RAPPORTEURS’ REPORTS

Development of Dryland Agriculture: Technological, Institutional, Infrastructural and Policy Imperatives

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INTRODUCTION

In semi-arid and arid regions of India, dry land agriculture has no substitute in providing nutritive food inter alia millets, coarse grains, oilseeds and pulses. Further, the economic opportunities for expansion of irrigated area is limited, and in addition the productivity in irrigated areas has plateaued. The predominant crops in dry lands include coarse cereals (85 per cent), pulses (83 per cent), oilseeds (70 per cent) and cotton (65 per cent) cultivated by bulk of the small and marginal farmers contributing around 44 per cent of the total value of the agricultural output. Dairy, the key complementary activity play a significant role in dry land agriculture accounting around 45 per cent of the total value of output from livestock. Dry land agricultural technologies in India have the legacy of development commencing from AICRP on dry land agriculture followed by CRIDA. Despite research and developmental programmes targeted towards improving the productivity of dry/rainfed crops, the productivity is low varying from 0.8 to 1.0 t/ha and the challenge is in doubling productivity to ensure food and nutritional security (CRIDA Vision 2030). A key driver of productivity growth is the development and adoption of new production technologies along with institutional, infrastructural and policy interventions. However, in relation to technologies in irrigated crops, the institutional, infrastructural and policy support are grossly inadequate. In addition, the rate of adoption of improved technologies in the dry land agriculture is low due to risk and uncertainty, lack of efficient input delivery, support services, post-harvest value addition and poor market linkages. The policy support to dry land agriculture in relation to irrigated agriculture is modest.

The emerging threat to dry land agriculture is climate change leading to frequent droughts, depleting groundwater, infructuous investments on wells, imperfect markets and lack of competitiveness of dry land agriculture. However, the threat to dry land sustenance has deepened further because of rise in non-farm wages which is weaning away employment from dry land, challenging the economic viability of dry

land. The agrarian crisis is deepening in dry land areas, due to adverse terms of trade squeezing net margins. Thus, the focus of dryland farmers is shifting from farm to non-farm activities and migration. In spite of such challenges of the physical and socio-economic environment, dry lands still offer potential economic opportunities, through integrated farming systems. In order to unlock this potential, the technological, institutional, infrastructural and policy support is required for ensuring security to farmers' investment. Groundwater scarcity is emerging as a major constraint jeopardising the performance of dry land agriculture. Thus, water efficient irrigation technologies including efforts to recharge groundwater, augmenting and saving water and energy are the need of the hour. These technologies need to be evaluated for their economic viability. The current electricity and water pricing policies in most states do not encourage wise use of water and energy. Watershed development interventions in dry land development like rainwater harvesting, soil and water conservation including on farm groundwater recharge need to be substantially supported. Further, their economic and social benefits need to be quantified for justification of investments.

The theoretical and empirical research contributions encompassing these issues were invited by the Indian Society of Agricultural Economics (ISAE) to address the technological, institutional, infrastructural and policy imperatives for raising productivity and sustainability in dry land farming focusing on following topics: (1) Drivers and impacts of agrarian crisis in dry lands of India, (2) Economic and social benefits of adoption of micro irrigation (MI) systems for dry land crops, (3) Impacts of electricity and water pricing policies on water and land productivity in dry land farming systems, (4) Analysing the trade-offs in enhancing economic returns from dry land farms with water efficient crops and MI technologies, (5) Economics of in situ water harvesting systems in dry land areas, (6) Institutional interventions and infrastructural support for agricultural development in dry lands. Among the 39 papers received, five are recommended as full length papers and twenty in summary form. The papers did not cover issues pertaining to economics of in-situ water conservation, economics of MI systems, indicating the scale of investments in MI, amortised costs of irrigation given the scarcity of water benefiting dry lands crops.

