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Goat Based Integrated Farming System: Farmers' Coping Strategy for Sustainable Livelihood Security in Arid Rajasthan

Shalander Kumar and A.D. Upadhyay*

The paper analyses the case of goat based integrated farming system evolved by farmers as a coping strategy under water scarcity and changing resource situations in arid region of Rajasthan. It has also quantified the magnitude of linkages amongst different components of the farming system. The study was conducted in Nagaur district in arid Rajasthan. The primary data were collected from randomly selected 60 goat-keeping households and 25 farm households without goats for the year 2004-2005. The static input-output model was used to quantify the linkages. Instead of opting for transhumance system, the farmers were innovative to evolve a farming system that allowed sustainable production of grains for family as well as feed and fodder for maintaining their small ruminants. Three farming systems, namely, I-Rainfed goat based farming system, II-Partially irrigated goat based farming system and III-Rainfed crop based farming system were delineated. In response to the emerging resource and environmental conditions, goat farmers utilised the potential synergy of linkages among different components of the farming system. On rainfed farms, the maximum area in *kharif* season was occupied by crops, but farmers kept about 20 per cent of their land fallow for grazing the animals. During this period farmers sold their restricted flocks due to lack of grazing resources. It was revealed that crop and livestock- especially small ruminants – enterprises were integrated components of the farming systems in the study area. Grazing on common and own fallow lands and lopping from trees on owned and common land was a major source of fodder for the small ruminants and other livestock. The small ruminants with long daily hours of grazing provided nutrients to the current fallow and common lands through their droppings and dung. Goat rearing contributed the major share of the total farm income in both the goat based farming systems and provided livelihood security to the farm family in the poorly endowed arid region. Per hectare net returns of rainfed goat based farming system were 60 per cent higher than the crop based farming system. Diversification and strengthened linkages among different components of the farming system had a synergistic effect on the functioning of the entire farming system and resulted in higher income. However, the farmers of the existing goat production need to be finely tuned with the modern goat rearing practices. The innovative idea of farmers of keeping part of their land fallow for grazing their goats and sheep during the lean season needs to be used as an

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opportunity to encourage the farmers to develop this fallow land as pasture with recommended legume and non-legume grasses. Moreover, provision of market information, enhancing competition in milk and live animal market through organised efforts, access to improved technologies, critical inputs like vaccines, improved fodder seeds, and easy institutional finance were identified as the crucial factors for strengthening the goat based farming systems in the study area.

**Externality of Groundwater Development, Emergence
of Water Market and Environmental Sustainability:
Policy Imperatives for Rainfed Areas**

B.C. Barah, D. Narasimha Reddy and V. Ratna Reddy[†]

The paper examines the nature and significance of the well irrigation in Rayalseema region of Andhra Pradesh among the selected farmers, assess the dynamics of resource-based change in cropping pattern and irrigation induced commercialisation. Availability of irrigation encouraged farmers to shift from dry crops such as millets, sorghum etc., to irrigated paddy, sugarcane and betel leaf, which increased farm income and improved technical efficiency. The input intensive technology responds to irrigation and fertiliser. Consequently, highly profitable private ground water market emerged. Irrigation charges increased phenomenally upto a third of the value of output. Water is sold on hourly basis as against the per acre basis. The improved income and water market induced further competitive digging of wells and deepening of wells. The changes however brought in problems including high incidence of dry wells, lowering water tables, which increased investment of deepening of wells, and accentuated the dependency and deprivation of more and more farmers who resorted to buy water (BW) from fewer large farmers selling water (SW) at high rate. This scale biased practice favouring large farmers resulted into the emergence of a new class of 'Water Lord'. More importantly, there is apprehension that continuation of uncontrolled digging could increase the chance of desertification in chronic drought prone areas such as Anantapur. Thus, while efficient water resource is *sin-qua-non* to agricultural development, but intervention is needed to regulate appropriation in areas, where water is premium. The agricultural economy will be at stake to add to the rural sufferings, if water resource is neglected.

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Quantifying Technological Change in Dryland Agriculture in Chitrakoot Dham Region of Uttar Pradesh

M.M. Rajput, Arimardar Singh and Rajesh Kumar*

Dryland area contributes above one half the production of coarse cereals, pulses, oilseeds and cotton in the country. Because of the diverse agro-climatic conditions under which these crops are grown and the rainfed nature of their cultivation, dryland agriculture is characterised by wide spatial-temporal variations in productivity. Over the years, location-specific technological practices have been identified and suggested to farmers to improve the productivity of crops, but their success has not yet been adequately assessed. In this paper, an attempt is made first to examine the extent to which these technological practices have expanded the production possibilities in agriculture in Uttar Pradesh. In doing this, a fuller characterisation of technology adoption than has been attempted so far has been done. Most studies do not account for the fact that technology is a multi-faceted phenomenon, and that single measures—such as the percentage of area under high-yielding varieties (HYVs) for example—do not capture this adequately. In this paper, we explicitly address the multivariate nature of technology itself. Apart from its productivity impact, technological change is also an important determinant of employment in agriculture. In this paper, we draw attention to this aspect, recognising that women account for a sizeable proportion of the work force, and that employment effects of new technologies may well vary by gender.

One of the unique features of the study is that an index of technology adoption has been constructed to capture the multi-faceted nature of a technology package, and use it to categorise farmers as ‘low’ or ‘high’ adopters, for each of three crops. A simple production function analysis suggests that production response surfaces are indeed different for the two groups, although in some crops, important variables have insignificant coefficients. A decomposition analysis suggests that in the case of cotton, half of the difference in productivity levels between low and high technology adopters may be attributed to technical change; the other half arising out of higher input use. A comparison of marginal products with the input-output price ratio suggests that many inputs are used suboptimally. However, the application of less than recommended doses of inputs is the characteristic of dryland farming, and occurs largely due to the presence of risky returns. The production function analysis undertaken here does not incorporate risk considerations. Technology adoption is positively correlated with the use of female labour particularly hired labour in all three crops. Wages increase, as expected, during times of peak agricultural activity—with peak wages being one-and-a-half times higher than that during the lean season.

