such example is the less known food crop legume *Flemingia vastita* (Ramakrishnan, 1992).

- Important bamboo species (e.g. *Dendrocalamus hamiltonii*), highly valued by the tribals, can concentrate and conserve important nutrient elements such as N, P, and K (Rao and Ramakrishnan, 1989). They could also be used as windbreaks to the loss of ash and nutrient losses in water.

- In case of shorter jhum cycle burning should be avoided to prevent volatilization of nutrients occurring during burning (Ramakrishnan and Toky, 1981). The crops and herbaceous weeds residues can be recycled in the systems in a scientific and well managed manner. In this context vermicompost may prove an able strategy to improve agriculture and residue management. It has been observed that 99% (t_{99}) decomposition of foliage materials requires less then one year and if these residues could be recycled, then 53-105 kg ha^{-1} nitrogen, 7-14 kg ha^{-1} phosphorus and 18-36 kg ha^{-1} potassium could be recycled into the system (Majumder *et al.* 2005).

- Redeveloping village ecosystems through the introduction of appropriate technology to reduce hard work and improve energy efficiency (cooking stoves, agricultural implements, biogas generation, small hydroelectric projects, etc).

- Strengthening conservation measures based upon the traditional knowledge and value system with which the tribal communities can identify, e.g. the revival of the sacred grove concept based on cultural tradition, which enabled each village to have a protected forest.

- Encouraging the cooperative efforts for carrying out forest based activities, i.e.making of basket, rope, cane furniture, and processing of minor forest produce, honey collection, etc. This will not only decrease dependence of farmers on shifting cultivation but will also help them monetarily.

Land use in agriculture is in conflict with other types of land use such as conservation of forests, recreation areas, protected areas, and so on. Despite traditional culture and local knowledge to manage and conserve the forest resource, the local people are excluded from the utilization and management as part of protected area to be managed but not as a stakeholder in the protected area management. There is a need to introduce a participatory approach in land use planning in the management of protected areas.

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Box 1: There are various practices traditionally followed by various communities in northeast India which favour to conserve the agro-biodiversity and management of agricultural practices

Multiple cropping (intercropping; mixed cropping; homegardens) - Maintains biodiversity as interdependent crop variability. Often reduces damage from pests and diseases favouring maintenance of agrobiodiversity.

Varietals mixtures - Maintains interspecific crop variability.

Crop selection- Cultivation of cereal crops under long jhum cycle of 30-years or more whereas tuber and vegetable crops under shorter cycle of 5-years or less is to emphasize upon the nutrient use efficient species under shorter cycle, which in turn also conserve agrobiodiversity.

Crop rotation - Decreases insect pests and pathogen damage and increases agrobiodiversity. Help in soil nutrient amendment.

Fallowing and rotation - Maintains soil biodiversity and fertility. Manages soil pathogens and pests (through interruption of life cycles) and soil nutrient amendment favouring crop health and maintenance of agrobiodiversity.

Organic amendments - Soil enrichment favours soil biodiversity. Development of suppressive soils. Manages soil pathogens and pests favouring crop health and maintenance of agrobiodiversity.

Flooding - Nutrient enrichment favours soil biodiversity. Reduces damage from weeds, pests and diseases favouring crop health (especially in paddy field) and maintenance of agrobiodiversity.

Burning - Slash and burn systems maintain considerable agrobiodivesity. Contributes to pest and disease management, crop health and maintenance of agrobiodiversity.

Mulching - Lowers soil temperature, protects against erosion, improve soil texture, provides nutrients and organic matter, reduces weed problems and suppresses soil borne pathogens contributing to crop health and maintenance of agrobiodiversity.

Raised beds - Improve drainage, fertilization, frost control and irrigation, supports management of soilborne pathogens and pests contributing to crop health and maintenance of agrobiodiversity.

Site selection - Avoids diseases, pests and weeds associated with previous crops, matches soil fertility and drainage to crop and variety contributing to crop health and maintenance of agrobiodiversity.

Manipulating shade - Maintains biodiversity as interdependent multiple crop variability, e.g. in coffee, cocoa and tea cultivation systems. Manages pathogens and pests favouring crop health and maintenance of agrobiodiversity.

Selective logging in agricultural fields (agroforestry) - The Jhumias of northeast India of northeast India conserves various tree species in their jhum field, which protect the field from soil erosion and wind. The tree species like *Alnus nepalensis*, species of *Albizia, Flemingia vestita* etc. are specially conserved if present in the field, as they are natural nitrogen fixer. Some of the bamboo species (e.g. *Dendroclamus hamiltonii*) are also conserved which can concentrate and conserve N, P and K.

Table 2: Distribution of wild relatives of cultivated crops in India and as a whole in the northeastern hill region

Crop	Number of Species	
	NE Himalaya	India
Cereals	16	60
Legumes	6	33
Fruits	51	109
Vegetables	27	64
Oil seeds	1	12
Fibre crops	5	24
Spices and condiments	13	27
Miscellaneous	13	26
Total	**132 (37.18%)**	**355**

Source: Upadhyay and Sundriyal, 1998

Table 3: Yield and efficiencies under different jhum cultivation systems of northeast India

Practices	Yield	Input		Output		Efficiencies	
		Energy	Monetary	Energy	Monetary	Energy	Monetary
		(MJ ha^{-1})	(Rs ha^{-1})	(MJ ha^{-1})	(Rs ha^{-1})		
Arunachal Pradesh							
[1]60-years cycle	3745	2855	4568	67171	7430	24	1.6
[1]30-years cycle	3125	2294	3888	60839	6657	27	1.7
[1]20-years cycle	3215	1599	3016	51660	5634	32	1.9
[2]15-years cycle	2069	1062	2435	33649	7176	32	3.0
[1]10-years cycle	3225	1194	2766	51774	6464	43	2.3
[1]5-years cycle	2450	853	2215	35474	4336	41	2.0
[3]3-years cycle	2915	8579	10671	41626	16585	5.5	1.6
Meghalaya							
[5]30-years	3460	1665	2616	56766	5586	34.1	2.1
[5]20-years	3430	1688	NA	60277	NA	35.7	NA
[6]-do-	2662	1352	NA	48985	NA	36.2	NA
[7]-do-	1786	1043	NA	32978	NA	31.6	NA
[6]15-years	2443	3675		19790		5.4	
[5]10-years	3366	1191	1830	56601	3354	47.5	1.8
[6]-do-	2267	1200	10548	52142	18370	22.6	1.7
[7]-do-	1359	794	NA	23158	NA	29.0	NA
[5]5-years	1584	810	896	44758	1524	55.2	1.9
[6]-do-	1590	1470	7431	26686	7520	18.1	1.01
[7]-do-	986	546	NA	15829	NA	29.0	NA
[6]3-years	NA	9054	8986	41030	12096	4.5	1.4

Table 4: Yield and efficiencies under other land use systems of northeast India

Practices	Yield	Input		Output		Efficiencies	
		Energy (MJ ha^{-1})	Monetary (Rs ha^{-1})	Energy (MJ ha^{-1})	Monetary	Energy	Monetary (Rs ha^{-1})
Arunachal Pradesh							
Valley cultivation							
[3]Wet rice	2932	7518	6474	42221	13194	5.6	2.0
[3]Mixed cropping	2468	7416	7061	36634	10012	4.9	1.4
[3]Mustard	597	3219	3259	14806	5373	4.6	1.7
[4]Aji							
Early variety (Paddy + millet)	3456	946	2798	58480	7817	61.8	2.8
Late variety (Paddy + millet + fish)	4046	907	2753	68182	10062	75.2	3.7
[4]Homegardens	5811	1774	3162	58873	10524	33.2	3.3
[2]Terrace cultivation	1172 (4475)	847 (6460)	1894	19058	2637	22.5	1.4
Meghalaya							
Valley cultivation							
[5]Double cropping	NA	2843	4843	50596	5565	17.8	1.1
[7]Single cropping	NA	11601	2388	41938	3876	3.6	1.6
[8]-do-	NA	3479	1316	43172	4460	12.4	3.4
Homegardens							
[6]	NA	NA	13093	NA	23155	NA	1.8
[7]	2590	1140	1650	26794	14667	23.5	8.8
Terrace cultivation							
[5]	NA	6509 (8003)	2542 (4544)	43602 (5.4)	3658 (0.8)	6.7	1.4
[6]	NA	12878 (13968)	6004 (12243)	21889 (1.6)	12561 (1.0)	1.7	2.1
[8]	NA	4846	6217	101525	11791	21	1.9
Cash crops (Broom grass)							
[6]Pure							
1st-year	620	NA	4670	NA	3348	NA	0.7
2nd-year	1095	NA	3930	NA	5913	NA	1.5
3rd-year	1500	NA	3870	NA	8100	NA	2.1
[6]Mixed							
1st-year	390	NA	4995	NA	6474	NA	1.3
2nd-year	660	NA	3886	NA	7953	NA	2.0
3rd-year	904	NA	3303	NA	9250	NA	2.8
Coffee	NA	8855	2754	8450	4560	1.0	1.7
Tea	NA	19425	14314	181310	37125	9.3	2.6
[6]Thatch grass	4133	NA	1716	NA	3827	NA	2.2
[6]Bamboo	14385	NA	3695	NA	6850	NA	1.9
Pineapple (mixed cropping)	NA	973	3096	17085	12090	17.6	3.9
Ginger	NA	1302	1830	56655	3354	43.5	1.8

Systems practised by [1]Nyshis; [2]Sulungs; [3]Chakmas; [4]Apatanis, [5]Garos, [6]Khasis, [7]Mikirs, [8]Nepali -Values in parenthesis are for the first year; NA- data not available

Source for table 3 and 4: Miakhuri and Ramakrishnan, 1990; Gangwar and Ramakrishnan, 1989; Toky and Ramakrishnan, 1981; Patnaik and Ramakrishnan, 1989; Gangwar and Ramakrishnan, 1987; Mishra and Ramakrishnan, 1981, 1982; Kumar and Ramakrishnan, 1990.

Table 5: Cost and Return (000Rs ha^{-1}) Analysis for *Thysanolaena maxima*

Item	Year 1st	2nd	3rd	4th	5th	6th	Total
Revenue	3.0	5.2	9.6	12.4	4.5	0.9	35.6
Production cost	3.7	1.4	1.55	1.55	0.85	0.4	9.45
Labour							
- Site Clearance	1.0						1.0
- Weeding (2x per year)	1.2	1.2	1.2	1.2	0.65	0.25	5.7
- Pit digging &rhizome planting	0.8						
	0.8						
- Transportation to godowns	0.2	0.2	0.35	0.35	0.2	0.15	1.45
Materials							
Small tools & implements	0.5	-	-	-	-	-	0.5
Efficiency	0.8	3.7	6.2	8.0	5.3	2.3	3.8

Source: Karki, 2001

Table 6: Nutrients accumulated (kg ha^{-1}yr^{-1}) through burning and their loss form different jhum fields and different cash crop plantation

		Jhum cycle			Cash crop plantation			
		30-years	10-years	5-years	Coffee	Tea	Pineapple	Ginger
Ash								
	Released	17.4	13.8	6.9	—	—	—	—
	Blown off	8.2	8.2	1.9	—	—	—	—
P								
	Released	313.0	262.2	150.7	—	—	—	—
	Blown off	147.1	155.6	42.7	—	—	—	—
	Run-off	1.1	1.3	0.9	0.59	2.56	0.61	1.68
	Percolated	0.1	0.1	0.1	0.22	0.30	0.19	1.0
K								
	Released	1739.0	2070.0	685.0	—	—	—	—
	Blown off	817.0	1228.5	194.0	—	—	—	—
	Run-off	64.7	91.2	51.0	22.01	54.67	15.15	41.03
	Percolated	15.1	21.2	13.7	9.45	5.90	3.80	15.86
Ca								
	Released 956.5	193.2	116.5	—	—	—	—	—
	Blown off	449.4	114.7	33.0	—	—	—	—
	Run-off	15.1	15.9	13.8	10.83	26.0	8.01	12.94
	Percolated	5.3	4.9	4.6	3.84	3.0	2.33	6.56
Mg								
	Released	208.7	151.8	113.7	—	—	—	—
	Blown off	98.0	90.1	32.2	—	—	—	—
	Run-off	6.3	5.4	9.5	8.97	36.94	6.37	10.86
	Percolated	2.5	2.1	2.3	2.33	4.55	1.62	5.58

Source: Toky and Ramakrishnan, 1981 & 1982

Table 7: Changes in surface soil before and after burning in different jhum cycle

Properties	15-year Before	15-year After	10-year Before	10-year After	5-year Before	5-year After
pH	5.1	7.5	5.3	7.6	5.5	7.5
Carbon (%)	1.9	1.6	1.8	1.7	1.6	1.6
Nitrogen (%)	0.26	0.25	0.26	0.25	0.21	0.20
Phosphorus (%)	3.5	3.6	3.4	3.6	3.3	3.5
K (mg 100 gm^{-1} soil)	13	61	11	56	12	51
Ca (mg 100 gm^{-1} soil)	10	32	12	28	9	21
Mg (mg 100 gm^{-1} soil)	8	23	10	21	9	20

Mishra and Ramakrishnan, 1992

Table 8: Loss of organic carbon and plant nutrients in jhum cultivation

Year	Organic C (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
1st year	84.70	0.08	1.60
2nd year	1321	0.21	12.50
Average	702.90	0.15	7.10

Source: Chauhan, 2000

Table 9: Physico-chemical properties of soil during cropping period in different agricultural systems

Properties	Valley cultivation: Wet rice	Valley cultivation: Paddy + maize	Valley cultivation: Mustard	Jhum cultivation
Textural class	Loamy sand	Sandy loam	Sandy loam	Loamy sand
Clay (%)	12.24	14.52	14.52	10.30
Silt (%)	14.02	21.04	21.04	10.25
Sand (%)	69.73	64.44	64.44	69.46
Moisture (%)	24.77±1.30	16.68±1.46	14.40±1.58	22.6±0.60
pH (1:2.5 w/v H_2O)	5.17±0.03	5.67±0.25	5.78±0.13	5.88±0.51
Organic C (%)	2.43±0.03	2.190±0.06	2.03±0.06	1.96±0.02
Total N (%)	0.184±0.02	0.171±0.02	0.133±0.01	0.15±0.01
C/N	13.21	12.88	15.27	13.22
Ammonium-N (μg g^{-1})	36.23±2.14	33.18±1.33	30.62±2.79	30.17±1.45
Nitrate-N (μg g^{-1})	23.37±0.17	11.04±0.14	10.93±0.10	11.47±0.10
Available P (μg g^{-1})	35.03±0.04	22.78±0.40	20.88±0.12	24.86±0.15

Table 10: Land use characteristics of different SALT systems

Production system	SALT-1	SALT-2	SALT-3	SALT-4
1. Base	staple crops	fodder	trees	horticulture
2. Major product	food grains	meat/milk/ manure	fuelwood/timber	plantation crops
3. Planting area (%)				
• Staple crops	75	20	20	40
• Food/cash crops	25	20	20	60
Perennials/trees				
• Forage/fodder	-	40	-	-
•Private forestry	-	20	60	-

Source: Conceived, tested and recommended by Mindanao Baptist Rural Life Center (MBRLC)/ Asian Rural Life Development Center (ARLDF).