II

DRIVERS AND IMPACTS OF AGRARIAN CRISIS IN DRY LANDS OF INDIA

Using CACP data for 1971 to 2009, the paper by A. Narayanaamoorthy et al., compares rainfed crops with that of irrigated crops focusing on seven dry land crops, viz., jowar, bajra, maize, tur, gram, groundnut and cotton. The study has the following findings: (1) farmers cultivating cereal crops in rainfed, incurred substantial losses more frequently than in irrigated conditions, (2) unlike cereal crops, pulses are profitable to the farmers in both the conditions. (3) rainfed groundnut in Gujarat was more profitable than in irrigation in Tamil Nadu, (4) Jowar, bajra and
maize were neither profitable under irrigated nor under rainfed conditions, (5) While groundnut and cotton were profitable in both rainfed and irrigated regions, their profit margin is modest. The study attributes that the increased cost of production has reduced the profit margins. However, the relative role of labour and material inputs is ambiguous. The study indicates that farmers cultivating these seven crops in both dry and irrigated have been facing severe crisis due to adverse terms of trade.

A large proportion of the cultivated area in Rajasthan and Gujarat is rainfed vulnerable to food security in drought years. Dry land farmers are unable to generate adequate income and their calorie intake is affected leading to malnutrition. Sumit Mahajan et al., have analysed the effects of prices of different foods on food security in Gujarat and Rajasthan using calorie intake and Real Monthly Per Capita Food Expenditure (MPCFE), as the measure of food security using NSSO 66th Round data on household consumption expenditure in 2009-10. Both ordinary least squares (OLS) and quantile regression are used to estimate the response of rural households to prices of major food products in terms of calorie intake and real MPCFE. The results indicated a strong negative effect of price rise on calorie intake. The negative impact of prices of foods particularly wheat, milk is relatively more on the rich than on the poor households as they have the capability to cut calorie intake in the event of price rise. But this is opposite for coarse cereals. Despite decline in per capita consumption of coarse cereals, pearl millet has remained an important staple for the low and middle income groups in dry regions, but coarse cereals have not been covered under PDS. The food prices particularly milk, wheat and pulses have high positive influence on food expenditure of poor households. The authors argue that prices of pulses and milk need to be stabilised as their prices have been remarkably high. Further pulses need to be included in PDS, as food security of the poor households is seriously compromised, evidenced by alarmingly low consumption of calories due to high prices. This is the failure of PDS in rural areas of dry land states. The government should re-orient the structure of PDS and make it more location-specific. Measures should be taken to stabilise the prices of food products in addition to initiating measures to increase the production.

The decadal diversification and transformation of dry land hill agriculture was analysed by S.P. Saraswat et al., with 2004-05 as the current study year, considering 1959-60 and 1989-90 as benchmark years. Data were collected through structured schedules from 338 village households against the total number of 221 (1989-90) and 124 (1959-60) households using census method. The Herfindhal Index, Ogive Index, Entropy Index, Modified Entropy Index and Composite Entropy Index were used to estimate diversification of agriculture. The study revealed that agriculture is no more the mainstay of village economy as a source of livelihood. Agriculture was the main occupation of 53.2 per cent in 1959-60, but declined to 16.7 per cent in 1989-90 and further to 4.4 per cent in 2004-05. Significant changes in demographic and occupational structure showed that the service sector and non-farm employment have acquired economic importance due to decreased size of holdings, increased the
educational status and opportunities in the service sector. The share of farm income in total household income decreased from 52 per cent in 1959-60 to 25 per cent in 1989-90 and further to 27 per cent in 2004-05. Similarly the proportion of farm employment also dipped significantly from 72 per cent to 40 per cent between 1959 and 1989-90 and later to 29 per cent in 2004-05. The livestock sector also shrunk, as the average animal units decreased from 3.29 to 1.21 per cent in the above period. The analysis of diversification also revealed dominant shift in the cropping pattern towards specialised farming of maize and wheat crops. Improvement of infrastructure, fillip to non-farm sector and positive price policy for pulses, fodder crops and other millets is called for the improvement of village economy.

The study by R.R. Kushawaha et al., have assessed the diffusion of technologies in the dryland crops, viz., cotton, bajra and sorghum in Bundelkhand of Uttar Pradesh. Field data were obtained from 300 farmers with different degrees of technology adoption. Decomposition analysis revealed that in cotton, about 50 per cent of the difference in productivity was due to technical change. A comparison of the marginal productivities with marginal factor costs indicated sub-optimal use of inputs. The technology adoption was positively correlated with the use of female labour particularly hired labour in cotton, bajra and sorghum accompanied by decline in the relative share of family labour.