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However, there are considerable wage differences among men and women, with men being paid nearly twice as much as women. Interestingly, the differential does not decline appreciably in the peak season. Unfortunately, in this study area, women's work is considered as merely secondary to that of men, even though families frequently subsist on women's earnings. The new technology appears not to have touched this fundamental inequity.

Impact of Rainfed Technology of *Kharif* Pulses in Agro-Climatic Zone II-A of Rajasthan

B.L. Sharma and R.N. Sharma[†]

An attempt has been made to identify the adoption level and impact of rainfed technology in *kharif* pulses in agro-climatic zone II-A of Rajasthan. Agricultural Research Station, Fatehpur-Shekhawati has generated and recommended technologies for *kharif* pulse crops to farmers for adoption. But the farmers are not using these recommended technologies to fullest extent due to various reasons. Hence, the present study was undertaken to assess the extent of adoption and impact of these technologies as well as to identify the constraints faced by the farmers in the adoption of recommended technology for *kharif* pulse crops. A multistage random sampling technique was adopted for selection of 270 sample farmers comprising 90 farmers each from small (upto 2 ha), medium (2-4 ha) and large (above 4 ha) farms, and the sample was drawn from 18 selected villages of the Sikar district. For the purpose of the study, data were collected by survey method with the help of a set of schedules during *kharif* 2005. The results indicated that a greater number of large farmers adopted high level (III level) of technology. The study revealed that in moth cultivation, 46.43 per cent farmers adopted recommended seed rate. The use of recommended seed rate decreased with increase in farm size. Further, recommended seed treatment, fertilisers and plant protection technology was not adopted by any of the farmers though few farmers on small and medium farms supplemented N and P through farm yard manure. Regarding technology adoption in cowpea, 44 and 40 per cent farmers adopted high-yielding variety seed and recommended seed rate, respectively. Seed treatment and plant protection technology adoption was also negligible. There was no significant income variation found in the level of technology due to poor yield and low and scanty rainfall in crop season. High cost and lack of knowledge about recommended variety seed and conviction of technology were the main constraints for pulse production. Seed treatment of pulses was not adopted by majority of farmers due to lack of knowledge regarding seed treatment chemicals and its advantages. Low and erratic rainfall, high cost of fertilisers, lack of suitable implements for phosphetic fertiliser application, high cost

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of plant protection chemicals and lack of knowledge about suitable plant protection measures were the major constraints for plant protection measures. Inadequate capital and lack of technical guidance for all aspects of crop production were the other constraints identified in the study area.

Micro-Level Analysis of Rainfed Rice Production System in Orissa

Dibakar Naik and Sushil Pandey*

In this paper an attempt has been made to study the economics of production under rainfed situation and to suggest policy issues for technological improvement for increasing productivity and household income in rainfed areas of Orissa. The study is based on data collected from 200 farmers of Kalahandi and Mayurbhanj districts in Orissa selected on the basis of proportional random sampling technique pertaining to the agricultural year 1999-2000. Orissa has made progress in expanding the coverage of modern varieties. From 4 per cent coverage in 1970, the area under modern varieties of rice has increased to 80 per cent during 2006-07. However, expanding the area under the current modern varieties alone will not result in a substantial yield increase. It is essential to provide access to farmers of newer modern varieties and better crop management practices suitable to their local conditions of rainfed situation. The analysis of data from household survey highlights some of the major characteristics of rice production systems as well as differences among households and across locations. The analysis of income structure indicated that livelihood strategy, especially of small and marginal farmers, is based on wage income – mainly from the non-farm sector. Farmers derived as much as 70 per cent of their income from non-farm employment. Such importance of non-farm income is something that is a new development in rural Orissa where such opportunities were much more limited during 1960s and 1970s. Obviously, this is driven by demand factors arising from the overall growth of the economy and is governed by macro-economic factors. Rice research must be cognisant of this reality of non-farm based livelihood strategy and must consider the effect of improved technology on labour productivity rather than on yield alone. Farmers may not accept rice technologies that increase the yield but at the expense of increased labour as such technologies will require withdrawal of labour from non-farm employment – a major source of livelihood. Thus, technologies need to be evaluated both in terms of land and labour productivity – as opposed to the conventional practice considering the yield (or land productivity) only. Labour intensive technologies would be acceptable only if they raise the labour productivity sufficiently to make additional deployment in rice production worthwhile relative to other income-generating activities.

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Impact of Watershed: An Increase in Livelihood Security of Farmers in District Jalaun of Bundelkhand Region, Uttar Pradesh

Babu Singh, Rakesh Kumar Singh, B.K. Gupta and D.S. Azad[†]

A study was conducted for assessing the impact of watershed development project in Bardh village of district Jalaun in Uttar Pradesh on improvement in income and employment surrounding the project area. The project was launched in the year 2000 and observations were made during the year 2005-06. For the purpose of study 60 farm households were selected from the Vardh village under the watershed project command area. The study observed that the average net cultivated area was 108.50 ha and 182.50 ha and 182.12 ha before and after implementation of the watershed project. This programme has increased 75 per cent cropping intensity and an increase through improved irrigation facilities has been observed on the farms. Livestock population shows a positive change in number before and after project implementation. The total livestock population in the village increased from 265 total livestock before project period to 554 after project period. Due to improved cropped area, irrigation facility and more raw material was easily available on farms. The effect of watershed project on the productivity of the crops grown on farms showed an increasing trend in productivity under wheat crops during post project period.

It is concluded that implementation of watershed development project has resulted in area expansion, increase in net cultivated area, increase in livestock population, improvement in crop productivity and employment days. Besides the watershed project could help arrest degradation of both arable and non-arable lands. All these have enhanced the farmer's income and employment opportunities at the local level and small holders have benefited more and has improved livelihood.