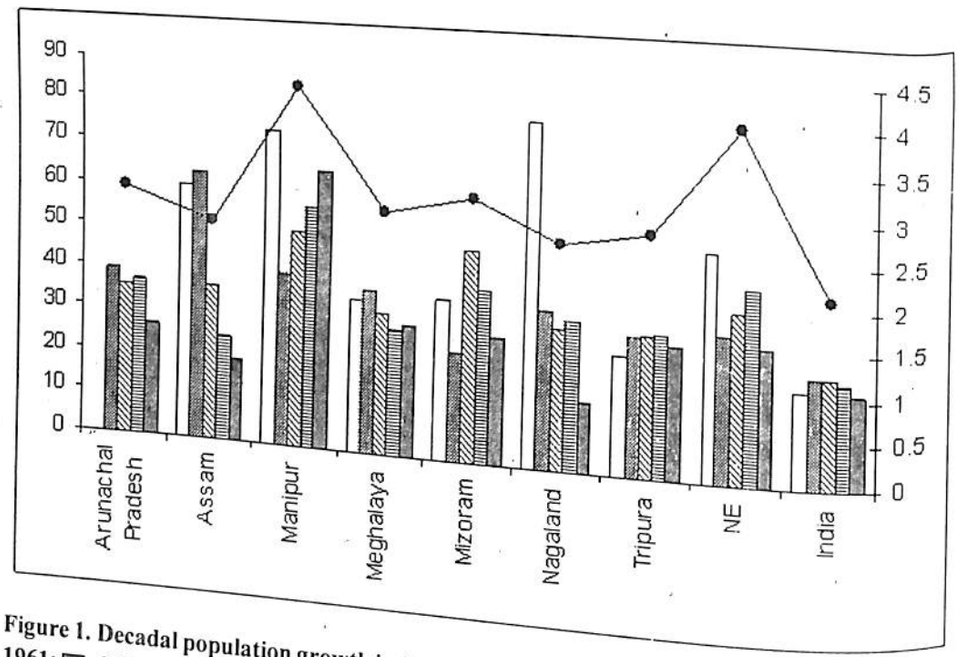

Figure 1. Decadal population growth in the northeastern hill region for last 40 years□- 1951-1961; ■- 1961-1971; ▨- 1971-1981;▤- 19981-1991; ▦-1991-2001; ●-Annual average exponential growth rate (1961-2001); The decadal growth rate of Arunachal Pradesh (1951-1961) and Assam (1961-1971) are not available.

Disparities in Socio-Economic Development of Arunachal Pradesh : An Analysis with Select Indicators

Debasis Neogi

Abstract

The socio-economic status of any region has tremendous impact on its overall development. Disparities in socio-economic status not only lead to a lop-sided development of the region, but also widen disparities further. For Arunachal Pradesh, given its strategic importance and geo-political sensitivity, development on a balanced scale is what is badly needed. The present paper makes an attempt to find out the existing disparities in the socio-economic scenario of Arunachal Pradesh. With some selected indicators the paper finds out the extent of disparities present in the state in 1993. It is then compared with the same in 2004. Apart from revealing the degree of disparities, the study gives an insight into whether the disparity is on convergence or divergence over a span of more than a decade.

Introduction

Economic development has faced a number of paradigm shifts over the last few decades. These changes were inevitable in the sense that they were the responses to the demand of contemporary time. With a rise in the socio-economic complexities across the world, these frequent shifts in thinking appear relevant. However, if the chosen path is not well planned, it will lead to asymmetric development. The demand for development will not be adequately and equitably met. At the same time, disparity will widen. The relatively well-off people, taking maximum advantage of development will become richer, while condition of the poorer will be worse. The disparity not only retards the pace of development, but also leads the economy into a vicious circle, where disparity aggravates disparity. In this sense, there is always a two-way cause-effect relationship between economic disparity and underdevelopment. In India, the issue of disparity has received the attention of the Government since independence. It got further momentum in connection with the effort on part of the Government to alleviate wide-spread poverty. In fact, rising regional inequality is bound to slow the trickle-down effect of growth on poverty reduction (Bhanumurthy and Mitra, 2004). Those who advocate policy reform in favour of agriculture cite the relatively higher poverty in rural areas. However,

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information asymmetry is a hurdle. Policy formulation without taking proper stock of the existing disparity may lead to further augmentation of the problem. Formulating a too pro-rural policy, for example, may transfer too much burden to the urban sector offsetting the consequent relative gains to the rural area. Thus, the policy will not augment net social benefit.

Apart from inter-state disparity in India, the intra-state disparity is also found in equal footing. Any state level study in India is likely to produce divergent results in terms of extent and causes of socio-economic disparities in different states. For Arunachal Pradesh the difficult geographical location along with its geo-political identity has rendered it a special status, where even distribution of the fruits of development has connotations for its strategic sensitivities. The present paper intends to find the level of disparity among the districts of the state. It is also a caveat to the policy makers as it makes a modest attempt to find whether the disparity is on convergence or divergence, especially between 1993 and 2004.

Data and methodology

At present, Arunachal Pradesh has 16 districts. However, for the present study, mostly those districts are selected whose data are available for both 1993 and 2004. These are Tawang, West Kameng, East Kameng, Papum Pare, Lower Subansiri, Upper Subansiri, West Siang, East Siang, Dibang Valley, Lohit, Changlang and Tirap, though for 2004, one additional district, Upper Siang, is also considered. For the purpose of time-specific comparative analysis, a few selected indicators of socio-economic development are chosen. These indicators reveal the relative position of the districts in development. The indicators include sex ratio, overall literacy rate and female literacy. The sex ratio indicates whether the society is balanced or it has discrimination against girl child.

Arunachal Pradesh has predominantly an agriculture-based economy. As per 2001 population census, 58.44 per cent of the workers in the state are cultivators and another 3.85 per cent are agricultural labourers. Such a huge dependence on agriculture necessarily calls for its rapid development. In the present paper, the parameters for agricultural development include use of fertilizer and net area brought under irrigation.

Attainment of adequate infrastructure is very crucial for a balanced socio-economic development in Arunachal Pradesh. The infrastructural development includes both physical and social infrastructure. The parameters considered for physical infrastructure

are the length of road per unit of area and proportion of people connected with drinking water facility. The student-teacher ratio in the primary schools and the average population per doctor represent social infrastructure.

The present study analyses the disparity in the economic development in Arunachal Pradesh in 2004 in comparison to that in 1993. The entire study is conducted with the secondary data available mostly in the *Statistical Abstract of Arunachal Pradesh,* 1993 and 2004 issues.

The study has used coefficient of variation and the Gini Coefficient estimated for the indicators suggests the relative concentration. To make the analysis more perfect, the paper has also used Lorenz consistent general entropy measures. Its sensitivity to both upper and lower parts of the data series is also considered in the analysis. Composite indices with respect to agricultural development and regional development are constructed for the indicators for both 1993 and 2004. These indices give an insight into the relative positions of the districts in agriculture as also in overall socio-economic perspective.

Results

First the relative performance of indicators across the state is considered. Table 1 shows these indicators in 1993. The largest share of population in the state in 1993 was in Lohit district while Tawang had the lowest share. In sex ratio, there is a wide difference. East Siang had 961 females per 1000 males, which was pretty higher than the state average of 859.

The scenario in literacy rate was very poor in the state in 1993 with the average being 32.8 per cent. The highest literacy rate was in Lohit at 38.47 per cent. The female education was, however, not so grim, given the overall literacy rate in the state. In the entire state, 42.88 per cent of the total students enrolled in the primary section were female. The highest proportion of female students in the primary section was in East Siang (47.71 per cent).

The student-teacher ratio in primary schools was the lowest in West Kameng. It stood at 27 as compared to the state level figure of 33. In other words, West Kameng had fewer students per teacher in primary education.

Table 1

Selected Indicators of Socio-Economic Development of Arunachal Pradesh: 1993

District	Population share	Sex ratio (%)	Literacy Rate %	Fertilizer used (in terms of materials) (MT)	Net Area Sown/ population	Net Irrigated Area/Net Area Sown*	Pupil-Teacher Ratio in Primary Section	% Girl students enrolled in primary schools	Length of Road per 100 sq km area	Population-Doctor ratio
Tawang	3.27	844	24.14	84	0.08	85	29	35.93	91	3536
West Kameng	6.53	822	36.48	79	0.17	38	27	42.62	13	9670
East Kameng	5.83	961	20.81	48	0.15	23	31	39.54	20	5599
Papum pare	8.42	830	43.06	7	0.08	45	28	42.08	14	2697
Lower Subansiri	9.62	956	24.24	24	0.25	28	39	42.06	14	2772
Upper Subansiri	5.79	867	30.83	29	0.13	12	41	44.41	11	3578
West Siang	10.40	872	35.5	28	0.24	89	36	46.01	15	3331
East Siang	11.53	861	35.29	51	0.27	52	30	47.71	14	2214
Dibang Valley	4.98	788	36.88	30	0.18	70	30	44.49	6	3589
Lohit	12.69	797	38.47	55	0.13	60	31	41.65	12	2676
Changlang	11.05	862	33.53	31	0.14	25	40	44.14	17	5028
Tirap	9.89	862	25.18	33	0.14	41	32	33.89	89	4072
Ar.P.	100.00	859	32.8	499	0.17	48	33	42.88	17	3179

* In percentage

Source: Government of Arunachal Pradesh, *Statistical Abstract of Arunachal Pradesh, 1993.*

The population-doctor ratio is lowest in East Siang, where one doctor treats, on average, nearly 2214 people. This is lower than the state level figure of 3179.

As far as the agricultural development is concerned, the relative positions of the districts in respect of all the three parameters are different. Use of fertilizer is the highest

in Tawang, where 84 tonnes of fertilizer was used in 1992-93. The highest per capita net area sown was in East Siang district (0.27 hectare). It is much higher than the state average of 0.17 ha. In terms of availability of irrigation facility in sown area is concerned, West Siang is in the best position, with 89% of its net sown area having this facility. At the state level this figure is, however, pretty low at 48 per cent.

In order to compare the socio-economic profile of Arunachal Pradesh in 1993 with that of 2004, we must find out the positions of the districts with respect to each of the indicators in 2004. Table 2 provides data on all the indicators in 2004. As per 2001 census the largest share of population is in Lohit district as it was in 1993. This district had 12.69 per cent of total population of the state. In terms of position, East Kameng had the highest sex ratio. It had 985 females per 1000 males, which was higher than the state average of 901.

In literacy Papum pare had the highest position with 71 per cent of its people being literate compared with the state average of 54 per cent. The scenario in female education in the state had improved markedly in 2004 over 1993.

The student-teacher ratio in 2004 was the lowest at 22:1 in both West Kameng and East Siang districts. At the state level, on average, 35 students were taught by one teacher. The average number of people attended by one single doctor was lowest in Upper Siang district, where a doctor used to treat nearly 1400 people. The situation, here, was better than the figure at the state level, where the population-doctor ratio was 2364:1.

As far as infrastructure development is concerned, the communication by road is an important ingredient. As a matter of fact, it is a pre-requisite of development of any region. In Arunachal Pradesh there are still many places, with all weather road communication. At the state level, the length of road per 100 sq km was meagre at 16.72 km. However, among the districts, Tawang had the largest of 35.58 km per 100 sq km, while upper Dibang Valley had the lowest of only 6.96 km of road per 100 sq km.

Table 2

Selected Indicators of Socio-Economic Development of Arunachal Pradesh in 2004

1	2	3	4	5	6	7	8	9	10	11	12	13	14
District	Population share%	Sex ratio (%)	Literacy rate	Fertilizer used (in terms of materials) (M.T.)	Net Area Sown/ population	Net Irrigated Area/Net Area Sown*	Pupil-Teacher Ratio in Primary Section	Percentage of Girl students enrolled in primary schools	Telephone per 100 population	Length of Road per 100 sq km area	Population provided with drinking water facility (%)	Population-Doctor ratio	Population below poverty line (%)
Tawang	3.58	963	41.14	245.39	0.10	13.63	30	50.04	7	35.58	81.55	2308	16
West Kameng	6.80	749	61.67	263.89	0.09	5.85	22	47.30	5	20.58	77.82	3105	66
East Kameng	5.20	985	40.89	69	0.21	12.76	48	44.54	4	19.49	96.38	3003	69
Papum pare	11.10	899	70.89	93	0.10	11.79	44	46.35	15	34.11	83.79	2174	46
Lower Subansiri	8.91	985	45.01	104	0.23	20.78	52.5	46.24	4	11.67	88.00	2273	67
Upper Subansiri	5.05	973	50.89	72	0.14	18.93	45	48.60	4	15.79	97.57	2306	84
West Siang	9.46	913	60.31	165	0.25	25.76	39	47.45	5	22.45	93.46	2076	48
East Siang	7.96	937	61.22	195	0.23	22.74	22	46.64	5	18.46	90.46	1648	44
Upper Siang	3.04	858	49.8	60	0.25	38.23	43	50.19	6	13.18	83.94	1390	45
Dibang Valley	5.25	840	59.45	180	0.40	5.05	44	47.04	5	6.96	79.94	3385	84
Lohit	13.08	857	56.05	242	0.20	9.49	46	44.51	4	11.38	82.24	2609	53
Changlang	11.43	905	51.98	105	0.14	53.03	29	42.76	3	22.99	89.36	3057	25
Tirap	9.14	911	42.01	80	0.14	3.37	48	39.99	2	40.14	87.80	2445	74
A.P.	100.00	901	54.74	1874.28	0.19	18.84	35	46.00	5	16.72	88.45	2364	54

Source: Govt. of Arunachal Pradesh, *Statistical Abstract of Arunachal Pradesh, 2004.*

* in percentage

Talking about tele-connectivity, while in Arunachal Pradesh only 5 out of every 100 people had telephone connections, Papum-pare had 15 per 100 people being connected with telephone facility. Provision of drinking water is another area, where Arunachal Pradesh has still some ground left uncovered. Overall, only 54% of the total population of the state had access to drinking water. Among the districts, Upper Subansiri had 97.57% of the total population having drinking water facility.

In the field of agriculture the advancement in terms of use of fertilizer has increased over the years. Among the districts, West Kameng had the highest fertilizer consumption – 264 tonnes in 2004, which was over 14% of the total fertilizer used in Arunachal Pradesh in that year. The per capita net area sown was the largest in Upper Dibang Valley district (0.40 ha.), while at the state level, the figure was only 0.19 ha. Out of the net area sown, in the entire state, only 19 per cent had irrigation facility. In Changlang over 53% of the net area sown had access to irrigation. It was the largest among all the districts in the state.

To find out the overall regional disparity existing in the state in respect of all the indicators, we use the coefficient of variation (cv) and Gini Coefficient. While coefficient of variation measures the relative variability of different indicators across the state, the Gini coefficient measures their concentration.

Table 3 gives coefficients of variation and Gini coefficients of indicators for 1993 and 2004.

Between 1993 and 2004, the CV has worsened, marginally for sex ratio and substantially for net sown area, irrigation and student-teacher ratio. However, this relative variation has reduced in use of fertilizer, in enrolment of girls at the primary level and in the availability of doctor. Reduction in disparity is also noticed in physical connectivity measured by the length of road per 100 sq km.