The study on evaluation of organic farming practices by B. Suresh Reddy revealed that productivity fell by 15 to 20 per cent in the initial years due to shift to organic farming. This was accompanied by significant reduction in input cost, making organic farming economically viable. The additional benefits from fodder and mixed crop products and by-products were also higher in organic farms despite lower productivity. Appreciable crop diversity and crop rotation were discernible in organic farms compared with conventional farms with implication for soil fertility management. The policy support for livestock, especially bullocks and cows for better results in organic farming is crucial.

The dry land crops are hungry and thirsty highlighting the need for application of optimum dose of yield augmenting inputs with, supplementary/protective life saving irrigations for enhancing the productivity. In the semi-arid and arid regions, physical and economic scarcity of water is a serious threat to farm based activities. Due to scarcity, the farmers are coping with adoption of micro irrigation technologies despite being capital intensive. Governments are also supporting micro irrigation by way of subsidies to enable the small and marginal farmers to adopt and reap benefits. The savings in water and electricity with yield enhancement are phenomenal. The extent of water saving depends on the agro-techno-ecological and environmental factors. However, the studies are limited in this area to quantify both positive and negative externalities due to adoption of MI studies.
ECONOMIC AND SOCIAL BENEFITS OF ADOPTION OF MICRO IRRIGATION (MI) SYSTEMS FOR DRY LAND CROPS

In the study on economic benefits from micro irrigation for dry land crops in the eastern dry zone of Karnataka receiving scanty rainfall, M.G. Chandrakanth et al., use slope and intercept dummy variables to quantify the marginal productivity of water in conventional irrigation and drip irrigation. The intercept dummy variable measured the shift in the net returns due to drip irrigation, while the coefficient of the slope dummy variable measured the rate at which the net returns increase due to drip irrigation. Among the farmers using drip irrigation, 36 per cent belonged to marginal category, 51 per cent belonged to small farmers with the proportion of well failure of 33 per cent. The cost of negative externality was Rs. 8404 per drip irrigation farm, while it was Rs. 4590 per conventional irrigation farm. The net returns per acre were the highest in grapes with drip irrigation (Rs. 52084 per acre), the lowest was for mulberry being Rs. 7621 per acre. The economic efficiency was at least 100 per cent higher in drip irrigation farms compared with conventional irrigation farms considering net returns per acre inch (Rs. 1384 in mulberry to Rs. 4723 in grapes), net returns per acre (Rs. 7621 in mulberry to Rs. 52,084 in grapes), and net returns per rupee of groundwater (Rs. 2.88 in mulberry to Rs. 12.84 in grapes).

The shift in the net return per farm due to drip irrigation was Rs. 9911 added to the threshold net return of Rs. 15292, totalling Rs. 25203 on drip irrigation farms. The marginal productivity of groundwater was Rs. 1960 per every acre inch of groundwater applied through drip irrigation. The marginal productivity of groundwater was Rs. 465 per acre inch of groundwater applied through conventional irrigation method. Thus, the marginal productivity of water = Rs. 465 + Rs. 1960 = Rs. 2425 per acre inch. The marginal productivity per acre inch of water in drip irrigation method (Rs. 1960) is 321 per cent higher than that in conventional irrigation (Rs. 465). Using Tobit model, the investment in drip irrigation by farmers is regressed on net return and water used (acre inches) per farm. The results indicated that the minimum investment for drip irrigation was Rs.10,262 per farm with an average drip investment of Rs.15,450 per acre. The log likelihood function was significant with an impressive value of -401. The results indicated that for every acre inch of water saved in drip irrigation, the willingness by farmers to invest on drip irrigation increases by Rs. 932. For every rupee increase in net return per farm, the willingness to pay for drip irrigation increases by 0.23 rupee. Thus, the scarcity value of water, is reflected. Net returns per acre inch of water accounted for 98.75 per cent of the total distance between the two groups of farms in the discriminant function. Thus net returns per acre inch of groundwater is the motivating force for the farmers to shift to drip irrigation. The paper however does not reflect the scale of investments on MI
including the respective amortised costs of irrigation including the social benefits in terms of saved water and energy and social costs in terms of displacement of labour.

The study titled social costs and economic benefits of micro-irrigation systems by Tata Rao, argued that the micro-irrigations systems are economically viable even after accounting all the private costs without subsidy due to surplus benefits from micro-irrigation technologies. It is argued that only large farmers could adopt such capital intensive micro-irrigations technologies and hence subsidies may not be desirable from the view point of equity. However, from the view point of improving water productivity, micro-irrigation is crucial. However, the paper do not empirically substantiate the findings.