Transformation in Dry Land Agriculture: A Case Study of Prakasam District

N. Subbarao*, P.S. Krishna Sudheer and L.K. Mohana Rao****

The study attempts to assess the emerging changes in dry land farming over the last four decades. For this purpose Prakasam district in Andhra Pradesh, with only 20.63 per cent area under irrigation and with a normal rainfall of 871.5 mm was studied. Secondary data on area, production and yield of principal crops for 37 years, i.e., from 1970-71 to 2006-07 was collected from the publications of Bureau of Economics and Statistics, Government of Andhra Pradesh. It analysed the

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exponential growth rate in area, production and yield of principal crops for the study period. The share of area under principal crops during 1970-74 to 2000-04 was examined to identify the shifts over time. Index numbers of production of output with 1970-74 as the base was computed to trace the trends in output. Attempts were also made to decompose the changes in output to identify the relative contribution of area and yield to the changes in output over the 37 year period. The study found significant changes in dry land farming with remarkable shifts in the cropping pattern from millets to pulses. This is also due to extension of area under cultivation by around 10 per cent during the period. It also shows that dry land farmers are averse to high cost and risk prone crops like cotton and tobacco, to pulses like Bengal gram a relatively low cost and less risk prone crop and with the availability of high-yielding variety seeds. Another notable outcome of this study is that HYV technology has not spread into the low cost millets. This is evident from the impact of higher negative yield effect on the changes in millet output. The findings of the study indicate that dry land farming is far from static as evident from notable shifts in cropping pattern. The changing composition of crop shifts from low cost millets to Bengal gram reflects that dry land farming has responded positively to market opportunities.

Yield Gap Analysis and Prioritisation of Constraints in the Production of Major Dry Land Crops of Rajasthan

Usha Rani Ahuja[†], P.S. Shekhawat[‡] and G.S. Jodha[‡]

An attempt has been made in the study to estimate the magnitude of yield gaps, causative factors and constraints for attaining greater potential yields in major arid zone crops in the rural areas of Jodhpur district of Western Rajasthan. The study is based on primary and secondary data. Primary data were collected from 100 sample farms from the rural areas of a representative district of arid zone and the data were collected during the agricultural year 2002-2003 and analysed using the IRRRI methodology on yield gap. The results of the study revealed a magnitude of total yield gap of 925 kg/ha for pearl millet, 350 kg/ha for sesamum and 250 kg/ha each for moong and moth bean. The magnitude of yield gap I was higher as compared to yield gap II which implies that due to environmental factors, technologies/package of practices could not be replicated completely at demonstration plots. The results of constraint analysis revealed that production losses were maximum due to insects/pests attack in oilseeds and pulses followed by disease management in pearl millet. Besides production constraints, the socio-economic constraints were also very important as farmers faced great difficulty in getting quality or reliable seeds in time

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and marketing their produce at reasonable price. Further small farm size, lack of technical know how and shortage of capital are the other major constraints that need to be addressed accordingly.

Analysing Investments in Micro Irrigation Structures in Sub-Mountainous Punjab: A Cost- Benefit Analysis Approach

Manjeet Kaur*, M.K. Sekhon* and Amrit Kaur Mahal**

An attempt has been made to carry out the cost-benefit analysis of the huge investment made by the Department of Soil and Water Conservation for construction of micro irrigation structures in Hoshiarpur district of Kandi area and the impact of the investment on farmers' land use pattern and income. Three types of micro irrigation structures were constructed, namely, small dams, lift irrigation structures and Makowal type structures depending upon the availability of water at site during the period 1991-92 to 1996-97. There were 25 structures comprising eight small dams, 4 lift irrigation structures and 13 Makowal type structures. Three structures one from each type were selected for the study and a total of 101 beneficiaries consisting of 31 farmers from small dams and 35 each from lift irrigation and Makowal type structures were selected randomly. The impact evaluation showed that the cultivated area in the selected villages were increased by 0.26, 0.7 and 0.79 per cent per annum and irrigated area by 16.15, 22.40 and 58.7 per cent per annum from 1991-92 to 2003-04 for small dam, lift irrigation and Makowal type structures respectively. The income of irrigated hectares fetched Rs. 14478 additionally than unirrigated hectare. Availability of fodder increased the livestock productivity.

The cost-benefit analysis revealed that the investment costs on sample irrigation structure were Rs. 27.0, 31.43 and 24.72 lakh per structure. The total return calculated from the area irrigated and additional area brought under cultivation, projected for the expected life of 20 years for each structure and were Rs. 584.56 and Rs. 1735.02; Rs. 1041.91 and Rs. 3374.98; Rs. 392.4 and Rs. 2135.7 thousands for small dam during 1992-93 and 2011-12; lift irrigation during 1994-95 and 2013-14; Makowal type structure during 1996-97 and 2015-16, respectively. Benefit cost-ratios were more than one and net present worth were Rs. 101.26, Rs. 1599.73 and Rs.377 at 40 per cent discount rate and FIRR was 26.80, 43.90 and 31.82 for small dam, lift irrigation and Makowal type structure respectively. The results of cost-benefit analysis showed that the returns to investment were positive and encourage for more such investment to meet and overcome the problem faced by the inhabitants of Kandi area of Punjab in general and Hoshiarpur district in particular.

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Impact of Drought 2002-03 on the Socio-Economic Condition of Farmers under Rainfed Farming in Raipur District of Chhattisgarh State

Dharam Pal[†]

The study seeks to assess the effect of drought 2002-03 on area, production and productivity of crops, (ii) examine the changes on income and employment of farm family members, (iii) examine the pattern of changes in migration of farm family members and (iv) to suggest policy intervention options in drought affected rainfed farming. The study is confined to Raipur district of Chhattisgarh state and 113 sample farm households were selected from Rohra and Tarpongi villages of Simga and Tilda blocks of Raipur district. To understand the serious repercussion of drought 2002-03 on farm economy of rainfed agriculture, a drought year 2002-03 as well as a normal year 2001-02 formed part of the study. The employment on on-farm and off-farm activities was found to be 20.65 and 52.70 per cent less in drought year 2002-03. Although, the farming community noticed the structural changes in income and employment during drought year, non-farm employment opportunities were negligible. As mono-cropped rainfed rice production system does not provide employment throughout the year and migration is common phenomenon among the members of farm families but migration was comparatively more in drought year. The study confirms that drought 2002-03 has adversely affected the livelihood of farming community. The trend in the income was reverse with respect to farm size holdings, irrespective of jobs. The empirical findings envisaged that the area under *kharif* crop was affected comparatively less than that of area under *rabi* crops in drought year over normal year. The production and productivity of rice in drought year declined drastically in drought year as compared to normal year.