All these measures give a clear picture of the level of disparity, existing in the state in its socio-economic perspective. However, they do not take into account the population share of each district. Now with due consideration to population share, we employ Lorenz-consistent General Entropy (GE) set of measures (Cowell, 1995 and Fedorov, 2002). These measures are sensitive to various parts of the distribution. It can be represented in the following manner:

Table 3
Coefficient of Variation & Gini Coefficient of Indicators in Arunachal Pradesh for 1993 & 2004

Indicator	Coefficient of variation		Gini coefficient	
	1993	2004	1993	2004
Sex ratio	6.21	7.48	0.03165	0.03821
Literacy rate	21.64	17.63	0.11586	0.65089
Fertilizer used (in terms of materials) (M.T.)	54.66	51.55	0.28346	0.03528
Net Area Sown/population	37.05	44.45	0.19731	2.08326
Net Irrigated Area/Net Area Sown	51.90	76.33	0.28144	0.23549
Pupil-Teacher Ratio in Primary Section	14.85	25.91	0.07981	0.18235
Percentage of Girl student enrolled in total enrolled in primary	9.47	6.12	0.04922	0.11616
Length of Road per 100 sq km area	114.30	48.27	0.45541	0.52259
Population provided with drinking water facility (%)	—	13.39	—	0.00015
Population-Doctor ratio	28.40	23.79	0.14690	0.00218
Population Below Poverty Line	—	37.81	—	0.5651
Telephone per 100 population	—	60.97	—	0.2810

$$GE = \sum_{i=1}^{N} \Phi(Y_i) \cdot [(I_i / \hat{I})^c - 1], \quad c \neq 0, 1$$

$$GE = \sum_{i=1}^{N} \Phi(Y_i) \cdot [(I_i / \hat{I}).\log (I_i / \hat{I})], \quad c = 1$$

$$GE = \rightarrow \sum_{i=1}^{N} \Phi(Y_i) \cdot \log (I_i / \hat{I})], \quad c = 0$$

where $\Phi(Y_i)$ = population share of district i

I_i = value of the indicator in district i

$\hat{I}$ = mean value of the indicator considered at the state level

When c = 0, the mean logarithmic deviation is more sensitive to lower values of index, which means lower part of the distribution.

The Theil Entropy measure i.e. putting c = 1, we have G E measure sensitive to the entire part of the distribution.

If c = 0, G E measure becomes sensitive to the middle part of the distribution. In the present analysis, the assigned value of c is 2. In Table 4, we have the results of these measures for all the indicators.

Table 4

Results of General Entropy Measure of Inequality

	C = 0		C = 1		C = 2	
	1993	2004	1993	2004	1993	2004
Sex ratio	-0.0684	-0.2206	0.0722	-0.0229	0.610307	0.95079
Literacy rate	0.1480	0.5090	1.9203	1.7647	3.734461	2.113118
Fertilizer used (in terms of materials) (M.T.)	-8.9287	-3.9771	2.6050	5.5321	10.19506	26.13274
Net Area Sown/population	0.5420	-4.5614	6.3252	1.9181	11.7119	15.72089
Net Irrigated Area/Net Area Sown	-5.2592	-11.8069	4.6905	12.7042	14.57001	61.56257
Pupil-Teacher Ratio in Primary Section	0.1124	-1.3333	0.9228	1.7470	3.231598	36.51683
Percentage of Girl student enrolled in total enrolled in primary	0.2238	-0.7105	0.5966	-0.5608	-1.27395	-1.40675
Length of Road per 100 sq km area	-18.2864	-3.6895	11.7646	5.4898	340.5777	98.45004
Population provided with drinking water facility (%)	—	-0.5828	—	-0.1173	—	1.197206
Population-Doctor ratio	-2.7506	-0.4522	0.5251	1.3956	24.79149	13.81042
Population Below Poverty Line	—	-3.9764	—	1.7422	—	12.79737
Telephone per 100 population	—	-3.3342	—	11.6019	—	46.1139

For c = 0, the G E measure, which is sensitive to the lower part of the distribution, shows improvement over the decade, in sex ratio, in per-capita net area sown, in student-teacher ratio in primary education and in share of girl students in primary education. Increased disparity is found in case of literacy rate, use of fertilizer, length of road per 100 sq km and population-doctor ratio.

The Theil index, sensitive to the whole part of the distribution (for c = 1), shows reduction in disparity in sex ratio. In literacy rate there was reduction, though marginally. The decrease in disparity was substantial in per-capita net area sown, proportion of girls enrolled in primary education and length of road per 100 sq km. The disparity aggravated in case of use of fertilizer, availability of irrigation facility in net sown area, in student-teacher ratio in the primary section and in the population-doctor ratio.

For c = 2, the G E which is sensitive to the middle part of the distribution, the improvement was noticed in case of overall literacy rate, proportion of girl students in primary section, length of road per 100 sq km and population-doctor ratio. However, the disparity has gone up for sex ratio, use of fertilizer, per capita net area sown, availability of irrigation facility in net sown area and student-teacher ratio.

On the basis of the above-mentioned parameters, we can rank the districts by constructing Composite District Development Index (CDDI) for both 1993 and 2004. While formulating the index we partly follow the norm of UNDP for constructing the Human Development Index. However, the number of indicators chosen for constructing HDI is three. In the present study, this number is 10 for the year 1993 and 12 for the year 2004. For those parameters, where lower figures indicate better impact on development, like student-teacher ratio; population-doctor ratio and below poverty line population, we use rank in ascending order as the component of the index. In each case, the largest value that is the worst case is ranked one and the least value is given the highest rank. However, for other parameters, the concerned values are taken into consideration. The development index is computed by simple average of all the indices.

$$C_j = \frac{1}{N}\sum_{i=1}^{N}\frac{(A_{ij} - L_i)}{(H_i - L_i)}$$

Where C_j = Composite District Development Index of district j

A_{ij} = Actual Value of the ith indicator in district j

H_i = Highest Value of the ith indicator among all the districts

L_i = Lowest Value of the ith indicator among all the districts

N = Number of parameters = 10 in case of 1993

= 12 in case of 2004

The rankings of the districts of Arunachal Pradesh on the basis of this index along with the values of indices are given in Table 5

Table 5

Composite District Development Index and Ranks of Districts of Arunachal Pradesh in 1993 and 2004

	1993		2004	
District	Development Index	Rank	Development Index	Rank
Tawang	0.5162	4	0.5576	3
West Kameng	0.5374	3	0.3832	8
East Kameng	0.3692	10	0.2970	12
Papum pare	0.4448	7	0.5369	4
Lower Subansiri	0.4434	8	0.3553	10
Upper Subansiri	0.2898	11	0.4184	7
West Siang	0.6033	2	0.5620	2
East Siang	0.6874	1	0.6024	1
Dibang Valley	0.4577	6	0.3371	11
Lohit	0.4748	5	0.3556	9
Changlang	0.2877	12	0.4570	6
Tirap	0.3770	9	0.2390	13
Upper Siang	—	—	0.4982	5

It is found that East Siang continues to be the most developed district in Arunachal Pradesh followed by West Siang. Both of these districts maintained their respective ranks from 1993 through 2004, though over the decade the respective indices faced a small decline. The index for Tawang had increased, while that of West Kameng decreased substantially. The socio-economic development of Papum pare had shown a high improvement over the decade. In 1993, the development index was 0.4448 with a rank of 7, and it increased significantly to 0.5369 in 2004 with rank elevated to 4. Lohit with largest share of population in the state had deteriorated over the years in terms of development. East Kameng is the least developed district and is yet to show any improvement over the years. While Dibang Valley faced sharp decline in development front, Changlang had shown remarkable progress in its socio-economic condition. The pace of development of Upper Subansiri is faster than that of Lower Subansiri. The relative development of Tirap had also slowed down over the period.

Since agriculture is still the largest source of occupation in this state it is natural that it will have a key role in the reduction of regional disparity. In this sense, knowledge regarding the status of the districts in terms of agricultural development will give us an

indication of the extent of disparity existing in this specific field. Applying the same method used for computation of CDDI, the Composite Agricultural Development Index (CADI) can also be found out by incorporating the three indicators related to agriculture, viz fertilizer consumption, per-capita net area sown and proportion of net irrigated area in the net area sown. Table 6 has the computed CADI for different districts of Arunachal Pradesh both in 1993 and 2004.

Table 6

Composite Agricultural Development Index and Ranks of Districts in Arunachal Pradesh for 1993 & 2004

	1993		2004	
District	Development Index	Rank	Development Index	Rank
Tawang	0.67	3	0.39	7
West Kameng	0.58	4	0.35	8
East Kameng	0.36	8	0.20	10
Papum pare	0.15	12	0.12	12
Lower Subansiri	0.45	7	0.33	9
Upper Subansiri	0.18	11	0.18	11
West Siang	0.71	1	0.50	3
East Siang	0.71	2	0.50	2
Dibang Valley	0.55	5	0.54	1
Lohit	0.52	6	0.46	5
Changlang	0.28	10	0.46	4
Tirap	0.35	9	0.09	13
Upper Siang	—	—	0.40	6

The CADI shows a mixed trend. While some of the districts improved, in some of the districts the development in this front was sluggish. The districts with high CDDI like East Siang and West Siang possess higher ranks in the field of agriculture also. Among the rest of the districts, Dibang Valley had improved a lot when its rank in CADI increased from 5 to 1, but faced a downfall in the value of the index. However, Papum pare remained backward in agriculture.

There is no denial of the fact that overall disparity in Arunachal Pradesh has increased over a period of 11 years. Though some of the indicators show improvements, yet given the span of time considered in the present study, these are really insignificant. Moreover, the Composite Development Indices computed for all the districts show a

variation within a range of 0.6874 and 0.2877 in 1993 and within 0.6024 and 0.2390 in 2004. Here one pertinent question is whether this development has any bearing on the level of poverty found across the state. Theoretically, of course, a negative relation must be there between these two variables. In order to know the extent of influence of this development, we regress poverty level existing in all the districts, represented by percentage of population below poverty line on development indices (CDDI) of the districts. To find out the impact of agriculture on the level of poverty, we also regress

Table 7

Results of Regression of Population Below Poverty Line on Composite District Development Index & on Composite Agricultural Development Index for 2004

Dependent Variable	Independent Variable	Constant	Coefficient	R^2
Population Below Poverty Line	CDDI	110.63 (6.27)*	-128.07 (-3.23)*	0.4862
	CADI	71.54 (4.86)*	-46.19 (-1.19)	0.1135

(Figures in brackets represent t-statistics; * denotes significance at 99% level)

The table makes it clear that negative relations exist between CDDI and poverty as also between CADI and poverty. However, development in agriculture has lesser effect (absolute value of the correlation coefficient being 0.33) on poverty as compared with the effect of overall development of the district on the level of poverty (the absolute value of the correlation coefficient being 0.70). As a matter of fact, the strong linkage between the CDDI and poverty indicates the need of overall socio-economic development of different districts.

Conclusion and policy implications

While undertaking any development initiative, especially in the socio-economic perspective, the Government must ensure that the fruits of development should spread evenly across the districts and the people for whom it is meant. The existence of regional disparity, as a negative offshoot of unbalanced development, has long ranging repercussions, which may shake the economic stability of the state. This state is inhabited by a large number of tribes and sub-tribes. The people belonging to these tribes have often differences, though not that sharp, in behaviour, food-habits, clothing and

other socio-economic paraphernalia. Taking into consideration the tribal sentiments attached to their lifestyles, development on a balanced footing is what is always sought. Moreover, for such a state, given its geo-political identity and strategic importance, evenly spread development is a prerequisite for maintaining political stability.

However, as is found from the present study, disparity on a large scale exists in Arunachal Pradesh. For most of the indicators, deterioration is noticed over the years. The sources of poverty, though varied, not only create inefficiency in the utilization of resources, but also lead the entire economy into vicious circle of undernourishment and underdevelopment. The computed Composite District Development Index is found to have high correlation with the number of people below poverty line.

The main source of occupation in Arunachal Pradesh is still agriculture. But even after completion of nearly two decades of statehood, there are deprivations and disparity in this front. In fact, the largest disparity found in the state after tele-connectivity is in agriculture. It is really shocking to find such a low level of development in such a field, where the state is supposed to have comparative advantage and where such a huge dependence on and attachment with agriculture is present. This inequality is the outcome of mal-allocation of resources. The policy maker has to take note of such inequality and make necessary arrangements for its redress. The use of fertilizer and the availability of irrigation facility are the symbols of advancement in agriculture, which is very much necessary, given that the primitive mode of production is still prevalent in the state. If such advancement is restricted to limited places, it will not only create disparity in agriculture, but also lead to increased inequality in other sectors of the society.

In this age of information technology, a proper telephone network along with internet facility is a pre-requisite of advancement of the society since adequate dissemination of knowledge depends a lot on it. In India also today any plan for rural development invariably incorporates the proposition for setting up of village knowledge centre, where knowledge is acquired through internet and disseminated. As a matter of fact, tele-connectivity is one of the main pillars of maintaining connectivity between rural and urban areas and also between remote and advanced areas. However, the study has noted that till 2004 the largest disparity in Arunachal Pradesh existed in the field of telephone connectivity. The Government needs to look into the matter also.

Given the present crisis faced by the state, the real solution lies in a two-prong massive reform programme. On the one side, the traditional sector, agriculture, needs more attention. Since most of the people get their livelihood from this source, balanced spread of its benefits will enhance the socio-economic status of the people. On the other side, the information system needs up-gradation. Availability of more telephone connections and other electronic modes in every corner of the state will bring in revolution in communication and information. This will also usher in a balanced augmentation

of the socio-economic capabilities of the people of Arunachal Pradesh.

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Determinants of HYV Paddy Adoption in Arunachal Pradesh

Bedabrat Saikia

Abstract

The paper highlights the factors determining the adoption of new technology in Arunachal agriculture. The specific technology studied is the adoption of high yielding variety (HYV) of paddy. It is found that in the diffusion of the HYV paddy both the agro-climatic conditions and the Government's policy play an important role.

Introduction

Although the new technology in Indian agriculture is no longer a new phenomenon, yet it has got a significant relevance for the regions which are under the embryonic stage of agricultural development. For example, hilly agriculture of Arunachal Pradesh lying under conditions of backwardness has yet to get benefit from the fruits of technological innovation. In the jhum-based Arunachal agriculture, till 1950s, the practice of settled cultivation was concentrated mainly in a few river valleys and foothills and the application of new farm inputs such as wooden plough, tractors, power tillers, HYV seeds, chemical fertilisers, pesticides, etc. were almost non-existent. Over the periods, the state agriculture has experienced some dynamic changes towards settled cultivation and has opened up the horizon of technology-oriented production approach. Many farmers have shifted from jhum to settled cultivation and adopted new farm technology. Application of new farm technology has made progressive inroads though it is much lower compared with the agriculturally developed states of the country. For example, during 2002-03, the area under high yielding variety of rice, wheat and maize came to occupy 37.28 per cent of area under these crops which increased by 9.47 per cent over 1985-86 (Department of Agriculture, Government of Arunachal Pradesh). The overall growth of the area under high yielding variety seeds during 23 years ending in 2002-03 is around 11.60 per cent per annum (Table 1 A).The consumption of fertilizers and plant protection chemicals, however, is not in a rosy position. During 1980-81, the consumption of different types of chemical fertilizers amounted to only 124 tonnes, while it rose to 720 tonnes during 2002-03. Likewise, during 1986-87 the consumption of plant protection chemical was 16 tonnes while it increased to 17 tonnes during 2002-03. In respect of irrigation also the state agriculture has not progressed much. By

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1995-96 only 25.66 per cent of its net sown area was irrigated. The adoption of new agricultural technology is a matter of infrastructure facilities, socio-cultural institutions, security of the returns of the new techniques and other different institutions. The studies by Tran (2001), Bhagat (1983), Behera and Sahoo (1975), Roy(1960), and Jaiswal and Singh(1968) reveal that the adoption of new agricultural technology depends on the availability of infrastructures such as irrigation, education, electrification, transport and communication, etc. Many a time; it is the social framework rather than the other factors such as education, demonstration, etc. that hinders the adoption of new innovations. The socio-cultural factors play a vital role in accepting the new technologies in any type of production activity. Traditions and customs vary between and within the regions and accordingly the degree of acceptance of technology among the regions and within the area varies considerably (Turare, 1998). The study by Mahapatra (1978) also pointed that innovation of techniques, their diffusion, acceptance and proper utilization are all linked to sociological questions, the structure of the society and its value and the personality structure. A comprehensive study incorporating the aspects of adoption of new agricultural technology in the hilly and tribal agriculture is necessary to get an integrated view. Thus, the present study, confined to hilly and tribal agriculture of West Siang district of Arunachal Pradesh, is an attempt to examine the factors affecting the adoption of high yielding variety of paddy.