Virendra Kumar et al., have assessed the economic viability of sprinkler irrigation for vegetable crops under rainfed situation in temperate high hills of Himachal Pradesh. The vegetables grown with sprinkler irrigation are cauliflower, cabbage, tomato, beans, pea, potato and capsicum. Their average productivity except cauliflower and cabbage were higher than the potential yield of these crops. However, the extent of difference in productivity with and without micro-irrigation is ambiguous. Similarly, the scale of investments on MI for different crops is lacking. The authors claim that the investment on sprinkler irrigation was beneficial as indicated by high discounted benefit-cost ratio and internal rate of return with 50 per cent subsidy. It is concluded that it would be worthwhile to encourage and keep incentivising the use of sprinkler irrigation in vegetable cultivation in Himachal Pradesh.

IV

ECONOMICS OF IN SITU WATER HARVESTING SYSTEMS IN DRY LAND AREAS

Groundwater recharge through rain water harvesting is crucial and water harvesting structures in dry land areas entail capital investments which need to be evaluated for cost effectiveness and resultant benefits. The studies indicated that the creation of water harvesting structures has enabled groundwater recharge, increasing productivity and profitability from groundwater crops. In addition, in-situ moisture conservation led to increased productivity. The discounted cost-benefit analysis indicated that investment on water harvesting structures is financially viable (Nagaraj et al., 2011). The investment analysis of water harvesting structures indicated that for every rupee of present investment on water harvesting structure there is a return of Rs. 2.79 from farm pond and Rs. 2.19 from groundwater recharge (pit). With an impressive IRR of 56 per cent for groundwater recharge for borewells, and 14 per cent from farm ponds, groundwater recharge should be given adequate emphasis in the wake of high probability of well failure (Nagaraj et al., 2011).

In the study by Babu Singh et al., on impact of water harvesting systems in Bundelkhand region of Uttar Pradesh indicated that gross cropped area increased from 148 ha to 299 ha (103 per cent), cropping intensity from 136 to 164 per cent
between pre- and post-implementation period. Further, creation of WHS’s improved access to irrigation, and facilitated utilisation of land for cultivation in post rainy season which otherwise would have remained fallow. The crops productivity increased sharply from 8 qtls to 18 qtls/ha between pre and post watershed implementation period due to in-situ soil and moisture conservation. In addition, there has been spurt in the number of livestock from 265 to 554 in the study period due to increased availability of fodder reflecting diversification of farming system that reduces risk. In this important area, papers were very limited.

V

ANALYSING THE TRADE-OFFS IN ENHANCING ECONOMIC RETURNS FROM DRY LAND FARMS WITH WATER EFFICIENT CROPS AND MI TECHNOLOGIES

The paper by O.P. Singh on hydrological and farming systems impact of water management in Gujarat, has the objective to study the water demand management interventions (Minor Irrigation (MI) technologies such as drip, sprinkler irrigation systems) and analyse the impact of these interventions on livelihood, and impact of water demand management on agricultural surpluses. The primary data base is from Banaskantha and Mehsana districts covering 114 adopter farmers and 51 non-adopter farmers using with-without and before-after minor irrigation technology. There is no indication in the paper regarding how the groundwater cost is measured. The paper concludes that MI adoption has resulted in savings in water and improved crop productivity which are obvious. Net returns from MI irrigated plots are higher than those irrigated by conventional methods for most crops enhancing the farm incomes by Rs. 100,000 per year. The apprehension of the study that MI systems may pose food security threat is unfounded since statistical significance of the MI impact is not performed in the study.

Among dry land kharif cereals, pearl millet is the key crop in the arid and semi-arid regions as also one of the rich nutritious cereals supporting food and nutrition security of poor people and livestock in dry land regions. Thus, according to the paper by Arjinder Kaur et al., improving production, productivity and value addition of pearl millet is crucial for improving the farm economy. The average growth rate of area, production and productivity of principal crops in India during 1994-95 to 2000-01 and 2001-02 to 2011-12 was computed. The area under pearl millet declined over time due to dominance of superior cereals since the inception of new technologies, but its production and productivity has increased due to improved cultivars and hybrids. Procurement details of bajra is lacking on the part of public agencies, but minimum support price as well as harvest prices of this crop has shown an increasing trend. Increasing marketed surplus ratio has indicated acceptability of grain in the changing demand scenario. There has been declining trend in grain consumption in India since 1993-94, in the rural and urban areas. But the share of pearl millet in the
consumption of coarse cereals is increasing over the time. The increasing research in their nutritional value is bound to add to its acceptability in food grains market.