The following policy interventions options are suggested: those farmers having assured irrigation facilities should adopt the flexible crop plan, water harvesting technologies should be adopted at the time of monsoon months, the State Government of Chhattisgarh launched some of the beneficial minor irrigation schemes to marginal and small farmers like Shakambhari Yojna, Rajeev Gandhi Jal Grahani Pariyojna, and farmers should take advantage of these schemes for generating irrigation facilities. As a good quantum of rainfall is received in the state, it is suggested that the state government should undertake construction of big dams through inviting the private and public expenditure sources. Besides public distribution system should be strengthened by developing good network and efficiency.

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Impact of Watershed Development Programme in the Rainfed Area in Indore District of Madhya Pradesh

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The paper attempts to examine the impact of watershed development programme in the rainfed area in Indore district of Madhya Pradesh. The specific objectives were to study the cropping intensity, production, cost and returns and input-output ratio on farms of different sizes in watershed development programme (WDP) and non-WDP areas. A multi-stage random sampling technique was adopted. The Gaudi Palasia micro watershed in Mhow block of Indore district was selected under the WDP area. A sample of 40 cultivators consisting of 20 small (less than 2 ha), 12 medium (2.1 to 4 ha) and 8 large (4.1 and above ha) farmers each were selected randomly from the list of total cultivators in the village of watershed area and non-watershed areas respectively. The study pertained to the year 2006-07. The analysis showed that the average cropping intensity was higher in WDP than in non-WDP area. The average yields per hectare of soybean, maize, wheat and potato were 19.50, 28.50, 35.40 and 184 quintals, respectively, in WDP area as compared to 17.50, 23.50, 28.70 and 152 quintals in non-WDP area. The average cost of production per quintal of soybean, maize, wheat and potato worked out at Rs.956.00, Rs.411.00, Rs.587.60 and Rs.311.00, respectively in WDP area as compared to Rs.976.00, Rs.412.00, Rs.588.28 and Rs.335.00 in non-WDP area. The average cost of production per quintal of soybean, maize, wheat and potato worked out to be lower in WDP area than in non-WDP area. The average benefit-cost ratio was higher for soybean, maize, wheat and potato in WDP area as compared to non-WDP area. The farmers in WDP area adopted improved technology due to financial assistance provided to them through subsidy and they used higher level of farm inputs which resulted in increased incomes. The analysis indicated that more importance should be given to encourage the adoption of recommended package of practices, developing suitable improved varieties of cereals, pulses, oilseeds and potato (less water consuming crops) which would increase not only the income but also enrich the soil fertility. The study revealed that the WDP is one of the most important strategies to bring socio-economic change in the rainfed system. Overall there has been a positive impact due to adoption of WDP in raising the level of income, employment and productivity of various crops in watershed area on small, medium and large farms. In some of the regions, it has silently revolutionised the agriculture and allied sectors through various technological interventions, particularly soil and water conservation, and crop diversification. For WDP, location-specific technologies are available. There is an overwhelming policy and political support. The only problem reported is lack of appropriate institutional arrangement. Therefore earnest efforts to enthuse

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stakeholders for their voluntary participation would sustain watershed development and bring prosperity in the rainfed areas. Institutionalising participatory monitoring and evaluation at watershed level is vital. Also, the local villagers' should be given proper training in monitoring and evaluation aspects. The study suggests measures like adoption of land, soil and water conservation practices by the farmers, better co-ordination among government functionaries, better co-ordination between development agencies and voluntary organisations and land development activities for effective implementation of WDP in rainfed areas. The periodic evaluation of watershed development programme is essential in order to measure the progress of work to make it more effective, share the experiences and compare with the programme of others and assess the strengths and weaknesses and improve the activities.

An Econometric Accountability for Productivity Differential in Dryland Agriculture of Bundelkhand Region of Uttar Pradesh

R.B. Singh[†]

The present paper deals with the sources of productivity differentials between two distinct production technologies in ragi enterprises of Uttar Pradesh. It is clear that ragi production in Bundelkhand region is governed by non-neutral technical change so far as varietal change is concerned, technical change appears to be fertiliser and labour saving with respect to change in sowing technique. The major focus of the present study has been to account for productivity differentials of about 23 per cent with the introduction of new planting technique in local variety paddy farms, and of about 45 per cent with the introduction of improved ragi varieties (IRV) in local ragi. For the disentanglement of the total productivity differentials into some meaningful components, an appropriate productivity partitioning model has been formulated, and the mechanics of the model has been illustrated with the analysis of days from dryland dominant Bangalore districts. A recapitulation of some of the major findings of the study is in order. First, the upward shifts in the production function with the introduction of transplanting method of planting and of improved *ragi* varieties have been substantial enough to indicate efficiency gain in production. Further, the technical change that has taken place with the introduction or improved method of planting and of new *ragi* varieties has been indicated to be of Hicks' non-neutral type. This has obvious implications for the demand for inputs and thereby for functional distribution of income. Second, the study has also indicated that more capital services could be employed profitably on both IRV and transplanted local variety (TLV) farms. The main derivative of this finding is that intensive use of dryland equipments leads to higher productivity on these farms. Lower output

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elasticities of fertiliser under IRV and TLV technology farms in the study region would call for more detailed agronomic and economic investigations. Third, the estimated productivity differentials have approximated the actuals in the case of both facets of technical change evaluated in the present study. This lends support to the argument that the productivity partitioning model developed in this study could be effectively used for measuring the contribution of technological and market parameters to productivity growth.