Methodology

For the purpose of the study, using the three stage stratified random sampling with circles, villages and the farm households as the first, second and third stages respectively, 20 farm households from each village were selected from Basar and Along circles of West Siang district of Arunachal Pradesh. The sample size totaled 80 households. From each of the sample circle, twoillages were selected. The sample villages come within the domain of thermic humid agro-climatic zone (mid hill and valleys) which is characterized by the annual average range of rainfall between 2000 mm to 5000 mm and temperature varies from 28^0 Celsius to 5^0 Celsius. Primary information on various aspects of agricultural production and new farm technology were collected through conventional survey method using well-structured and pre tested questionnaire. The data pertain to the agricultural year 2002-03.

In order to identify the factors affecting the adoption of HYV of paddy, a linear regression function, taking the proportion of area under HYV of paddy to permanent land as dependent variable and a few independent variables which are expected to have a bearing on the adoption of new innovation is taken into consideration. The general adoption function is modeled as

$$H = b_0 + b_1 X_p + b_2 X_j + b_3 X_i + b_4 X_l + b_5 X_d$$

where,

H= proportion of area under HYV of paddy to permanent land.

U = random variable with E (U) = 0 and σ^2_u, a constant.

X_p = proportion of area under permanent paddy land to total land

X_j = proportion of area under jhum land to total land

X_i = ratio of irrigated land to total permanent land

X_l = educational level of the household head.

X_d = dummy variable for demonstration programme. ('1' for attended and 'o' for not attended)

b_0 is the intercept, b_1, b_2, b_3, b_4, b_5 are the regression coefficients of the respective factors. The literacy index of the household head is scored by scaling as '1' for illiterate, '2' for primary, '3' for secondary, '4' for higher secondary and '5' for post higher secondary.

Results and Discussion

The regression analysis, having a comparatively high value of co-efficient of determination ($R^2 = 0.70$), gives information about the nature of relationship between adoption of HYV of paddy and its determinants in the study area. Table 2A reveals that in the study area the permanent paddy land plays a significant role in shaping agriculture and has facilitated the adoption of HYV of paddy. The coefficient of the permanent paddy land is 0.77 and significant at 1% level (Table 2A). On the other hand, the impact of jhum land on adoption of HYV of paddy is insignificant. The coefficient of jhum land is 0.0008 and t value is 0.994. By its very nature, the jhum cultivation can hardly accommodate new farm inputs. A farmer's ownership of higher proportion of permanent land and lower proportion of jhum land has created the environment for adoption of HYV of paddy and thus the relationship between jhum land and application of HYV of paddy may be negative. On the other way, a farmer's ownership of both permanent and jhum land also facilitate for adoption of HYV of paddy and the relationship between jhum land and the application of HYV of paddy may be positive. It is interesting to note

that the increase in the level of adoption of HYV paddy is positively correlated with the permanent paddy land. This clearly confirms that the permanent paddy land has a direct bearing on the level of adoption of HYV of paddy in the study area.

Table 2A depicts that other variables have played a peripheral role in influencing the adoption of HYV of paddy. All the variables except demonstration programme attended by the farmers were positively associated with the adoption of HYV of paddy. This indicates that improvement in these major factors might be leading to higher level of technology adoption. In the regression analysis, the impact of irrigation on adoption of HYV of paddy in the study area is insignificant (0.163) during the study period while a good number of studies in different parts of the country had shown the significant role of irrigation on adoption of HYV of paddy.

Table 2A further reveals that the co-efficient of educational level of family head is 0.084 and has not come out as a significant factor in influencing the extent of use of HYV of paddy. In their study in Arunachal Pradesh Saikia et al. (2004) found that the literacy rate has positive correlation with the rural nonfarm employment. Generally, the educated people prefer to activities other than agriculture and hence, increasing literacy doesn't mean availability of skilled manpower in the agriculture sector. Thus, inspite of the increasing literacy, agriculture has to go with the illiterate people and unskilled labour force who depend on agriculture. The impact of educational level of family head on the adoption of HYV of rice in West Siang district appears insignificant.

Effective and quick transfer of technology depends on systematic and retraining opportunities for extension workers (Joshi et al. 1979). In our study area, the coefficient of the dummy variable, the demonstration programme attended by the sample farmers, takes negative sign for adoption of HYV of paddy. As reported by some of the sample farmers, adoption of HYV of paddy and chemical fertilizers in previous years caused crop failure and as a result not only the victim farmers but also others don't want to take risk in the next time and continue with the traditional method. Hence, demonstration programme attended by the sample farmers has not come out as an effective way for diffusion of HYV of paddy in the study area.

Conclusion

The area under study was characterized by the gradual expansion of technology adoption and in this process of dynamic transformation, the permanent paddy land has facilitated significantly. Of course, in Arunachal Pradesh traditions, institutions, customs, and process of production, exchange, distribution and consumption pattern of each tribe have also a great impact on acceptance of the new farming system. Moreover, the

reasons cited by some of the sample farmers for not using the HYV paddy extensively are lack of taste, risk and uncertainty of success of HYV of paddy, low resistance of the crops to pest attacks and diseases, and HYV paddy being not suitable to prepare local beer '*Apong*'. In the context of the adoption of HYV of paddy and permanent paddy land in the study area, the physiographic, climate, socio-cultural tradition, commercialization of agriculture, subsidized provision of farm inputs and availability of agricultural labourers from other states have also affected the rate of adoption of modern agricultural technology to a great extent. These findings thus call for a new strategy of agricultural development which includes extension of settled cultivation, commercialization of agriculture, crop insurance to cover risk and motivation of the farmers by proper demonstration. This would lead to more dynamic agriculture by diffusion of new technology. Its outcome is sustained growth in land and labour productivity, higher income from agriculture and reduction of jhumming.

Appendix

Table 1A

Growth Rate of Area under HYV seeds

Period	Estimated Equation	R^2
1980-81 to 2002-03	log H = 8.82251+ 0.1160 t	0.91

N.B. (i) H is for area under high yielding variety seeds comprising paddy, wheat and maize.

(ii) It is time in years.

(iii) Data source: Department of Agriculture, Naharlagun, Arunachal Pradesh.

Table 2A

Regression of area under HYV of paddy on different factors

Independent variables	Coefficient
Constant	-0.494
Permanent paddy land	(-2.132) 0.774
Jhum land	(12.111)* 0.0008
Irrigation ratio	(0.994) 0.163
Literacy	(1.060) 0.084
Demonstration programme	(1.345) -0.030
R^2	(-0.230) 0.70
n	80

N.B. (1) The parenthesized figures represent t values

(2) * Significant at 1 percent level.

(3) The dependent variable: Area under HYV of paddy.

(4) n is the no. of observations.

(5) Data source: Field survey.

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Improved Rice Technologies in West Bengal
What Prevent Farmers from Accepting the Recommendations

Dr. N. Ali

Abstract

In recent past much has been talked about the performance of agricultural growth in West Bengal under the Left Front Government. The underlying factor that made it possible is the constant expansion of summer paddy cultivation during eighties and early nineties with the improvement of irrigation and intensive application of all the production inputs like fertilizer and pesticides in appropriate quantity which resulted in less technological gap and consequently less production gap and hence more closer the production efficiency frontier. But this does not mean that the rice farmers in the State are operating most efficiently. Farmers may otherwise apply all the necessary inputs as recommended by the adoptive Research Farm in the region but due to some reasons they are not using them in the form of a package and at the level recommended by the agricultural experts. The present paper is an attempt to identify the factors responsible for non-adoption of recommended modern rice technologies as recommended.

Introduction

The growth of agricultural productivity is associated with the so called 'green revolution' which was initiated in the country in mid-sixties. In the beginning emphasis was given to bring the land under modern improved varieties having higher yield per hectare from the traditional varieties without much concern about the level of application of other associated inputs such as irrigation, fertilizer, and pesticides. Despite all efforts to expand the adoption of modern rice technologies total rice cropped area in Kharif season has not been possible to bring under the high yielding varieties in West Bengal. This is because of a large number of socio-economic, technological and infrastructural problems. Several studies have been conducted to identify the constraints to adoption; the lack of irrigation facilities, non-availability of quality inputs like HYV seeds, fertilizers, pesticides and lack of credit were reported to be important problems faced by the farmers (Adgaonkar, 1978). Ballav and Prasad (1985) observed that lack of knowledge of the farmers about improved technologies was the main reason for non-adoption. The other impediments of transfer of technology as pointed out in many studies were high costs of inputs (Marothia, 1985), lack of capital (Sinha, 1978) and risk orientation (Bhaskaran and Praveena, 1982). The technological constraints of the adoption of new rice technologies as noticed are the lack of irrigation facility (Singh, 1977), disease and pest control (Tripathy, 1977).

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Despite the problems associated with the adoption of modern improved rice technologies some studies (CMIE 1993: Saha and Swaminathan, 1994; Sawant and Achutha, 1995) have shown that the performance of agriculture particularly rice production in West Bengal in the mid 1980s and early 1990s has been highest among the major States of the country. It is argued that besides successful implementation of land reforms programme rapid expansion of boro paddy area (Rawal and Swaminathan, 1998) during this period has been the reason behind this splendid achievement. How far land reforms have contributed to the growth of agricultural productivity has been controversial and hence needs a close examination but there is no doubt about the significant role of boro cultivation to the growth in the State's agricultural sector. While examining the inter-districts variation of agricultural growth De (1999) found that fertilizer and irrigation were two factors responsible for higher and lower growth in yield of rice in various districts of the State. According to Pillai (2001) input productivity has indeed played an important role in the growth performance and this improvement in productivity in West Bengal has been brought about both by efficiency and technology in the presence of variations across seasons and seed varieties.

Under such a situation it is important to find whether the rice farmers in the State are producing on the optimum production frontier. This is extremely crucial for future productivity growth in the State which is almost stagnant in recent years. This requires the examination of resource use efficiency of the farmers and reasons for inefficiency if any. A recent study (Ali, 2005) reveals that the rice farmers in the State are not efficient and efficiency varies across the seasons. The summer paddy producers are found to be more efficient than kharif season producers as yield of a particular variety was found to be close to potential output achieved in the Adaptive Research Farm because of narrow gaps in the application of production inputs like fertilizer as recommended (op cit). This implies that in spite of sufficient availability of economically efficient technologies, farmers do not accept them, and if they accept at all, accept partially, while the whole package is recommended to obtain maximum yield. This might be due to some constraints hindering the farmers from implementing the improved practices in required proportions. The present paper is an attempt to examine the important factors that obstruct the farmers from the adoption of all the modern rice technologies at the level of recommendation.

Sampling technique and methodology

In the present paper, an attempt has been made to identify and assess the factors responsible as perceived by the cultivators for non-adoption/ or partial adoption of modern rice technologies. The study is confined to Birbum district of West Bengal. Using the three-stage stratified random sampling with blocks, villages and farm households

as the first, second and third stages respectively, 100 farmers, proportional to their numbers in the respective size groups, were selected from 10 villages scattered in the Mohammad Bazar Administrative Block. Primary data on various aspects of the adoption of improved rice varieties were collected through conventional survey method using specially structured and pre-tested questionnaire. To measure the degree of constraints, the respondents were asked to indicate on a four-point continuum the extent to which each constraint was perceived as hindering the adoption of improved package of practices for rice crop recommended for them. The scoring procedure was followed as very much – 3, much – 2, not so much - 1 and not at all – 0. The data related to the agricultural year 2000-01. Based on the existing area of holdings the whole farm households were divided into four categories – category I (less than 1 acre), category II (1 – less than 2.5 acres), category III (2.5 – 5 acres) and category IV (above 5 acres). The numbers of sample of the groups were 14, 26, 40 and 20 respectively.

In order to measure the level of adoption of new technology for rice cultivation, an adoption index of individual farmers was developed with the help of the following formula.

$$AI = \sum_{i=j}^{n} \sum_{j=1}^{m} \sum_{k=1}^{r} \left(\frac{AH_{ji}}{CA_i} + \frac{PA_{jki}}{PR_{jk}} \right)$$

Where

i = 1,2,3,..... n, and n = total number of farmers

j = 1,2,3, ...,m, and m = total number of high yielding rice varieties practiced by the farmers

k = 1,2,3, ..., r, and r = total number of practices such as farm yard

$$X_j = \sum_{J=I}^{p} I_{jr}, F_r$$

Where p is the number of factors retained and F_r (r = 1,2,3,.....,p) represents common factors and I_{jr} are factors loading of the original variable X_j on factor F_r. A limited number of useful factors with eigen values more than one are retained to account for the same information.

A large number of constraints were selected initially. The following (X_1, X_2, X_3, ...X_{49}) 49 of them of different types were retained in this study after completing the pre-testing of the schedule. The adoption index which varies from 0 to 100 per cent depending upon the farmer's degree of adoption was considered as dependent variable

and the whole matrix was processed through computer. However, identifying the factors responsible for non-adoption of each category was not visible due to lack of degrees of freedom as the number of variables was greater than the simple size of every individual category. Hence, all the size groups were pooled in a single group to apply the analytical tool..

The variables included in the model are:

X_1 = lack of ownership of land
X_2 = fragmentation of land holding
X_3 = lack of moisture retention capacity of land
X_4 = lack of irrigation facility
X_5 = high irrigation charge
X_6 = non-availability of irrigation in time
X_7 = occurrence of flood
X_8 = low rainfall
X_9 = drought
X_{10} = lack of capital
X_{11} = lack of easily available credit
X_{12} = lack of adequate credit
X_{13} = lack of timely credit
X_{14} = lack of statutory price of rice
X_{15} = lack of marketing faculty
X_{16} = lack of market demand of rice
X_{17} = lack of transportation facility
X_{18} = low market price of rice
X_{19} = non-availability of farm yard manure
X_{20} = non-availability of seed treatment chemical
X_{21} = non-availability of fertilizer
X_{22} = non-availability of skilled farm worker
X_{23} = high labour wage
X_{24} = not profitable
X_{25} = lack of technical knowledge of skilled application
X_{26} = guided by the adoption of neigbourers
X_{27} = lack of availability of genuine production inputs in time
X_{28} = inadequate training
X_{29} = lack of advise and guidance
X_{30} = non-availability of quality HYV seeds
X_{31} = non-availability of plant protection chemicals
X_{32} = inadequate supply of HYV seeds
X_{33} = inadequate supply of fertilizer

X_{34} = inadequate supply of plant protection chemicals
X_{35} = non-availability of HYV seeds in time
X_{36} = non-availability of fertilizer in time
X_{37} = non-availability of plant protection chemicals in time
X_{38} = non-availability HYV seeds at fair price
X_{39} = non-availability of fertilizer at fair price
X_{40} = non-availability of plant protection chemicals at fair price
X_{41} = non-availability of agricultural machinery on hire
X_{42} = high prices of inputs
X_{43} = complicated process
X_{44} = lack of own bullock
X_{45} = lack of family labour
X_{46} = lack of knowledge about proper recommendation
X_{47} = lack of agro-service centre
X_{48} = lack of good road for transportation
X_{49} = lack of soil testing facility

Analysis of findings

The result of the investigation has been presented in table 1 which shows that out of 49 variables considered 12 factors are found to be more influential with eigen-value of each factor greater than one. Lack of knowledge about proper recommendation (X_{46}) has been found as the most important constraint perceived by the farmers for non-adoption of improved rice technologies at recommended level. In every region depending upon the land situation agricultural experts recommended certain HYVs as more suitable with specified doses of other inputs and time of application for obtaining the optimum production. This varies from variety to variety of rice. In cases where farmers do use various components of the improved package, they do not follow the process and amount that are to be implemented in toto. This is so because, in village society the farming situation may permit the implementation of new technology but farmers are lacking from the proper and sufficient information about the new innovations and whole package with recommendation which prevent them from adoption of improved rice practices at exact level.