VI
IMPACTS OF ELECTRICITY AND WATER PRICING POLICIES ON WATER AND LAND PRODUCTIVITY IN DRY LAND FARMING SYSTEMS

Dinesh Kumar’s paper indicates a combined physical and economic productivity as returns per cubic meter of water, with a naïve assumption that the numerator is economics and the denominator is physical. The methodology of Kumar et al., (2008) used for estimating the economic value of irrigation water in agriculture for individual farms is ambiguous and not mentioned in the article. The paper indicates that in the north Gujarat, the average size of land holding is higher for tube well owner who are paying power tariff on connected load basis (3.45 ha) as compared to their counterparts with metered connections (2.95 ha). However, there is no great difference between 3.45 ha and 2.95 ha, unless the difference is statistically proved significant. Similarly, there is no appreciable difference between 1.35 ha and 0.94 ha in Uttar Pradesh and south Bihar. As the cost of groundwater in both the regions is crucial since the year of construction is not the same for all wells, the methodology indicated in the paper is ambiguous. For instance, the economic basis for assuming the life of the system as 20 years is unclear along with the discount rate used. The same well life used for both Gujarat, Bihar and Uttar Pradesh is untenable. In addition, in hard rock areas life of wells refers to wells which already yielded and have failed to yield beyond a certain point. Age of wells, refers to wells which are still yielding water at the time of obtaining field data. As well construction year has to be different for farmers in a region and over different states, the method is to compound the cost of well construction to the latest year using the appropriate discount rate (debatable issue) and then amortise the cost over the average life of wells experienced by farmers to obtain the annual cost to which the cost of operation and maintenance be added. The difference in water productivity between farmers with flat rate connection and those with metered connections is not discernible. On the other hand, in Gujarat the water productivity is Rs 6 to Rs 8 per cubic meter, while in Uttar Pradesh, Bihar it is Rs 9 to Rs 13 per cubic meter (Table 6). It is not clear from the paper regarding how and by how much the unit rates charged by diesel pump owners for irrigation services are different than those of electric pump owners. The proportion of area allocated for paddy cultivation range from 22 to 26 per cent in diesel pump wells and 12 to 15 per cent in electrical pump wells and are not very different for well owners and water buyers, unless statistically proved significant. The cost of groundwater per cubic meter ranges from Re. 0.18 to 0.77 for electrical pumps, and Rs. 1.38 to 2.81 for diesel pumps in Uttar Pradesh and Bihar; Rs. 1.07 to Rs. 1.60 for electrical pumps in Gujarat. However, in this paper the cost of negative externality due to high probability of premature and initial well failures due to
Cumulative interference among irrigation wells, a major feature in hard rock areas has not been considered, as the life of the well is assumed as 20 years. Thus, the cost of groundwater is grossly underestimated. Comparatively in Karnataka, part of the hard rock area, the groundwater per cubic meter ranges from Rs. 3 to Rs. 5 per cubic meter, which includes the cost of negative externality due to cumulative interference among wells. Also, from Table 3, other than paddy, wheat, potato, no crop crossed double digit in cropping pattern proportion. This shows that the high diversity of low water intensive crops in the areas studied. Further, there are unrealistic numbers in Table 5. For instance, the depth of irrigation in potato cannot be 192 mm, 2.5 times that of paddy. Also water productivity for maize, berseem and mustard is not mentioned. How and why the water productivity is the highest for potato is also not explained. In addition, how is water productivity measured (Table 6) is not clear. The Table 7 indicates wide differences in pump hours per ha across states and regions. However it does not indicate the differences in volume of water pumped across states. The crop pattern is also not very different across states, as crops such as wheat, paddy (and potato in one instance) have crossed 10 per cent of area in crop pattern. Hence there are no compelling reasons to believe, how and why the pump hours are different other than pro rata, flat rate, water buying, water selling. Table 8, too has unrealistic net income from dairying as Rs. 6000 to Rs. 45000 as net income per day, perhaps this is per year. In addition, one finds unrealistic figures of net income at farm level and per ha. For instance, Rs. 3 lakhs from crops and paltry income from dairy, how the total income is Rs. 7 lakhs, is difficult to be appreciated.