Socio-Economic Impact of Canal Irrigation in Arid Regions of Haryana

R.K. Khatkar*, V.K. Singh* and Anupama**

The study attempts to assess the socio-economic impact of canal irrigation in arid regions of Haryana. For the purpose of study, two districts, Sirsa and Bhiwani were selected and a sample of 100 farmers each comprising 50 each from canal irrigated and non-irrigated farm situations were selected from the two districts. The data were analysed using simple statistical tools. The study concluded that dairy enterprise played a major role in providing gainful employment to the farmers in general and to non-irrigated farmers in particular in arid regions of the study area. The crop enterprise provided higher employment on irrigated farms compared to non-irrigated farms in the study area owing to higher cropping intensity on the former category of farms. Crop farming provided more employment on irrigated farms in comparison to unirrigated farms. Male members got higher employment in crop farming while female members engaged themselves more in livestock sector and household work. Employment through hiring out labour was found higher on unirrigated farms. The per capita per annum consumption expenditure on cereals, pulses and milk was found higher on unirrigated farms while expenditure on education, cloth and health was observed higher on irrigated farms. It indicated the rise in human development index due to introduction of canal irrigation on irrigated farms. The nutrient intake in human diet was found lower on unirrigated farms in comparison to irrigated farms. Some adverse socio-economic effects of introduction of irrigation emerged due to problems of incidence of new pest and diseases in crops, water logging, residual effect of chemicals, incidence of water borne diseases both in human as well as livestock sector after the introduction of canal irrigation in the study areas. A need is suggested to adopt corrective measures through suitable changes in cropping pattern and input use. Water use efficiency needs to be improved through its judicious use in different crop enterprises and other uses in the arid areas.

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Oilseeds in Rainfed India: Prioritising Production Constraints and Implication for Future Research

B.C. Roy and Anjani Kumar[†]

India is the third largest producer of oilseeds in the world. There has been gradual increase in the productivity of oilseed crops over the last three decades. However, the enhancement in the productivity was particularly spectacular in better irrigated environments and in harsh (rainfed/dryland) environments, there was no significant improvement in the productivity. In such environment not only the yields are low but also it fluctuates erratically. Introduction of exotic varieties could not mitigate this problem instead with the intensive foliage and nutrient contents in them they become good recourse for insect pests and disease pathogens. Concerns are raised on increased evidences as well as emergence of new insect pests and disease pathogens for various oilseed crops, particularly for groundnut, soybean, castor and sunflower. Concerns are also being raised on the rising demand supply gaps in oilseeds resulting in higher import dependence. On the other hand, if yield gap statistics are any indication then there exists a large potential to raise productivity of rainfed oilseeds particularly in groundnut and soybeans. Thus, as we move to the next century, additional supplies of oilseeds must come from rainfed areas. Keeping these issues in mind, efforts have been made in this study to delineate major oilseed based production system, to identify production constraints that cause significant production losses, and to rank these constraints in terms of their impact on production losses. The study also explores researchable issues on the basis of prioritised constraints in oilseed based production system under rainfed agro-ecosystem. The findings of the study calls for, among other things, concerted effort in developing high yielding drought tolerant and multiple disease resistant varieties, encouragement of intelligent water management practices, promotion of crop insurance schemes, and a well-developed input-output delivery system for rainfed oilseed system.

Rainfed Agriculture in Orissa – Issues for Policy

R.K. Panda*

The study attempts to analyse the disparity in the agricultural growth between different sub-regions within rainfed region in the state of Orissa and identify the factors for low agricultural performance in the rainfed agriculture. The study is based on secondary data obtained from published sources. Taking into account the definition of the Ministry of Agriculture, Government of India on rainfed agriculture

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(area having less than 30 per cent area under irrigation) 18 districts out of the total 30 districts fall under the category of rainfed region in the state. Further, on the basis of triennium average of actual rainfall over the years 2002-03 to 2004-05, the districts under rainfed region were classified into two sub-regions, viz., the Low Rainfall and High Rainfall Regions. To study the growth performance in agriculture, the data on area, production and yield of major crops/crop-groups grown in the rainfed region were collected and examined. Triennium average on area, production of crops selected is worked out for base and current year to study the growth performance. The log-linear growth model is fitted to the data to get the yield trend of the crops over the period. Multiple regression technique is used to study the poor performance of agriculture for the individual sub-regions as well as rainfed region as a whole. Rice being the principal crop of the region in terms of acreage is taken as the dependent variable and the operational size of holding (XI), actual rainfall during the year 2004-05, percentage of S.C and S.T. population, literacy level, per capita crop loan and road density are the independent variables of study relating to the years 1998-99 to 2004-05. The findings of the study reveal that the agricultural growth performance of the rainfed region as observed from the growth in area, production and yield of major crops selected show some mixed results. For crops like rice and pulses, while growth in terms of area and production is found quite encouraging for oilseeds there is some concern. In case of oilseeds the productivity growth is found to be negative. Between low and high rainfall sub-regions the former is found to be at a greater disadvantageous position over the latter in terms of growth in crop yield. The regression analysis reveals that institutional and infrastructural factors along with rainfall influence low crop yield (rice yield) in the rainfed region. While inadequate rainfall affects rice productivity in the rainfed region as a whole, for high rainfall region, the excess rainfall affect rice yield significantly. The study suggests that more attention to developing water harvesting structures in rainfed region be given along with improving infrastructural facilities and institutional credit delivery mechanism. In the case of high rainfall region along with the developing infrastructural and institutional facilities, there is urgent need to construct field channels to drain excess rain water from crop field. The farmers should be provided extension education in better management of rain water.

Technology Adequacy and Economic Viability in Rainfed Agriculture - A Study on Mustard Farming

Lijo Thomas, A.K. Sharma, Arvind Kumar, S.K. Jha and R.C. Sachan[†]

The study aims to analyse and compare the variations in adaptability and technological rigour of the research outputs developed for rapeseed-mustard under

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irrigated and rainfed farming conditions to determine the impact on economic viability of farming. The data on whole package Frontline Demonstrations (FLDs) conducted under All India Coordinated Research Project (Rapeseed – Mustard) under rainfed and irrigated conditions were used for the study. Data from a total of 1576 FLDs over a period of ten years from 1997-98 to 2006-07 were analysed. Four parameters, namely, Percentage Yield Increase over farmers' practice (% YIOFP), International Benefit cost ratio of demonstrated technologies (IBCR), Percentage increase in Cost of Cultivation of adoption of improved technology (% COC) and Technology Potency (TP) have been used to compare between the technology demonstrated in rainfed and irrigated areas. The results indicate that the yield advantage (% YIOFP) is higher for rainfed demonstrations showing higher relative impact of technology package in rainfed regions. It is also seen that the rainfed FLDs have failed to convert the advantage in yield improvement into real economic advantage due to higher magnitude of cost escalation in technology adoption. The sharply declining technology potency levels in rainfed areas indirectly signals the need to upgrade the technologies for higher visibility and acceptance by the farming community.