The second most influential factor is the lack of irrigation facility (X_4) which is considered as the key factor of the package of modern rice technology. Due to lack of assured irrigation farmers could not take the decision of adoption of the high yielding varieties and application of other inputs at appropriate rate. The first two factors have eigen-values more than 4 and together explained 21.1 per cent variation.

Conversion of non-repatriable equity invested by NRIs in foreign exchange into repatriable equity allowed under the automatic route provided the original investment was made in foreign exchange under the FDI scheme notified under the Foreign Exchange Management Act (FEMA) regulations and the sector/activity in which the investment is proposed to be converted into repatriable equity is on the automatic route of FDI.

FDI in post globalised India: an evaluation

The sweeping changes that took place after 1991 mark a radical departure from the past and reflect a positive approach towards foreign capital in India economy. The structural changes facilitated freedom to foreign investors to make debut to Indian industry. Since then the emphasis has been on access to capital, technology, and market in order to induce greater industrial efficiency and integration of the domestic economy with global economy. The enlarged FDI sphere now includes refining and marketing, mining, oil exploration, power generation, telecommunications, tourism and hospitality and many more. The most striking feature of the present liberalisation policy in India is the freedom provided to the level of equity participation. FDI is no more accompanying technology transfer which was mandatory earlier. FDI is now automatically approved in listed priority areas like tourism, software development, etc. Even 100 per cent equity is permitted in power sector and wholly export oriented industries. Besides, Central Government has liberal and friendly approach towards Non Resident Indians (NRIs) for promoting foreign investments. No ceiling has been imposed on raising of Global Depository Receipts (GDRs), American Depository Receipts (ADRs), Foreign Currency Convertible Debentures (FCCBs). Thus, the libaralisation marks a radical change in relation to FDI entry in the country. Over the past years, there has been a move towards an international framework under World Trade Organization (WTO) for governing investment through Multilateral Agreement on Investment (MAI). The primary concern for our country is impact of MAI on the exercise of sovereign choice in the regulation of FDI. It led to foundation of competitiveness in investment climate, exports and imports. The latest Confidence Index, prepared by A.T. Kearney, the Management Consultant puts India as the second best investment destination in the world, behind China and ahead of the US (table 1) (Hill 2005, UNCTAD 2003).

Table 2 depicts the FDI approvals since globalisation. In terms of FDI approvals, however, Maharastra topped the list followed by Delhi, Tamil Nadu, Karnataka, and Gujarat. Maharastra and Andhra Pradesh which have traditionally been the FDI hubs witnessed tough competition from their poor cousins. At present capital investment by Japan is limited mostly to Haryana, Maharastra, Tamil Nadu and Karnataka. In terms of the destinations of FDI flows Delhi, parts of UP and Haryana, Maharastra, Dadra & Nagar Haveli and Daman & Diu accounted for almost 50 per cent of the total FDI inflows into India.

It is evident (table 3) that US still remains India's major partner. However, Mauritius is India's largest investment partner in the new millennium. Its share in FDI

Significance of FDI

Globalisation and economic development is now an urgent global necessity. Its potential relevance is also evident when policy changes sharply in the direction of more or less openness. The significance of FDI policy regime as a determinant is best illustrated by the fact that *FDI cannot take place unless it is allowed to enter into a country.* The liberal FDI approach has become the dominant of policy changes in external investment sector. In order to utilize the benefits of scientific and technological innovations in different sectors of the economy, it is imperative that capital formation should take place at a higher rate than before. Foreign capital especially FDI can help immensely in this regard. FDI plays two important roles: firstly it supplies foreign savings to supplement the investment needs in the host country and secondly it provides traditional gains from trade to home country. FDI vitalizes the domestic credit market and provides positive gains. Studies have revealed that FDI is an important vehicle for the transfer of technology thus contributing to the faster growth of the host country (IMF 2003). FDI spearheads the increasing rate of investment in the economy and supplements the investment needs in following ways:

- It gives access to latest technology and ideas,
- It invites foreign capital investments across the world and facilitates foreign (technical) collaborations,
- Very importantly, it generates competitive pressure for dynamic change on domestic trade and investments, and
- FDI allows further utilization of idle capacity and rising exploitation of natural resources.

Prevailing policies on FDI

Since 1991 with the simplification procedures, FDI in India has been approved through automatic approval by the Reserve Bank of India (RBI) and Foreign Investment Promotion Board (FIPB). RBI accords automatic approval within a period of two weeks (provided certain parameters are met) to all proposals involving:

- Foreign equity up to 50% in 3 categories relating to mining activities (List 2).
- Foreign equity up to 51% in 48 specified industries (List 3).
- Foreign equity up to 74% in 9 categories (List 4).
- Where List 4 includes items also listed in List 3, 74% participation would apply.

The lists are comprehensive and cover most industries of interest to foreign companies. Investments in high-priority industries or for trading companies primarily engaged in exporting are given almost automatic approval by the RBI. Some of the specific measures, which have been taken to boost FDI, are as follows:

- FDI cap in the domestic airlines sector has been enhanced from 40 per cent to 49 per cent and NRI investment is permitted up to 100 per cent with no direct or indirect equity participation by the foreign airlines.

approvals has gone up from 12.57 per cent during 1991-99 to 25.67 percent during 2002-03. In the past we had to depend largely on US for capital inflows. The liberalisation and new millennium have witnessed a drastic change in the source of foreign funds in the direction of foreign investments as shown in table 3. In fact, a number of developed Western countries have substantially increased their stake in foreign direct investment inflows in India over recent years. U.K's share in FDI has gone up sharply from 9.01 percent during 1991-99 to 15.29 percent during 2002-03. However, our FDI approvals fell drastically in 2002 following decelerations in FDI flows world over. FDI to India was as low as $ 5.3 billion in 2004 as compared to $ 60.6 billion to China and $ 16 billion to Singapore. After exhibiting a downward trend for two years since 2001-02, FDI (net) flows grew by 36 per cent in 2004-05. The increased flows were mainly to the electrical equipment (including computer software and electronics) and service sector. Higher inflows of equity investment valued at US $ 3.7 billion in 2004-05, as compared with US $ 2.2 billion in 2003-04. What is worth noting is that unlike in the past, India no longer depends on developed countries for the foreign investment and capital inflow. Many a developing and developed nations have come forward to invest their funds in Indian soil.

Procedural simplification and inclusion of more sectors under the automatic route coupled with a change in the global scenario and a strong acceleration in FDI in developing countries during 2004, led to an increase in FDI inflows. FDI inflows increased by 25.0 per cent in 2004 and a further 33.8 per cent in 2005. India's share in global FDI increased from 0.5 per cent in 2002 to 0.8 per cent in 2004. Nevertheless, FDI inflows into India continue to lag far behind in comparison to some of the developing economies of Asia. As per the latest available figure, the cumulative amount of FDI approvals, till November 2005, was Rs. 2,57,952 crore (US $69 billion). During 2005-06 (up to November 2005), FDIs to the tune of Rs. 5,947 crore (US$ 1,351 million) have been approved. In terms of cumulative inflows and its geographic origin, Mauritius topped the list accounting for 37.2 per cent of the total inflows. USA was second with a share of 15.92 per cent. The sectoral composition of FDI shows that electrical equipment is the largest recipient of the FDI inflows (table 5).

In terms of investment in project, South Korean steel giant Pohang Steel Company (Posco) is at the top, its proposed FDI of $ 12 billion in Orissa is the largest ever in India. Incidentally, Posco's proposed investment in Orissa was the biggest single investment in the world during 2005.

In fact, in this race for attracting more FDI no state in India likes to go slow. It is felt that aggressive posture by several states in attracting foreign investments may enhance the inflow of FDI manifold in coming days. However, the states need to do a lot of homework before jumping into FDI race. A concerted strategy at the Central and State level needs to be evolved to ensure a more equitable regional distribution of such flows.

- FDI cap up to 100 per cent under the automatic route is now permitted for development of township, housing, built up infrastructure and construction of development projects. The minimum area requirement has been reduced to 10 hectares for serviced housing plots and 50,000 square metres built up area for construction –development projects.
- FDI cap has been increased from 49 per cent up to 74 per cent in basic and cellular telecom services. The revised caps include both FDI and portfolio investment.
- FDI has been permitted in FM Radio Broadcasting up to a maximum of 20 per cent.

This is inclusive of FDI, Non Resident Indians (NRI), Persons of Indian Origin (PIO) and Foreign Institutional Investors (FII) (Table 4).

- Guidelines for approval of foreign/ technical collaborations for projects with existing joint venture /collaboration in the same field have been reviewed.

The government of India took several measures in 2005-06 in the sphere of FDIs in further pursuit of its already committed policy of transparency and liberalisation in FDI (Government of India 2001-2005). FDI up to 100 per cent is now permitted on the automatic route in all sectors/ activities except:

- Activities requiring industrial license under the industries (Development and Regulation Act),
- Proposals where the foreign investor had an existing joint venture/technical collaboration/trade mark agreement in the same field of activity,
- Proposals for acquisition of shares in an Indian company in the financial services sector and where SEBI Regulations, 1997 are attracted, and
- All proposals falling outside notified sectoral policy/caps or under sectors in which FDI is not permitted.

As a measure towards simplifications of the existing procedures in FDI, the following activities have been placed on the general permission route of RBI:

- Transfer of shares in an existing Indian company from residents to non-residents and vice-versa (except in the financial sector and where SEBI code is attracted);.
- Conversion of external commercial borrowings (ECB)/loan into equity, provided the activity is covered under the automatic route and the foreign equity after such conversion falls within the sectoral gap;
- Conversion of preference shares into equity provided the increase in foreign equity participation is within the sectoral cap and the activity is under the automatic route: and

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External Capital Inflows in Post-Globalised India

Dr. Rama C. Parida

Abstract

The Industrial Policy, 1991 ushered in dramatic changes to attract FDIs in India. Such a positive and open door policy towards FDIs and technology transfer have been in contrast to our earlier restrictive approach. In fact, in the world of intensifying competition and technological innovations, foreign capital is very precious particularly in a vast country like India. The structural changes facilitated freedom to foreign investors to make debut to Indian industry. What is worth noting is that unlike in the past, India no longer depends on developed countries for her foreign investment and capital inflow. Many developing nations have come forward to investing their funds in India. At present India is adjudged as the second best investment destination in the world, behind China and ahead of the US.

Introduction

Globalization and liberalisation have stimulated the development of closer financial and trade relations amongst developed and developing countries. Many developing countries have moved towards market through widespread reduction and removal of trade barriers, deregulation of internal markets, privatization and liberalisation of foreign capital inflows. Our economic reforms and structural adjustments have triggered in friendly foreign trade and investment environment with liberalized and simplified procedures. There have been significant changes in our external sector through EXIM Policy, foreign collaborations, Foreign Direct Investment (FDI), etc. The opening up of various sectors to foreign investors has helped to remove huge trade deficit. The Industrial Policy, 1991 ushered in dramatic changes to attract FDI in India. Such a positive and open door policy towards FDIs and technology transfer is in contrast to our earlier restrictive approach (Chopra 2003, Bhalla 2004). Various policy measures have been adopted to liberalise foreign investment regime through multilateral and bilateral initiatives. Following the liberalization, there has been unprecedented growth of FDI inflows in the economy. An economy, which wants to raise its growth rate, is required to enhance its efficiency and productive capacity at faster pace especially in post liberalised environment. It seems, therefore, that how developing countries respond to challenges and opportunities thrown by developed countries depends upon reforms in foreign investments consisting of FDI, Foreign Institutional Investors(FIIs), technical collaborations, capital market reforms, etc.

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Lack of capital (X_{10}) and non-availability of irrigation at time (X_6) jointly explained 17.2 per cent variation in the adoption of modern technology in its full package with eigenvalue greater than 3 in each case. Shortage of capital has been rightly observed as one of the major problems faced by the farmers in transferring the new rice technology because small and marginal farmers are poor while new inputs are capital intensive. Rice cultivation requires a constant supply of water but due to poor irrigation system (such as canal irrigation) it is a common feature of non-availability of irrigation water at the time of need which is a hindrance to adoption of improved practices of rice. So assurance of timely irrigation is related to the application of other inputs and practices such as fertilizer and weeding.

Table 1

Constraints in the adoption of Recommended Rice Technologies perceived by the Farmers

Constraints	Communality	Eigenvalue	% of variance	Cumulative %
Lack of knowledge about proper recommendation (X_{46})	0.49105	4.19749	10.80	10.80
Lack of irrigation facility (X4)	0.49694	4.02686	10.30	21.10
Lack of Capital (X_{10})	0.43451	3.66439	9.40	30.50
Non-availability of irrigation in time (X_6)	0.40737	3.04092	7.80	38.30
Lack of Advice and Guidance (X_{29})	0.59482	1.66157	4.30	42.60
Lack of land ownership (X_1)	0.30471	1.59030	4.10	46.70
High rate of labour wages (X_{23})	0.52711	1.41601	3.60	50.30
Non-availability of quality HYV seeds (X_{30})	0.58466	1.38052	3.50	53.80
High prices of the inputs (X_{42})	0.55664	1.36702	3.50	57.30
Lack of adequate credit (X_{12})	0.88863	1.19561	3.10	60.40
Not profitable (X_{24})	0.57737	1.07798	2.80	63.20
Lack of availability of genuine production inputs in time (X_{27})	0.32387	1.01711	2.60	65.80

Eigen value of the remaining eight factors individually is greater than one and they together explain 27.4 per cent variation; 67.80 per cent of the total variation is explained by the selected 12 variables which indicate that by controlling these constraints adoption performance of the farmers can be improved to a significant extent. Since farmers are ignorant about the new technologies and their method of application, they need advice and guidance to increase the rate of diffusion as it has been observed as a factor of non-

adoption in the present study and in a study conducted by Singh (1980). Land ownership (X_1) has been found as another constraint and this is supported by Sagar (1983). The reason behind this finding is that the farmers generally take more interest for permanent improvement of cultivable land and they can take independent decision regarding the adoption and level of adoption of new rice practices in case of own land only. High wages (X_{23}) and high prices of labour inputs (X_{42}) also appear to be obstacles for transfer of rice technologies in farmers' field. This is consistent with the finding of Singh (1974). The study of Waghmare and Waghmare (1985) reported that non-availability of quality HYV seeds (X_{30}) was a factor responsible for non-adoption which is also one of the findings of the present study. Lack of availability of credit (X_{12}), low profitability (X_{24}) and non-availability of genuine production inputs (X_{27}) such as fertilizers and pesticides are other problems faced by the farmers in accepting the improved rice technology.

Conclusion

It can certainly be envisaged that the growth in the agricultural production in West Bengal during last 20 years or so could have been even higher, had the factors preventing the farmers from optimal application of modern rice inputs been eliminated. The findings of the study point out that the extension of the State's agriculture is in a very bad shape. Therefore, more attention is called for to make the farmers more efficient in the adoption of modern rice technologies by addressing the problems they face to apply recommended doses of inputs to harness optimum rice production in their fields so that the State can raise the agricultural growth in future.