The paper sweepingly concludes that raising power tariffs to achieve efficiency and sustainability of groundwater use is socially and economically viable as farmers facing marginal cost of water and electricity realize higher water productivity, use less groundwater per ha, and realize higher net return per ha. The paper indicates that energy quota for farms, metering and charging for power on pro rata basis using prepaid meters will best manage groundwater. These conclusions need to be further validated by (1) statistical significance of the data used in the results (2) including transaction costs of metering and meter reading of the vastly dispersed groundwater farmers, (3) including relative costs to marginal, small, medium and large farmers, in areas of differing well failure probabilities due to cumulative well interference, as also in areas of varying crop patterns reflecting levels of food security, (4) considering the varying life and age of different types of wells reflecting inter alia, negative externalities, (5) considering the relative efficiency in conventional, drip/sprinkler/micro irrigation methods) (6) considering different rates of groundwater recharge and (7) considering different degrees of urban-periurban influence. In addition, in Bihar and Uttar Pradesh and in most other States, where there is no metering, both the electricity used and the volume of groundwater pumped are mere estimates. In such situations, the water / market prices too do not reflect the true cost of groundwater. In most States, groundwater pumped as well as electricity supplied are estimated as there is no metering. Thus, linear extrapolation of social benefit of
reduced carbon emission of Rs. 709 crores (which is approximately Rs. 284 per well (for all wells in India), or Rs. 1418 per well (for wells of study area) per year is merely a linear estimate.

Thus, electricity subsidy provided, forms the tip of the iceberg of the cost of water, the bulk being the cost of drilling, casing, cabling, piping, pump and also the cost of well failure externality of prematurely failed wells and initially failed wells. Thus, electricity subsidy whatever offered cannot be a windfall gain to groundwater farmers in hard rock areas. Even with metered pricing in Gujarat, the crop patterns as compared with Uttar Pradesh and Bihar, where there is no metered pricing, do not widely differ even after considering the water requirement of crops. Thus, there are no compelling economic reasons to agree with the conclusions of the study.

The paper by Nitin Bassi reviewed the institutional and market based instruments that are now being advocated by scholars and practitioners as potential instruments for sustainable groundwater use. With the hypothesis that users tend to allocate the resources efficiently when it is priced reflecting its marginal cost plus the cost of negative externality, researchers have suggested rational pricing of electricity as a potential fiscal tool for sustainable groundwater use. Many argued that a flat rate based pricing structure in the farm sector creates an incentive to over extract it, as the marginal extraction cost is zero. The findings of the review suggest that enforcement of private and tradable water rights in groundwater can bring about a significant increase in farm outputs, with reduction in aggregate demand for water in agriculture. Further, it was found that flat tariff regime whether rationed or managed has a limited potential to control groundwater and energy use in agriculture. It is crucial to note that low cost groundwater metering has to receive priority rather than electricity metering, since it is possible to educate and convince farmers regarding water budget and economic efficiency of water use, through which electricity use can be estimated, rather than electricity metering. This aspect also covers diesel pump owners, as otherwise they would be excluded.