Extent and Associates of Crop Diversification in Rainfed Agro-Ecosystem of Madhya Pradesh: District-based Analysis

S.B. Nahatkar*

An attempt is made to examine the extent of crop diversification with the help of Herfindahl index (HI) in districts of Madhya Pradesh using secondary data. The correlation coefficient between HI and net sown area, gross sown area, assured source of irrigation, proportion of agricultural workers to total workers, proportion of small and marginal farmers to total farmers, annual rainfall (mm) and agricultural income is worked out. The results indicate that the maximum number of districts (20) are having either oilseed-cereal (soybean-wheat) or cereal- oilseed (bajra-mustard) based cropping systems when categorised on the basis of index of maximum proportion. Only 11 districts with heavy rainfall are having cereal-based (mainly paddy-wheat) cropping system. The prominently soybean growing districts, viz., Ujjain, Mandsaur and Neemuch have oilseed (mainly soybean) based cropping system. Pulses was predominant in the cropping pattern of only two districts (Narasingshpur and Damoh). The annual agricultural income and crop diversification shows positive association revealing that crop diversification helps in increasing farm income and vice-versa. The maximum number of districts of Madhya Pradesh shows diversified cropping system despite of only 30 per cent of irrigated area, indicating that in rainfed agro-ecosystem diversification took place due to diverse favourable agro-climatic

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conditions and varied soil type (the State is divided into 11 agro-climatic zones). Only few districts, viz., Umariya, Katni, Mandla, Annupur, Balaghat and Shahdol, which are having high rainfall and thus growing paddy in *kharif* as mono-cropping seems to be specialised but these are not actually specialised because productivity of paddy in these districts are still stagnant around 1 tonne/ha. But recently due to introduction of hybrid rice and SRI method of paddy cultivation these districts will turn as specialised paddy growing districts of the State. The factors like increase in net sown area and gross sown area, area under assured irrigation (tube wells and wells) and annual agricultural income will help in diversification of crops in the cropping pattern of different districts of the State. The agricultural income in districts with highly diversified cropping ranged between Rs. 12,625 to Rs. 15025/ha. Net area sown, gross area sown, area under assured irrigation and annual agricultural income is associated with crop diversification while higher number of small and marginal farmers and higher rainfall with uneven distribution of rains will not help in crop diversification in the state. At the same time, in a labour surplus economy of the state, higher proportion of agricultural workers will not help to spread risk through crop diversification.

Economic Feasibility of Sprinkler Irrigation in Bikaner District of Rajasthan

Madhu Sharma[†], Javed Bhati[‡] and Rajesh Sharma[†]

An attempt is made to study the economic feasibility of sprinkler irrigation system vis-à-vis surface irrigation for major crops of *rabi* and *kharif* season in Bikaner district of Rajasthan. Thirty farmers using sprinkler irrigation system and thirty farmers using surface irrigation method (through canal) were selected using multi-stage random sampling technique and in *kharif* season groundnut crop and in *rabi* season gram crop was selected for the study. The secondary data were collected from various published sources. The study observed that the total cost of cultivation of selected crops was marginally higher on sprinkler irrigated farms than on surface irrigated farms. The gross returns, farm business income, returns to labour, net returns, benefit-cost ratio, cropping intensity and per cent area irrigated of total land holdings were higher on sprinkler irrigated farms than on surface irrigated farms for all the selected crops and in all the selected size groups under study.

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Economic Performance and Promotion of Tank Modernisation Programme for Sustaining Rainfed Agriculture

I. Sekar*

A study was conducted in Tamil Nadu state where tank density is more and many tank modernisation programmes were operational, to assess the tank performance and net productivity gain from crops, using before and after approach and also to determine the factors affecting farmers participation in tank modernisation activities. Adjusted tank performance, paddy crop yield, net revenue and irrigation efficiency in the tank command increased after modernisation in both seasons of the crop. Farmers' association and collective action during modernisation phase is active however, it is minimal after the programme ends. Binary logistic regression model employed to examine the factors affecting farmers' participation in tank modernisation programme reveals that targeting young and educated farmers in modernisation can be effective. Caste, extension, and training are found to be significant variables, which can be given due importance while planning and execution of tank modernisation programmes. These study results are of potential use for water policy planners and watershed development planners as irrigation tanks are one of the components of watershed development programmes.

Rainfed Agriculture in India : Analysis across Semi-Arid Regions

S.S. Kalamkar[†]

Indian agriculture in general has shown a spectacular growth in terms of both production and productivity during the last five decades of planned development. As spread of green revolution was highly skewed in favour of certain states and regions, this led to high growth in agricultural output in selected regions while the other regions suffered from stagnancy or poor growth in agricultural output. It is often argued that the new technology of high-yielding varieties which is based on high doses of water and fertiliser is not suitable for rainfed agriculture in general and for semi-arid tropics in particular. Therefore, agriculture in these conditions is reported to be progressing very slow or even stagnating and therefore, needs priority attention as the proposals for growth of Indian agriculture depend to a significant extent on the potential of rainfed agriculture which has not been effectively harnessed so far. The rainfed agriculture plays an important role in Indian economy and contributes significantly in the country's development. In the emerging context of Indian agriculture, the perspective on farmer in rainfed agriculture assumes critical importance because of the growing concern about slow agricultural growth and

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persistence of rural poverty and backwardness. The cropping pattern of rainfed sector is dominated by jowar, bajra, gram, tur, groundnut and cotton crops. The share of rainfed sector in the total production of crops is relatively lower because of low productivity. If the target of over 4 per cent agricultural growth envisaged in the National Agriculture Policy is to be achieved, all areas where rainfed farming is predominant will need to contribute substantially to incremental output and augment food security by producing marketable surplus more reliably by improving productivity and promoting the agri-business activities in rainfed areas. This requires the reorientation of extension system and other institutions working in rainfed areas including their strengthening so that the requirement of the sector can be met.