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Utilization of FDI

FDI is a promoter of an economy's economic growth. It is an established fact that China's record in foreign investment and trade is far superior to that of India. India is considered as underachiever in FDI and foreign trade. However, case backlogs frequently lead to long procedural delays. There is lack of enthusiasm among investors due to procedural delays. The reason is that after independence India developed a highly protected, semi-socialist economy. Structural and bureaucratic impediments were vigorously fostered, along with a distrust of foreign business. The present climate in India has seen a sea change in smashing barriers and actively seeking foreign investment inflows. Indian condition is often considered to be both frustrating and challenging at the same time. There is a considerable flow of FDI in India in spite of difficulties, contradictions and challenges, because Indian middle class is large and growing, wages are low, many workers are well educated and fluent in English. Developing a basic understanding of potentiality of the Indian market, envisaging and developing a Market Entry Strategy (MES) and implementing these strategies, when actually entering the market, are three basic steps to make a successful entry into India. However, there are still some problems as given below:

Infrastructural hassles: The rapid economic growth of the last few years has put heavy stress on India's infrastructural facilities. The projections of further expansion in key areas could snap the already strained lines of transportation unless massive programes of expansion and modernization are put in place. Problems include power demand shortfall, port traffic capacity mismatch, poor road conditions (only half of the country's roads are surfaced), low telephone penetration, etc.

Indian Bureaucracy: Although the Indian government is well aware of the need for reform and is pushing ahead in this area, business still has to deal with slow-moving bureaucracy. It is an area of concern for foreign investors.

Check on Economic Policies: The general economic direction in India is towards liberalization and globalization. But the process is slow and tardy due to political considerations. Before jumping into the market, it is necessary to discover whether government policies exist relating to the particular area of business and if there are political concerns which should be taken into account. Hence, the Government has to build confidence among investors for upsurge in foreign investments.

Conclusion

In our increasingly deregulated economy FDI is the barometer of economic development. With the WTO negotiation the global trade investments have become more flexible. The process of globalization has made Indian economy utmost competitive. However, the ultimate aim of economic reform is improvement of social welfare and bringing benefit to all citizens. But it is not up to mark even after one and half decades of globalization. The foreign trade and investment reforms are to be vigorously taken up.

As of now globalisation process is irreversible. India, amongst the European investors, is believed to be a good place for investment despite political uncertainty, bureaucratic hassles, shortages of power, and infrastructural deficiencies. India presents a vast potential for overseas investment and is actively encouraging the entrance of foreign players into the market. No company of any size aspiring to be a global player can, for long, ignore this country which is expected to become one of the top three emerging economies. Success will depend on the correct estimation of the country's potential; underestimation of its complexity or overestimation of its possibilities can lead to failure. For those who take the time and look to India as an opportunity for long-term growth, not short-term profit, the investment will be well worth its cost.

On the other side, there is widespread apprehension that more open an economy, the more susceptible it is to external events. Appropriate policy framework can handle international fluctuations, at least. There is keen competition among developed and developing countries to attract foreign capital. This drive to lure investment often extends to the sub national level, with different regional authorities pursuing their own strategies and assembling their own baskets of incentives to attract new investments. In fact well-thought out and holistic approach needs to be taken at central level, in order to compete with other countries, meaningfully in attracting foreign investments. What's required is an investor-investment-friendly climate. A recent World Bank Report on doing business in India states that entrepreneurs are expected to go through 11 steps to launch a business over 71 days on average. Also, entrepreneurs in India must make 59 payments, spend 264 hours, and pay 43. 2 per cent of gross profit in taxes. In fact, the World Bank report which is based on parameters like hiring and firing, registering property, availability of credit, tax paying procedures, closing a business, etc which ranks India at 116 in the world. Economic development is now an urgent need all over the world and FDI is an important instrument to raise the overall productivity throughout the world.

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Appendix

Table 1

Top ten FDI destinations in the World

Country	Rankings	
	2004	2005
China	1	1
India	3	2
US	2	3
UK	4	4
Poland	12	5
Russia	11	6
Brazil	17	7
Australia	7	8
Germany	5	9
Hong Kong	8	10

Source: A.T. Kearney, The Economic Times, 11th December, 2005

Table 2

State–wise FDI Approvals

(From August 1991 to Nov. 2004) *(Rs in Crore)*

States	Approvals	Amount of FDI approved	% of total FDI approved
Maharastra	5,037	37,020	14.80
Delhi	2,810	30,519	12.20
Tamil Nadu	2,681	22,642	9.05
Karnataka	2,639	19,075	7.63
Gujarat	1,236	12,437	4.97

Source: Economic Survey 2005-06, Government of India.

Table 3

Country-wise Break up of FDIs in India

(Amount in Rs. Crore)

Country	1991-99	2000	2001	2002	2003 (tillApril)	1991-03 (in %)	1991-99 (in %)	2000-03 (in %)
USA	46184.5	41950.0	4921.5	2051.1	10.7	57562.7	26.15	23.91
Mauritius	22198.7	7234.0	2892.6	1846.6	243.4	34414.9	12.57	25.67
U.K	15976.6	411.2	4994.2	1804.4	66.4	23252.9	9.05	15.29
Japan	9107.7	827.5	735.3	740.8	42.4	11453.7	5.16	4.93
S. Korea	9690.1	41.1	66.8	29.0	3.01	9830.0	5.49	0.29
Germany	7903.3	593.8	413.9	253.1	89.2	9253.3	4.47	2.84
Netherlands	4695.5	4.6	3693.6	552.4	12.0	8957.9	2.66	8.96

Country	1991-99	2000	2001	2002	2003 (tillApril)	1991-03 (in %)	1991-99 (in %)	2000-03 (in %)
Australia	6555.2	61.7	84.4	77.3	4.8	6783.4	3.71	0.48
France	5035.4	202.1	679.8	622.9	19.3	6559.5	2.89	3.20
Malaysia	5560.6	15.9	105.8	372.6	5.6	6060.5	3.15	1.05
Singapore	4159.8	323.2	379.9	372.2	68.0	5303.0	2.36	2.40
Italy4	447.5	107.3	171.5	70.5	8.1	4805.0	2.52	0.75
Belgium	3918.7	79.1	162.1	349.6	1.8	4511.3	2.22	1.25
Israel	4234.7	0.1	8.7	0.1	0.01	4244.6	2.40	0.02
Switzerland	2739.5	71.7	107.5	145.1	65.9	3129.6	1.55	0.82
Canada	2381.9	154.4	53.8	286.1	0.13	2876.3	1.35	1.04
China	712.9	0.00	0.00	0.01	0.24	713.2	0.40	0.00
Russia	267.60	0.00	0.30	0.12	0.00	268.0	0.15	0.00

Source: The Economic Times, Dated 7th July 2003, p-10.

Table 4

N.K. Singh Committee Report on Sectoral Caps in FDIs

Sector	Existing limit
A. Recommended for 100% FDI	100
1. Drugs	26
2. Petroleum refining	74
3. Oil marketing	74
4. Diamond, precious stone	50-100
5. Petroleum exploration	50
6. Coal & lignite	50
7. Coal washery	74
8. Airports	74
9. Total bandwidth	74
10. Telecom gateway	51
11. Pipelines for gas & oil	49
12. Banking	49
13. Investment companies	100
14. Internet service providers	100
15. E-mail & voice mail	74
16. Radio paging	74
17. Advertising	51
18. Trading	100
19. Courier service	0
20. Commercial complexes	0
21. Individual housing /buildings	
B. Recommended for 74 % FDI	49
1. Basic mobile telephone services	
Sector	
C. Recommended for 49 % FDI	
1. Small scale industries	24
2. Civil aviation	40
3. Insurance	26
4. Broadcasting (DTH, kV)	20
5. Plantation	0

Source: India Today, September 30, 2002

Table 5

Sectors attracting highest FDI inflows

(Amount in Rs. Crore & in US $ in million in parenthesis)

Rank	Sectors	2002-03	2003-04	2004-05	2005-06 (April-Nov.)	Cumulative inflows(from Aug1991-Sept. 2005)	Share of inflows (in %)
1.	Electrical Equipments (including computer software and electronics)	3,075 (644)	2,449 (532)	3,281 (721)	3,687 (223)	20,898 (4,862)	16.62
2.	Transportation industry	2,173 (455)	1,417 (308)	815 (179)	741 (168)	13,073 (3,124)	10.39
3.	Services Sector (financial & non-financial)	1,551 (326)	1,235 (269)	2,106 (469)	1,742 (398)	11,981 (2,908)	9.53
4.	Telecommunications (radio paging, cellular mobile basic telephone services)	1,058 (223)	532 (116)	588 (129)	763 (156)	12,076 (2,863)	9.60
5.	Fuels(power & oil refinery)	551 (118)	521 (113)	759 (166)	81 (19)	10,678 (2,514)	8.49
6.	Chemicals (other than fertilizers)	611 (129)	94 (20)	909 (198)	843 (191)	7,444 (1,887)	5.92
7.	Food processing industries	177 (37)	511 (111)	174 (38)	158 (36)	4,677 (,1173)	3.72
8.	Drugs and pharmaceuticals	192 (40)	502 (109)	1343 (292)	485 (11)	4,047 (946)	3.21
9.	Cement & gypsum products	101 (21)	44 (10)	01 (00)	1967 (452)	3,229 (746)	2.57
10.	Metallurgical industries	222 (47)	146 (32)	881 (192)	544 (122)	2,679 (624)	2.13

Source: Economic Survey, Government of India, 2005-06, p-140.

Types of Ancient Indian Republic

Dr. Oinam Ranjit Singh

Abstract

The present paper deals with different types of ancient Indian republic. Oligarchies, aristocracies and democracies have all been labeled as republics. Republics form very important part of political history of ancient India. Monarchy and republic were the two prevailing forms of government in ancient India. The non-monarchical forms of the state are known as aristocracies, oligarchies, democracies or republics. In ancient Indian context, all these terms were described generally as synonymous. In fact, the line of difference between them is so thin that it is very difficult to distinguish one from the other. However, republic may be distinguished from oligarchy. Oligarchy is a form of government in which the supreme power is placed in the hands of a small exclusive class or body. Whereas in the republican state, the supreme power is placed in the hands of either certain privileged members of the community or in the whole community. In north-west India, republican states were many and oligarchical states were very few. The ancient concept of republics, oligarchies or democracies are totally different from that of the modern times. However, in case of north-west India we find that some non-monarchical states had both republican or oligarchical character in terms of their forms, constitutions, administrative procedure and functioning, and some republican states were quite distinct from the oligarchical states.

Gana, the technical word for the republic, is mentioned forty-six times in the **Rig-Veda,** nine times in the **Atharva Veda,** and at several places in the **Brâhmanas.** It has been interpreted in the sense of "assembly" or "troops". K.P. Jayaswal, a pioneer in the field of the study of ancient Indian republic, translated it as an assembly or government by assembly and was strongly supported by F.W. Thomas. The *gana* and *samgha* denote the two different forms of government. In the states having the *gana* form of government *(Ganarâjya)*, power was vested not in one person but in *gana* or group of people. Ancient Indian *gana* states or republics are more or less similar to the ancient states of Greece and Rome. It has been rightly pointed out that "Sovereignty in these states was vested not in one individual, nor in a small number of persons, but in a fairly numerous class"[1]. But in the states having the *samgha* form of government (*Samgharâjya* or confederate state), power was jointly shared by the representatives of two different communities or states forming confederacy.

In *Mahâbhârata gana* stands for the whole body politic, the whole community, or a large number of people who managed the affairs of the states[2]. The leaders of the *ganas* vested with power haye also been referred to therein[3]. The *ganas* generally formed *samghas* or confederacies[4]. It is also clearly stated in the same text that the *ganas* formed a confederacy for their safety and security.[5] The *Astâdhyâyi* of Pânini (who flourished in about the fifth century BC) contains valuable information about the republics.

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Pânini has used *gana* and *saṃgha* as identical words (*Sûtra*, III, 3, 86)[6] for a republic. He speaks of the Yaudheyas (of the Punjab) as a *saṃgha*, but they refer to themselves as a *gana* on their coins in the post Pâninian period.[7] Pânini refers not only to *gana* and *samgha* but also to "member states of a union, leagues or confederacies as in the case of *Trigartta-Shashtha* (V.3. 116)"8. He has also used the term *samgha* for a *Nikaya* which represents a corporate body where the distinction of upper and lower does not exist (III,3,42)[9]

Kâtyâyana (ascribed to the fourth century BC) in his commentary on Pânini's *Sûtra* (IV,I,168) informs us that the ruling Kshatriya tribes were governed by two-fold constitutions, monarchies and *saṁghas* or republics. He takes *samgha* as a form of government distinct from *Ekaraja*, where sovereignty was vested in one (*ekadhina*), and not in the many as in the *samgha* (*gana dhina*)[10]. According to Patañjali (*Mahâbhâsya*, V.I.59)[11], the term *gana* signified the form of government and *samgha* the state. The two terms, *gana* and *samgha*, have wide connotation. However, one can not be equated with the other. In fact, they denote two different types of the republican state with two different forms of government[12].

The state ruled by the *gan?as* or group of people was called *gan?arâjya*. The noted *gan?a* states in north-west India were those of the Yaudheyas and the Mâlavas. At the time of Alexander's invasion they formed a confederacy or *sam?gha* for fighting unitedly against the invader. And hence, this is also an example of confederatestate or *sam?gharâjya* . In fact, the *samgha* stands for confederation of the tribes as well as states. The union of the Trigartta- Shashthas of Pâninian period and the confederacy of the Kshûdrakas and Mâlavas of Alexanderian period are noted examples of the *samgha* form of republic. Some of the republican states joined together and formed federations or confederations for better security, greater military strength and all-round prosperity. Sometimes they formed leagues for a short period to avert an imminent danger. But they maintained sovereignty of the constituent parts. K.P. Jayaswal has correctly described *ganarâjya* as a "government by assembly or parliament"[13]. J.E. Schwartzberg has categorically stated that the state followed both oligarchical and republican constitution[14].

Kautilya (fourth century BC) has divided *samgha* into two classes, *râjaúabdopajivin samghas* and *œastropajivin samghas*. He has placed under the former class the Madrakas and other republics whose elected leaders or chiefs were entitled to be called rajas. The *œastropajivins* (who did not bear the title of the raja) lived not only by the military profession but also by the profession of trade and agriculture. He has put the Kâmbhojas, the Kshatriyas, the Srenis and others under the latter class of republic[15]. His classification of the *samghas* is based on the two different characteristics of republic. Kautilya's *œastropajivin samghas* corresponds exactly to the *âyudhajivin samghas* of Pânini. The *œastropajivins* of the former is absolutely identical with *âyudhajivins* of the latter (V. 3.91) . These free or independent communities were the most famous for their military skill. The Punjab and the Indus Valley were two noted centres of the *âyudhajivin*

samghas. Only the Brahmans and Kshatriyas belonged to this *samghas* and not any other social class. But in case of Sindh, we find that the republican communities belonged to not only Kshatriya and Brahamana class but also to a class of Sudra called Sodrai by the classical writers. Pânini mentions that the Brahmans and Râjanyas of the Vâhika region (the Punjab and Sindh) as members of the *âyudhajivin samghas* (*Sûtra*, V.3. 114)[17]. This region is said to have been "the cradle-land of martial tribes who cultivated military art as a way of life"[18]. Pânini includes in the list of the republican communities of this *samghas* the Vrika, Dâmani, Trigartta-Shashtha, Yaudheya, Parúava, etc. (*Sûtra* V.3. 115-17)[19]. The *Kâsikâ* (on *Sûtra*, V.3.114) has added the Kshûdrakas and the Mâlavas in the list concerned. The *âyudhajivin samghas* mentioned in the *Gana-Pâtha* include "Damanyadi, Parsvadi and Yaudheyadi groups"[20]. The Kathas (Kathaians), Kshûdrakas (Oxydrakai), Mâlavas (Malloi), Agra-Úrenis (Agalassians), Sibis (Siboi), Yaudheyas (identified by some scholars with Ossadioi), Ambashthas (Abastanoi) and Kshatriyas (Xethroi) of the Punjab and Brâhmanas (Brachmans) of Sindh as mentioned by the Greek historians of Alexander also fall under the *âyudhajivin samghas*. Some of them had well-organised armed forces which faced Alexander's army. The military training in their states was compulsory for both men and women. They took up the arms to defend their states against the external danger. The numerous *âyudhajivin samghas* in north-west India continued to exist down to c. 300 BC.