VII

INSTITUTIONAL INTERVENTIONS AND INFRASTRUCTURAL SUPPORT FOR AGRICULTURAL DEVELOPMENT IN DRY LANDS

Over time dry land research institutes, universities, government have developed several dry land farming practices and tested for their sustainability but farmers seldom adopt them due to certain constraints. The introduction of new crop cultivars and new technologies to enhance productivity in small farms has been the focus in the past four decades. Increased production does not necessarily lead to higher incomes, particularly in situations where prices fluctuate greatly, markets are unorganised and inefficient, market access is limited, or bargaining power is weak. The most common complaint of small farmers in rural India is lack of access to stable markets.
In the study by Nagaraj et al., on the technological and institutional interventions in enhancing livelihood of farmers in SAT areas, it has been empirically demonstrated that in SAT areas, provision of technological and institutional interventions such as jowar-cattle combination in Maharashtra, and pearl millet-buffalo combination in Gujarat, Rajasthan and Haryana along with provision of quality seeds, efficient input delivery and market linkage, can economically benefit farmers substantially. Thus, it is crucial for the policy makers to support sorghum and pearl millet for food and fodder security on rainfed lands. Due to interventions of the HOPE project, there has been significant productivity gain to the tune of 103 per cent in Gujarat, while the productivity gain has been modest in Rajasthan (34 per cent) and Haryana (13 per cent). For rabi sorghum in Maharashtra, the productivity gain is 56 per cent. The net returns per ha increased by at least 200 percent in both Gujarat and Maharashtra, while in Haryana and Rajasthan the increase was 16 per cent and 50 per cent respectively. During the phases of lack of support to millets and coarse cereals, this study amply proves that for semi-arid tropical areas, support to millets, coarse cereals, cattle and buffalo will pave the way for enhancing the food, fodder, livelihood, health and economic security. The paper makes a crucial observation that dry land agriculture is the hope in SAT areas since the potential for irrigation is limited. Thus, dry land agriculture accounts for 58 per cent of net sown area cultivating pulses, oilseeds and millets. But these cannot be contributed by irrigated agriculture. Thus, there is no substitute for crops cultivated in dry land agriculture given the harsh agro-climatic conditions.

The study by M.S. Jairath and P.M. Charyulu have examined the availability of different marketing infrastructure in the dry land areas in arid state of India and offers policy measures for strengthening marketing infrastructure facilities in arid western region of India especially in Rajasthan. Based on secondary data, the study indicated that the available infrastructure like marketing and market information, post-harvest, storage, transport, communication, processing and grading facilities are highly skewed towards irrigated regions. Thus, dry land agriculture has been starved with lack of adequate infrastructure. Thus, there is a greater need for public/co-operative/private partnerships in the areas of agro-processing and value addition, marketing, transport, storage, refrigerated and rapid transportation system in order to stimulate the growth of dryland agriculture.

The problem of food and nutrition security could be effectively addressed by promotion of dry land agriculture with appropriate technological, institutional and policy interventions that stimulate the growth of dry land agriculture. In a study by Rakesh Singh et al., the performance of dry land agriculture was analysed in terms of the crop production pattern and growth trend and variability in area, production, productivity and minimum support price of major crops in SAT and non-SAT states using secondary data for 1986-87 to 2010-11. The variability was high in area, production and yield of crops in SAT states. Due to access to irrigation, area under millets, pulses and oil seeds is falling, while the area under soyabean, wheat and
sugarcane is increasing. Out of the gross value of output, the share of SAT states is around 44 per cent and livestock sector is 45 per cent in India. Further, the authors argue that the crop output of SAT states with low fertiliser use intensity should be treated as organic and accordingly price premium should be provided in order to improve the income of farmers. The safety net programmes should be provided to SAT farmers due to high risk of crop failure along with higher MSP and market support in order to improve the income levels.

An attempt has been made by Jharna Pathak and Itishree Pattnaik to examine the growth and instability of agricultural production in seven agro climatic regions covering 24 districts of Gujarat in three different time periods 1980-89, 1990-99 and 2000-2009. The instability index was computed to ascertain whether instability has increased in the period characterised by varying growth rates. Overall the analysis shows that in Gujarat along with increase in the growth rates, the instability also increased in the recent decade. Growth has eschewed southern Gujarat represented by south hills. The state which is highly dominated with semi-arid climate has shifted its focus from high growth-heavy rainfall zone to other regions by extending the irrigation coverage through groundwater irrigation. This has led to extensive use of groundwater in the semi-arid regions posing serious concerns towards its sustainability. The analysis shows that cropping pattern in Gujarat has undergone changes in favour of non-food crops (from 48 to 57 per cent) like cotton, groundnut and castor. The study also indicates that development of irrigation and associated new technology during last decade has not been effective in curbing the instability in crop production in the state as well as in different regions.