Poverty and Rainfed Agriculture

S.V. Hariharan and M. Anandan*

An attempt is made in the paper to relate agriculture and poverty in a general framework with available data. The area of rainfed agriculture in most of the states is greater than the irrigated area. Haryana, Punjab and Uttar Pradesh are few states in India where irrigated area is greater than the rainfed area. In the majority of the states, rainfed area forms approximately two-third of cultivated area. Assam, Gujarat, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Orissa, Rajasthan, Sikkim, Tripura and West Bengal are the major states where rainfed area forms more than 75 per cent of the cultivated area. The all India average of percentage of rainfed area is more than 67 per cent. The study observed that the percentage of population living below the poverty line has been declining steadily. However, in most of the cases they do not distinguish between urban and rural poverty. Generally, poverty in rural areas is more severe than the poverty in urban areas and the actual size of population living below the poverty line in rural areas would be many times higher than the size of population below the poverty line in the urban areas. Agricultural yields are more unstable in rainfed areas than areas where irrigation is assured. Hence income of the farmers will also be found to be more unstable in the rainfed areas. Rainfed areas are characterised by higher poverty than irrigated areas. The measures taken by the government have not helped much to increase the income of the farmers and they are not effective enough to reduce the poverty prevailing in the agricultural sector. Much more serious, effective and target oriented measures need to be implemented by the government for the farmers depending on rainfed agriculture

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Optimal Irrigated Agri-business Management in Nigeria: Case Study of Tomato Production Maximisation under Fadama Condition using Irrigation Schedule Approach

A.L.E. Mofoke and S. Kushwaha[†]

An unconstrained optimisation analysis was carried out for tomato production under small-holder irrigation along the Jama'a *fadama* in Zaria, Kaduna State in Nigeria. The optimisation procedure involved a regression analysis of the production function and an iso-profit line. The results revealed an optimum seasonal application depth of 730 mm. The associated optimum irrigation schedule is to irrigate every five days, applying about 33 mm of water each time. The projected optimum crop yield is about 36.7 t/ha. The total production cost at this level is approximately ₦ 729,000/ha (₦ = Naira, the Nigerian currency). However, the generated income is close to ₦ 770,385/ha, giving an attractive profit margin of ₦ 41,385/ha and a Benefit–Cost ratio of 1.06. The optimum irrigation level was found to be very close to the maximum irrigation level of 775 mm of water, the difference between them being only about 5.8 per cent. Also, the optimum yield was found to be 1.1 per cent lower than the maximum yield of 37.09 t/ha. However, the profit obtainable at the optimum irrigation point is up to 12.1 per cent higher than the profit achievable at the maximum irrigation level.

Watershed Programmes and Agricultural Development in Rainfed Areas in Karnataka

M.B. Belavatagi, B.G. Javali and D.C. Math*

The study aims to explore the impact of watershed programme on rainfed agriculture in Koppal district of Karnataka in terms of cultivation of land, cropping pattern, crop yields, change in the livestock and employment generation. Primary data were collected from a sample of 250 farm households comprising 40 per cent of total households of all the three selected villages, namely, Yadiapur of Yalburga taluka, Nageshamhalli of Koppal taluka and Kurubanal of Kustagi taluka during 2000-01 to 2005-06. It focuses on the impact of the watershed programmes mainly on small and marginal farmers. Three watershed programmes were selected in three villages which were started in 1990 and completed in 2003-04. It examines the impact on agriculture before and after the watershed programme. Watershed

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development led to significant changes in the additional area brought under cultivation. It is observed that the area of cultivation increased by 125 per cent. The average yield per acre increased from 457 kgs to 813 kgs and employment opportunities increased by 67.40 per cent. Similarly the income of the households increased by 102 per cent. The generation of employment opportunities has reduced the migration. Thus the field survey shows that watershed project has improved the infrastructure in the sample villages and thereby watershed development will certainly go a long way in the development of rainfed agriculture.

Rainfed Agriculture in India: Concept, Opportunities and Challenges

S.P. Bhardwaj[†]

Livestock systems, crop-livestock systems, and crop systems are all important components of dryland agriculture. The most important opportunity for improving water management in dryland cropping systems is increasing the use of crop residues as surface mulch, but this has also the most serious constraint. It is a constraint not only because there is not sufficient residue produced in dry years, but in many developing countries, crop residues are commonly removed from the land and used for animal feed or household fuel. In many developing countries, the rapid increase in population is closely linked to soil degradation and this is particularly true in dryland regions. Indian agriculture is predominantly a rainfed agriculture under which both dry farming and dry land agriculture are included. Out of the 143 million ha of total cultivated area in the country, nearly 70 per cent area are rainfed. In dryland areas, variation in amount and distribution of rainfed influence the crop production as well as the socio-economic conditions of the farmers. The dryland areas of the country contribute about 42 per cent of the total foodgrain production. These areas produce 75 per cent of pulses and more than 90 per cent of sorghum, millet, groundnut and pulses from arid and semi-arid regions. Most of the coarse grains like sorghum, pearl millet, finger millet and other millets are grown in dry lands only. Investments in rainfed agriculture have large payoffs in yield improvements and poverty alleviation through income generation and environmental sustainability. The major problem which the farmers have to face very often is to keep the crop plants alive and to get some better economic returns from the crop production. But this single problem is influenced by several factors. There is an urgent need for widening the policy scope to include explicit strategies for water management in rainfed agriculture, including grazing and forest systems. Attention to land tenure, water ownership, and market access is also needed to ensure the full benefits from water management interventions. Even after utilising all the available water resources, about 50 per cent of our cultivable area is still dependent on rains.

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Therefore, our agricultural scientists, policy formulators and farmers should appropriately realise the magnitude of the role that rainfed agriculture or dryland farming can play. They should thoroughly examine the problems of dryland agriculture from different viewpoints and evolve appropriate technologies, crop varieties, etc., for these areas to improve the economic position of the farmers. The study emphasises the need to be extra careful about the utilisation of available rainwater, selection of crops and protection of crops from different harmful physiological or biological agents, only then one can make dry farming as profitable as irrigation farming itself.