Ancient Indian republics stand in comparison to the ancient Greek and Roman republics. In the city-states of Athens and Sparta in Greece power was not vested in the whole body of the citizens but in a small class of full fledged citizens. Their assemblies or councils like those of some ancient Indian republic were not represented by the whole population. The Roman Senate was represented only by some privileged members of the society or a small aristocratic class like the aristocratic republics of ancient India. In both Greece and Rome, the franchise was confined to a small minority, who governed a vast majority. None of them possessed full democratic character. They stand in sharp contrast to the well-developed democracies of the modern type. Nevertheless, their city-states concerned are described as seats of democracies. Greece is even considered as the birth place of democracy. In contradiction to the monarchies, in all ancient republics the powers were after all not centralized in the hands of one individual, but in a group of persons. This constitutes the common feature of all the republics. The decentralization of powers constituted the back-bone of these republics.

At the time of Alexander's invasion, a large number of republics existed side by side with monarchies in north-west India, which can best be qualified in the statement of Megasthenes. "Most of the cities adopted the democratic form of government, though some retained the king, until the invasion of the country by Alexander"[21]. These republics were not much larger than the city states of ancient Greece. The republican states on the whole fell under five categories (a) free, independent or autonomous states where the

sovereignty was vested in the whole tribal community and popularly known as sovereign democratic republic; (b) some states were governed by a body or council of members elected or unelected; (c) there were confederate states also where the representatives of two different states jointly shared political power; (d) the states which were ruled by the members of aristocratic family and known as aristocratic democracy; (e) in some states the executive power was held by the members of a few families on hereditary principle, but with circumscribed authority.

V.A. Smith, while making observation about the republics of north-west India stated that "... ancient India exhibited a greater variety of political constitutions and large areas were occupied by nations, tribes or clans who ... governed themselves under some form of aristocratic or democratic constitution. The Greek writers gave us glimpses of such communities ... in the Punjab during the fourth century BC and later times ..."[22]. The testimony of contemporary Greek writers shows that there were many forms of non-monarchical states in ancient India. In the Punjab, in the days of Alexander the Great non-monarchical states were more extensive and powerful than the monarchical ones. The accounts of Greek writers have not been attached the importance[23] they deserve.

R. Fick's view that "the autonomous states of the Greek writers were individual cities or small states that maintained their independence in the neighbourhood of great monarchies like that of the Magadha"[24] can only be partly accepted. Because individual cities mentioned by Greek writers belonged to independent sovereigns and they formed parts of kingdoms not autonomous states. The autonomous states of course included small states or city states that maintained their independence in the neighbourhood of monarchical states.

In the time of Alexander, some republican states of north-west India included both towns and villages. Some independent villages had more or less republican type of government. J.W. McCrindle has clearly stated that the Greek took each of the rural or village units to be an independent republic[25] which A.S. Altekar[26] and K.P. Jayaswal[27] have not accepted on the ground that the Greek authors have not mentioned the village government and did not mean by the independent or autonomous states the village republics. But we on the basis of our research into the subject find that McCrindle's statement is not totally wrong because some big villages had also a republican system of government. As a matter of fact, the Greek writers have not made a clear cut distinction between the cities and villages or between the two systems of government. In fact, the free tribes living in both villages and cities were under the republican form of government.

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An Experimental Evaluation of Karanja based Bio-diesel as a Supplementary Diesel Fuel for Rural Applications

P. Lingfa

Abstract

The depletion of the world petroleum reserves coupled with the global environment problems stimulated the search for alternative sources of petroleum-based fossil fuel. In the present work non-edible vegetable oil (pongamia piñata) has been chosen for the work. Biodiesel from karanja oil was produced using esterification process and their physical, chemical, performance and emissions characteristics were tested in a medium scale diesel engine, which are widely used in rural sector. Economic analyses were also carried out for production of biodiesel from small-scale biodiesel reactor and comparisons in terms of cost per litre are made. A brief analysis of oil cake for karanja seed was also made.

Key words: Biodiesel, economic analysis

Introduction

In view of the escalating energy (fuel) crisis and environmental degradation non-edible vegetable oil is one of the sources for replacement of petro-diesel, thereby reducing country's dependence on importing petroleum from overseas. The concept of producing fuel from non-edible vegetable oil for diesel engine is not a radically new one. When Rudolf Diesel first invented the diesel engine, about a century ago, he demonstrated the principle by employing peanut oil and hinted that vegetable oil would be the future fuel in the diesel engine.

Historical review

Ever since the advent of the I.C engine, researchers in various countries tried and carried out many experiments using vegetable oils as a substitute for diesel in I.C. engine and other applications. They concluded that vegetable oils as fuel for I.C engine can be used in engine without any modifications to existing design of the engine and it can also play a vital role in helping the developing and developed world to reduce the environmental impact of fossil fuels and pollutions.

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Use of non-edible vegetable oil (bio-diesel)

The use of vegetable oil as a substitute for diesel helps

- to provide energy security to the rural people,
- to provide employment and income generation to rural people,
- to reduce expenditures on health problems arising out of vehicular emission.
- to reduce expenditures on health problems arising out of vehicular emission.
- to protect environment, reduce emission, cut oil import, and
- to neutralize the effects of rapid increase in price of petroleum and uncertainty about their supply.

Materials and Methods of production of biodiesel from non-edible vegetable oil

Biodiesel is a fatty acid or methyl ester made from virgin or used vegetable oils (both edible and non-edible) and animal's fats. There are four primary ways to produce vegetable oil. They are as follows:

- Direct use or blending in diesel fuel
- Micro emulsions
- Thermal cracking (pyrolysis)
- Transesterification

Out of these, transesterification is one of the most popular and best way to produce vegetable oil for the use of the diesel engine. There are two basic routes to produce biodiesel by transesterication of vegetable oil i.e. based catalyst and acid catalyst.

Based catalyst is the easiest, popular and most commercial used process because of the following reasons:

- Greater than 90 percent of all bio-diesel is produced by this method.
- Low temperature (60°c) and pressure (1 atmosphere) are required
- High conversion (greater than 98 % can be obtained).
- Minimum side reactions.
- Direct conversion without intermediate steps
- Require only ordinary materials of construction of the set up

Transesterification process

CH2-OOC-R1 — catalyst → R1-COOR + CH2OH
CH2-OOC-R2 + 3ROH → R2-COOR + CHOH
CH2-OOC-R3 → R3-COOR + CH2OH

Triglyceride Alcohol → Esters (Bio-diesel) Glycerol

R1, R2, R3, are long chain alkyl group and R, short chain alkyl group

Steps involved in the production of biodiesel using medium capacity biodiesel reactor

The production of biodiesel through transesterification of vegetable oil reduces the viscosity of vegetable oil and makes it comparable with that of pure diesel. Any vegetable oil can be converted into biodiesel through transesterification using ethanol or methanol.

In the production of biodiesel the following steps are involved:

1. Mixing of alcohol and catalyst

The alcohol (methanol) and catalyst (NaOH) were mixed in required proportion to study the effects on transesterification process. The 1% catalyst was used to complete the reaction.

2. Reaction

The non-edible vegetable oil (karanja) was charged into the reactor, then the required amount of alcohol and catalyst (Molar ratio 12:1) were added to the reactor. Now the mixture was heated for 3 hours at a constant temperature of 60-70° C. It was then stirred vigorously, with electric stirrer until the temperature reached a constant value.

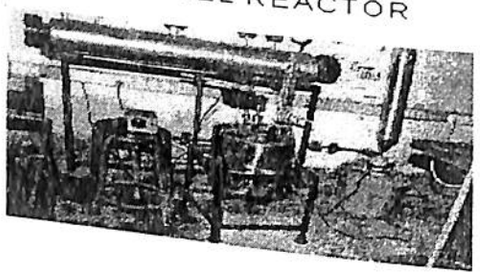
2. Separation

After the completion of reaction, the mixture mainly consisted of two products, namely, biodiesel and glycerol. Then, it is separated by using funnel. Since two layers are formed, the upper layer being methyl ester and the rest being glycerol. The two layers are clearly seen. The light layer on the top is the biodiesel while the darker layer is glycerol.

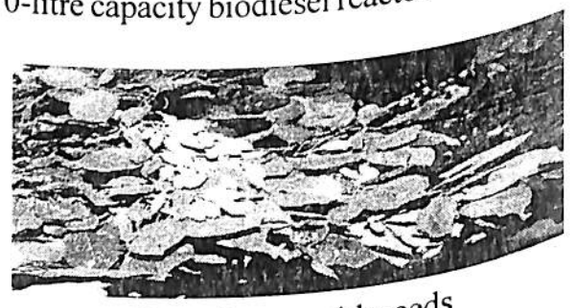
3. Bio-diesel after Water Washing

After discarding the glycerol layer from the separating funnel the methyl ester was mixed with, distilled water, shaken gently and allowed to settle for 10 minutes. The procedure was repeated for 3 to 4 times. The product obtained is the methyl ester of the Karanja oil.

Experiment set-up

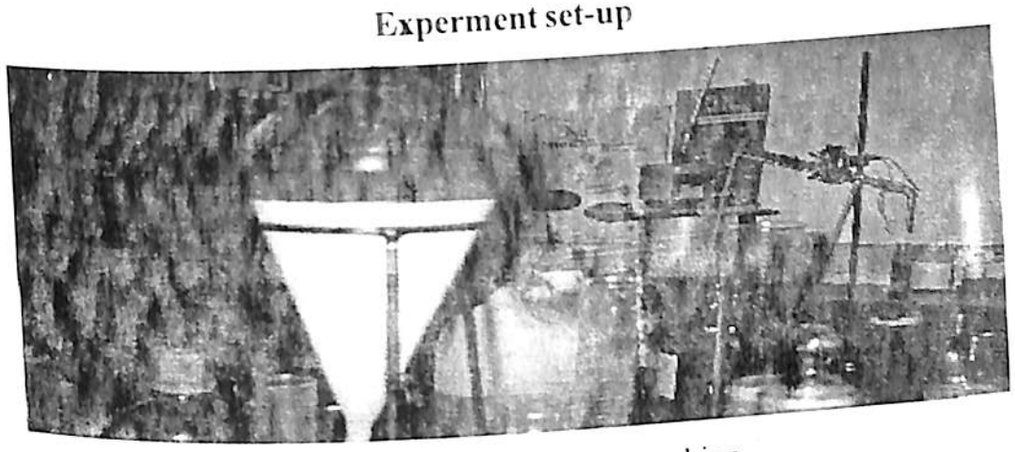


10-litre capacity biodiesel reactor



Karanja tree with seeds

Experment set-up



Biodiesel after water washing

Table 1

Observation for physical properties of biodiesel, karanja and diesel

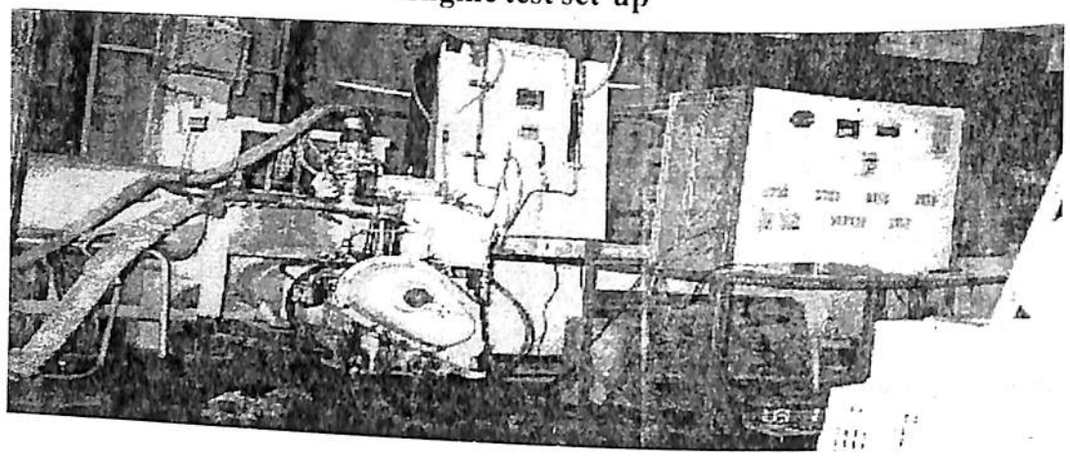
Sl.No.	Name of oils	CV Mj/Kg	Viscosity at 40°C	Specific gravity (mg/ml)	Flash Point (°C)	Fire Point (°C)	Cloud Point (°C)	Pour Point (°C)
1	Karanja oil	36.00	20.18	0.921	230	270	-	-
2	Bio-diesel	38.02	4.7	0.875	185	225	21°C	8°C
3	Diesel	43.47	4.2	0.825	135	150	-	-

Table 2

Observation for distillation of commercial diesel, biodiesel and vegetable oil

Sl. No	Volume recovered (%)	Temperature (°C) diesel	Temperature (°C) vegetable oil	Temperature °C)Bio-diesel
1	0	140	136	96
2	10	190	280	260
3	20	202	290	292
4	30	248	296	314
5	40	258	290	318
6	50	270	288	317.8
7	60	290	276	318.9
8	70	302	272	312
9	80	320	284	296
10	90	350	290	306

Engine test set-up



Single cylinder four stroke diesel engine

The aim of the engine test is to find out feasibity of using bio-diesel (karanja oil) produced from small-scale biodiesel reactor as a partial substitute of diesel oil in CI engine and for rural applications. Hence the performance and emission test were carried out using blends, pure bio-diesel and diesel in single cylinder 4-stroke diesel engine at different load conditions.

Observations

Table 3

Performance and emission characteristics of the engine when running on pure diesel oil (D100)

Speed (rpm)	Voltage (volt)	Time for 10 ml fuel consumption(sec)	Manometer Reading(mm)	Inlet air emp (0c)	Opacity (%)	HC (ppm)	O_2 (% in vol)	CO_2 (% in vol)	CO % in vol)	NO_x (ppm)	BP (V*I) KW	TFC *10 -4 (kg/sec)	BSFC (kg/kw-hr)	Current Amp)	Exhaust Gas temp (0c)	Brake Thermal Efficiency
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1308	172	91.04	21	20	53.9	16	22.2	1.56	0.09	37	0	9.06	0	0	175	0
1312	190	70.93	21	20	81.7	21	19.1	3.01	0.15	125	0.46	1.16	0.911	2.40	208	9.09
1313	199	58.32	21	20	93.8	27	18.2	3.85	0.15	205	1.11	1.42	0.459	5.55	256	18.03
1311	206	43.10	20	20	95.9	51	16.7	5.64	0.15	382	2.11	1.92	0.326	10.25	340	25.34
1303	209	33.24	20	21	98.8	72	14.7	7.76	0.14	489	3.15	2.48	0.284	15.07	430	29.17
1306	209	29.77	19	21	100	96	13.9	8.45	0.10	491	3.68	2.77	0.272	17.64	494	30.5

Table 4

Performance and emission characteristics of the engine when running on B-10 (10% bio-diesel: 90% diesel)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1320	172	96.65	21	23	33.4	26	21.57	0.01	0	0	0	8.639	0	0	181	0
1317	189	78.39	21	23	48.5	31	19.59	2.77	0.09	108	0.43	1.065	0.892	2.28	210	9.73
1308	200	60.52	21	23	53.9	48	18.80	3.75	0.13	275	1.06	1.379	0.468	5.30	253	18.52
1305	205	44.04	20	24	75.4	59	17.2	5.62	0.12	360	2.03	1.896	0.336	9.90	336	25.79
1303	208	33.23	19	24	95.5	68	16.37	5..90	0.14	427	2.95	2.513	0.306	14.20	424	28.28
1308	208	30.06	18	24	98.6	112	15.08	7.1	0.25	438	3.41	2.777	0.293	16.40	486	29.59

Table 5

Performance and emission characteristics of the engine when running on pure bio-diesel oil (B100)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1306	172	75.22	22	20	48	19	20.02	2.25	0.16	55	0	1.183	0	0	178	0
1312	190	60.01	21	20	77.5	21	19.52	3.42	0.19	145	0.45	1.483	1.186	2.37	208	7.36
1314	201	53.69	21	20	94.7	24	18.68	4.08	0.19	217	1.12	1.657	0.533	5.56	263	16.41
1314	209	39.22	20	20	97.9	33	17.17	6.13	0.18	430	2.12	2.269	0.385	10.12	340	22.67
1313	209	29.93	20	20	98.6	60	14.43	8.09	0.26	515	3.15	2.974	0.339	15.10	440	25.71
1314	212	27.03	19	20	99.7	80	13.25	9.36	0.41	552	3.67	3.291	0.323	17.30	491	27.07

Table 6

Performance and emission characteristics of the engine when running on B-5 (5% bio-diesel: 95% diesel)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1313	174	87.44	22	23	40.1	34	19.41	2.33	0.10	40	0	9.49	0	0	170	0
1308	190	72.45	22	23	64.5	42	19.04	2.96	0.11	89	0.44	1.146	0.937	2.30	206	9.14
1314	203	56.13	21	23	80.8	48	18.31	3.83	0.14	207	1.07	1.478	0.497	5.30	257	17.23
1316	209	42.53	21	23	85.6	55	16.96	5.58	0.12	368	2.17	1.952	0.328	10.26	340	26.11
1306	298	33.36	19	23	99.4	67	16.01	6.04	0.22	380	3.08	2.488	0.291	14.80	474	29.49
1306	212	28.81	18	23	99.6	97	15.60	6.64	0.31	392	3.46	2.881	0.299	16.31	504	28.59

Results and Discussion

a) **Measurement and comparison of physical and chemical properties of pure biodiesel, raw karanja and diesel oil**

The detailed measurement of physical and chemical properties of pure biodiesel, raw

karanja oil and diesel oil were carried out. From the analysis, it was observed that physical and chemical properties of pure biodiesel and diesel are comparable.

b) Engine test results

i. **Effect on brake thermal efficiency of brake power**
From the test results it is observed that initially with increasing brake power the brake thermal efficiency of the diesel fuel and bio-diesel and its blends increases. But there was a considerable increase in efficiencies with the blends of biodiesel as compared to the efficiency of diesel fuel alone. The lower brake thermal efficiency for B100 could be due to reduction in calorific value and increase in fuel consumption when compared to diesel, B10 and B5.

ii. **Effect on specific fuel consumption of brake power**

It is observed that specific fuel consumption of all the fuel decreases with increase in brake power. Very little difference can be seen for all the blends of biodiesel at higher load; however, as brake power increases the specific fuel consumption decreases for all fuels, pure as well as blends. The specific fuel consumption of the B100 is higher than that of diesel because of its lower calorific value.

iii. **Effect on unburned hydrocarbon in exhaust of brake power**
There is considerable increase in HC emissions with the increase in brake power; the fuel quantity injected is increased thereby contributing to increased HC emission. Moreover, minimum HC emission level was achieved with neat bio-diesel.

iv. **Effect of oxygen in Exhaust of brake power**
As the brake power increased the oxygen content for all blends of biodiesel, neat diesel fuel tended to reduce significantly. This was due to reduction in air fuel ratio at higher loads.

v. **Effect on carbon dioxide on brake power**
It was observed that, CO_2 content in the exhaust gas increased for all fuels with increasing brake power. Maximum CO_2 content at maximum power was also nearly the same.

vi. **Effect on CO in Exhaust of brake power**

The carbon monoxide in the exhaust gas increased with increase in brake power. The air fuel mixing process was affected by difficulty in atomization of heavy compounds. The resulting locally rich mixture causes more CO to be produced during combustion, due to lack of oxygen.

vii. **Effect on exhaust NO_x emission of brake power**
NO_x increases with brake power. This is probably due to formation of higher combustion chamber temperature and presence of oxygen in biodiesel.

viii. **Effect on Exhaust Smoke Opacity of brake power**
Smoke opacity increases as the brake power is increased, but at maximum brake power smoke opacity is nearly same for all fuels. Smoke opacity of the biodiesel is high, due to presence of high moisture in the fuel. But this may be reduced by optimizing the injection timing.

FIG 1 EFFECT ON BRAKE THERMAL EFFICIENCY OF POWER

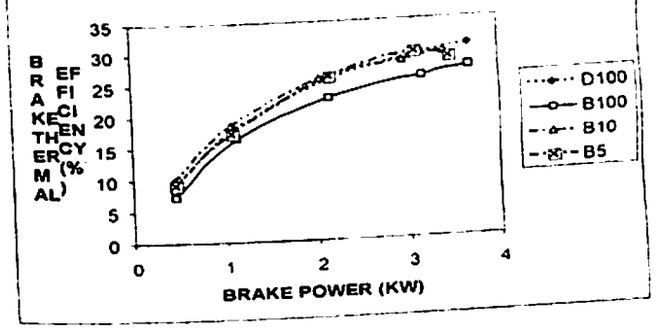


FIG.2: EFFECT ON SPECIFIC FUEL CONSUMPTION ON BRAKE POWER

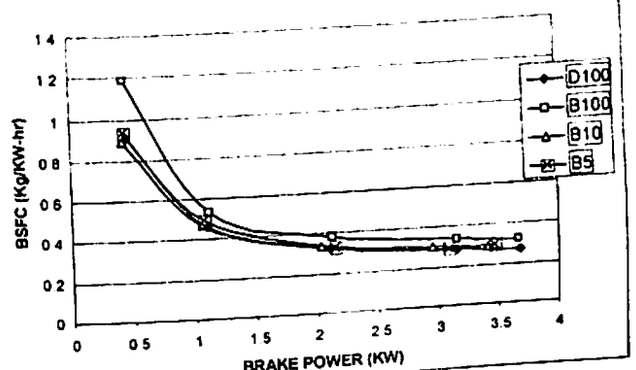


FIG 2 EFFECT ON UNBURNED HYDROCARBONS OF BRAKE POWER

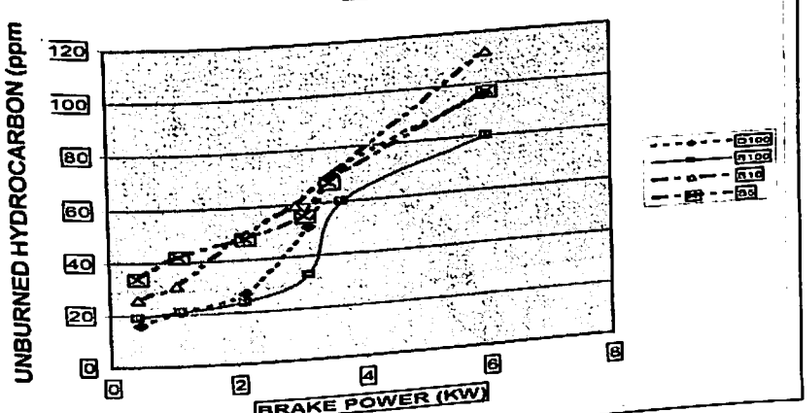


FIG. 4: EFFECT ON OXYGEN CONTENTS OF BRAKE POWER

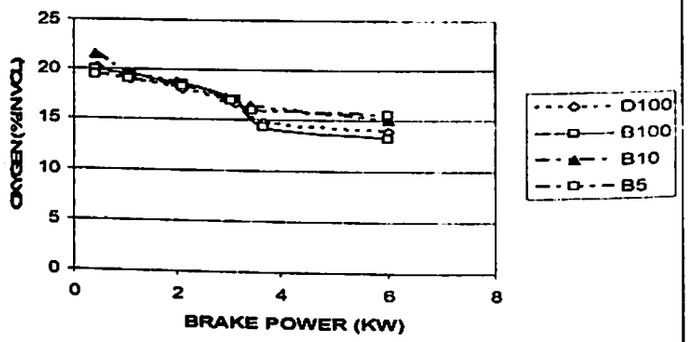


FIG5 EFFECT ON CARBONDIOXIDE OF BRAKE POWER

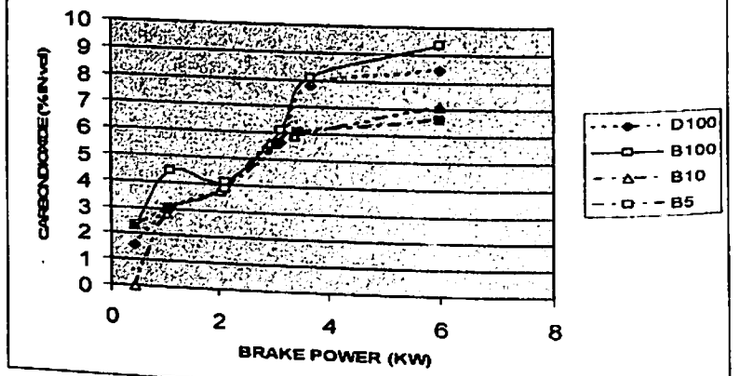


FIG 6: EFFECT ON CARBONMONOXIDE OF BRAKE POWER

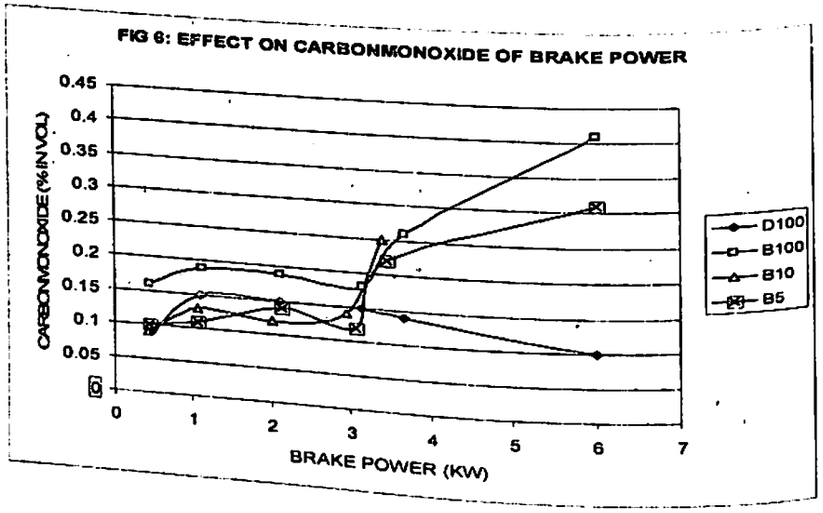


FIG 7: EFFECT ON NOX,EMISSION OF BRAKE POWER

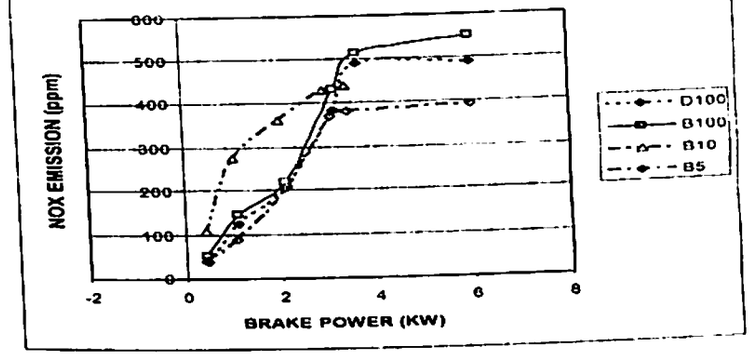
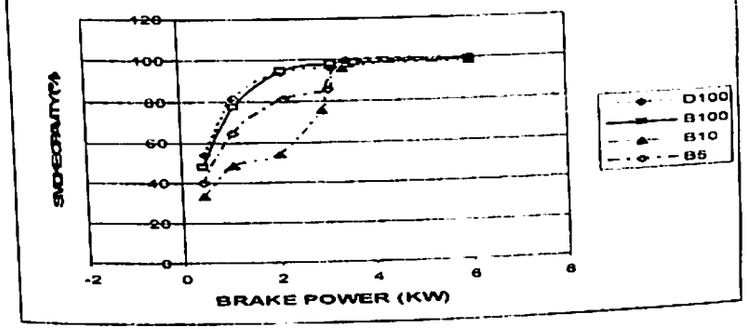


FIG. 8: EFFECT ON SMOKE CAPACITY BRAKE POWER



Economics of biodiesel production

The cost of biodiesel can be reduced if we consider non-edible oils of plants such as *karanja, jatropha, neem, mahua,* etc, which are available in India and its improvement in conversion technology. For biodiesel production, the cost involved include seed production, crushing and esterification.

Total cost of biodiesel /litre

Economics of bio-diesel produced from small-scale capacity bio-diesel reactor

Calculations

Yearly fixed cost

a) Cost of plant = Rs 22000/-
b) Care and maintenance (6% of the fixed cost)= Rs 1200/-
c) Life of plant is 10 years
d) Interest is negligible

So the yearly fixed cost: *Depreciation+maintenance+interest* = 2000+1200 = Rs 3200/-

Yearly variable cost

a) Seed requirement per day for 10 litre = 32.6 Kg, so the cost of seed/day @ rate of

Rs 5/-Kg = 32.6 X Rs. 5 = Rs 163/-

So cost of seed per year = 300 X Rs.163 =Rs 48900/-

b) Cost of extraction of oil/year = 32.68 X 0.90 X 300 = Rs 8802/-

c) Cost of transesterification per year = 300 X 10 X 6.67 = Rs 20,010/-

d) Cost of chemicals:

i) Methanol required/year = 3000 X 0.2 X 30 = Rs 18000/-

ii) NaOH required/year = 300 X 10 X 10 = 30000gms = 30Kg = 30 X 500 = 15000/-

e) Cost of labour for processing like, water washing, studies of properties, storage, etc. are neglected.

Total cost/year

3200+48900+8802+20010+18000+15000 = Rs. **1,13,912/-**

Income of farmer

i) Quantity of oilcake produced per year @ Rs 5/- per Kg

2.23 X 10 X 300 X 5 = Rs 33450/-

ii) Glycerol produced for 3000 litre of bio-diesel (10% byproduct) per year @ Rs 60/- per litre.

60 X 300 X 10 X 0.1 = Rs 18000/-

Total income of farmer/year

33,450+18,000 = Rs 51450/-

So,

Total expenditure - income of the farmer

113912 – 51450 = Rs 62462/-

Therefore, bio-diesel per litre:

= 62462/3000 = Rs 20.8/kg and Rs **18.2/-** per litre.

Other benefits

Farmers of good agricultural land can also benefit by planting non-edible oil along the boundary of their fields. Non-edible oil trees are not a large plant that can obstruct air/sun to the main crop. In addition being non-edible it will protect main crop from stray animals. Moreover biodiesel cropping will provide income to farmers who are around the degraded land and are facing economic hardship.

Conclusion

On the basis of present investigations the following conclusions are drawn:

1. Methyl ester bio-diesel was produced from non-edible vegetable and recovery of more than 84 percent bio-diesel was obtained.
2. The viscosity of vegetable oil drastically reduced after esterification.
3. The physical properties of methyl ester (bio-diesel) and diesel were found to be comparable.
4. Short term engine performance indicates the suitability for substitute of bio-diesel produced from small-scale bio-diesel reactor with diesel oil.
5. The cost of bio-diesel and diesel per litre are also comparable.

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