A Comparative Socio-Economic Analysis of Potato Cultivation under Irrigated and Rainfed Agriculture of Himachal Pradesh

Arun Pandit*, Anil Kumar*, Rajesh K. Rana*, N.K. Pandey* and N.R. Kumar**

The present study was undertaken in Kangra (irrigated) and Mandi (rainfed) districts of the state during 2005-06 to study the socio-economic conditions of potato cultivators in Himachal Pradesh under two distinct conditions, viz., irrigated and rainfed. The socio-economic indicators were worked out to assess the socio-economic status of the farmers in the study area. Overall adoption of potato technologies was worked out by assigning weights of different technologies as per their contribution to the overall potato yield. The study found that the farmers of irrigated area allocated higher proportion of cultivated land for potato, had more non-farm income and grew mainly Kufri Jyoti variety of potato. On the other hand, farmers of rainfed area grew some other varieties, albeit to a lesser extent, in addition to K. Jyoti and they had lower adoption rates of technology. Regression analysis revealed that one per cent increase in the adoption of potato production technologies would increase potato yield by 0.96 and 0.88 per cent in irrigated and rainfed areas, respectively. Lack of sufficient quantity of healthy seed, followed by lack of late blight forecast mechanism, non-efficiency of Mancozeb against late blight were the major constraints faced by potato farmers of both irrigated and rainfed regions. Shortage of capital, PTM, cut worm, white grub infestations in irrigated area and lack of technical know-how about scientific potato cultivation, scarcity of water for irrigation and marketing problems in rainfed area are some of the other problems. Extension functionaries should impress upon the farmers to adopt new potato varieties such as K. Himalini, etc. which possess different degree of late blight resistance. State government should formulate guidelines and mechanism of contract farming in order to safeguard the interests of the farmers against powerful potato processing

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companies. Government can declare Mandi as 'seed zone' and develop proper market infrastructure to upgrade the socio-economic condition of the potato farmers.

Economic Analysis of Arable Crops Production in Kachchh District of Arid Gujarat

Khem Chand, B.L. Jangid and S.P. Vyas[†]

The objectives of the study are (i) to work out the cost of cultivation of major arable crops in arid Kachchh district of Gujarat. The study is based on primary and secondary sources of data. A total of 60 farmers having assured irrigation facilities were randomly selected from five selected villages of the study district. Multistage stratified random sampling technique was used for selecting talukas, villages and sample households. In Kachchh district farmers were cultivating pearl millet, groundnut, sesame, cotton, castor and vegetables in *kharif* season and wheat, mustard and coriander in *rabi* season. Except wheat and pearl millet all other crops were cultivated for market purpose. Farmers incurred highest cost in cultivation of cotton and coriander crop per ha in *kharif* and *rabi* season, respectively. The farmers were getting highest net returns of Rs. 44,408 with B:C ratio of 2.32 from cultivation of cotton followed by groundnut and castor among *kharif* season crops while wheat followed by coriander recorded highest net returns in *rabi* crops. It is concluded that production of all the major crops found place in the cropping pattern of Kachchh district and was economically viable having B:C ratio more than unity. The farmers were allotting more area to those crops which were giving higher net returns with high B:C ratio and vice-versa. It implies that farmers in Kachchh region are well aware of limited agriculture resources and invested in them to get the maximum returns. But in the fragile agro-ecosystem of Kachchh district where ground water is depleting at an alarming rate cultivation of arable crops on sustainable basis requires adoption of modern efficient irrigation methods, viz., drip irrigation system and micro sprinkler and sprinkler irrigation system, etc.

Assessment of Output Risks, Technology Adoption Gaps and Production Constraints of Rainfed Agriculture: A Study of North Bank Plains Zone of Assam

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The study attempts to assess the yield risks associated with the production of important field crops grown under rainfed situation in the North Bank Zone of

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Assam. Six important rainfed field crops of the North Bank Plains (NBP) Zone of the state, viz., sali rice, ahu rice, wheat, rapeseed and mustard jute and sugarcane are selected to assess the output risks, technology adoption gaps and production constraints. The farm level data pertaining to the year 2006-07 were collected from 120 farm households representing medium land, and low land rainfed situations of Sonitpur and Lakhimpur districts of the zone. To assess the relative risks associated with the production of important crops, estimation of random disturbances relating to output was carried out. The variance-covariance matrices of output disturbances were estimated for the selected crop portfolio. Seven numbers of technology components were selected to assess the technology adoption gap of each of the crop. To study the levels of technology adoption, the average gap index for the selected set of technology components for each of the selected crops was computed. Based on farmers response production constraints for the selected crops were identified. The study indicates that in all the selected crops adoption gaps are higher in the low land situation as compared to the medium land situation. Being grown under rainfed situation as expected the adoption gaps in terms of the technology component irrigation (T5) in all the selected crops are in the range of 77.42 per cent in sugarcane grown in medium land to 88.66 per cent in Sali rice grown in low land followed by manuring and fertilisation. The existing production systems of the crops indicate adoption gaps of significant quantum for various technology components which need to be minimised to increase the output of the crops. The risks of sali rice product was due to the fact that the production season of this crop confronts two severe situations first in terms of heavy to very heavy rainfall in certain period and secondly moisture stress in certain period due to less rain fall or no rainfall. In both cases the yield has declined by varying degrees. About 59 per cent of ahu rice and sugarcane farmers and about 46 per cent of sali rice farmers reported non-availability of quality seeds and planting materials as one of the major production constraints. Loss of yield due to moisture stress during reproductive stage, occasional submergence of land due to heavy rainfall and pest and disease problems are the other major yield constraints in case of *sali* rice. High yielding *ahu* rice varieties having semi-tall stature, drought tolerance during seedling stage and temporary dormancy when subjected to continuous rain spell during harvesting time need to be developed and popularised. The expansion of area under wheat would be a positive step towards shift in the paddy-paddy dominant cropping systems to paddy-wheat cropping systems such as early *ahu* - *sali* rice-wheat, provided irrigation system is ensured.