The study by M.H. Wani et al., is undertaken with the hypothesis that improved maize composites have raised livelihood status of dry land farmers of uplands of Kashmir valley. The authors use Technology Adoption Index (TAI) = (1/4)* [(Actual seed used/recommended seed rate) + (Actual nitrogen used/recommended nitrogen) + (Actual phosphorus used/recommended phosphorus) + (Actual potassium used/recommended potassium)]/100. However, there is no justification for using 25 per cent for the different factors. Also in the area receiving rainfall of a meager 150 mm, how the farmers have access to irrigation is a major question. Even with impressive R², the reasons for a large intercept of Technology Adoption Index of 3 to 6.30 especially in the Central C6 and South C8 regions in the first two levels of adoption categories (as in Table 1) is difficult to comprehend. Also there may be the likelihood of multicollinearity between family and female literacy, livestock capital and capital on the farm needs. In the economic surplus approach, it is not possible to have a linear supply function with unitary elasticity, since for a linear function, the elasticity varies at every point, unless it is a log linear function. The same comment holds good for demand function assumed to be linearly inelastic. When the authors have preselected sample of adopters and non adopters, assigning 1 for adopters and 0 for non adopters, using the probit model is not tenable, since this is conditioned by a loss ratio of 1.00 (where p = (1-p)). Maize being an almost commercial crop, why the
marketable surplus forms less than 20 percent of the output cannot be comprehended (Table 3). The partial budgeting analysis does not indicate the additional over the check or control variety (Table 4). With such a low rainfall of 150 mm, how the elasticity of supply is assumed as 0.65, as also how the elasticity of demand of 0.5 is considered to be lower than the elasticity of supply has no rationale. Maize in India is catching up, largely due to the market integration with poultry feed. However, the study does not indicate the economic scenario in Kashmir which is enabling Maize adoption and the economic policies required for upscaling maize in Kashmir for the benefit of farmers.

Among dry land crops, pulses play a key role not only from the view point of nutrition security but also from the view point of improving soil fertility. In addition, they also provide excellent feed for livestock. India is the largest producer, consumer, importer and processor of pulses in the world. Despite the largest production of pulses in India, import of pulses is surging and is a cause of concern. Since pulses are grown in the dryland conditions its performance has been fluctuating greatly. Among pulses, chick pea occupies over 48 per cent of total production in the country. Brahm Prakash and A.K. Sharma have attempted to analyse the dynamics of resource allocation to chick pea production at national and dry land region describing the technological imperatives for improving its production in the dry land areas and suggest suitable institutional, infrasstructural and policy measures for increasing chick pea production. Based on the secondary data, the study revealed that there have been concerted research efforts in crop improvement and management practices resulting in enhanced productivity. So far, more than 125 varieties have been released through NARS which are resistant to biotic and abiotic stress and adopted in different agro ecological zones. Despite all these efforts, the chick pea production could not increase to the desired level due to poor adoption of improved technologies, lack of appropriate farm implements for dry land agriculture, huge post harvest losses, lack of market infrastructure and long chain of intermediaries leading to market inefficiency. In order to improve the profitability of chickpea, the study suggests contract farming with backward and forward linkages, tie-up with retail chains, consolidation of supply chain and creation of facilities for processing that adds more value.

Supply response has been a crucial research issue in India since the introduction of policy reforms in the agricultural sector. Resource allocation is influenced by government interventions. In a study on supply response analysis of major pulse crops in India by S.M. Vembu et al., the extent to which farmers respond to economic incentives for gram, arhar, urad and mung was studied. Gram, wheat, rapeseed and mustard were the potential competitive crops. In the case of arhar, rice revenue growth negatively influenced the production. The findings suggest that, yield is a significant variable in the selected pulse crops, implying in the long run, the stagnation can be overcome by varietal development and improvements in cultivation practices. Cereal crops are competitors of major pulses. However, cereals are not
competitive for black gram and green gram. The prices of pulses have been increasing during the past few years. However, producers are still not attracted towards pulses cultivation. The reason for this may be the relative difference in revenue generated from pulse crops and their competing crops. To increase pulse production, either technological change has to be brought about or the prices of pulses have to be increased to such an extent that revenue from a pulse crop becomes higher than that from its competing crops.

Watershed development for dry land agriculture is both a productive and protective infrastructure similar to surface irrigation for irrigated agriculture. Some of the interventions like in situ soil and moisture conservation, rainwater harvesting for groundwater recharge, plantation of dryland horticultural crops have received greater social acceptability. The institutional interventions in terms of formation of self help groups with less investments have proved worthy in generating alternative sources of income. Further, this has helped in capacity building of local people's institutions to take over the future maintenance. The impact of watershed project attempted by Subhash Chand et al. has been encouraging in terms of technological, socio-economic and participatory aspects and bio physical including tangible and intangible benefits. Therefore, using bottom up approach for development and management of natural resource conservation programmes such as watershed are likely to deliver the dividends for long time.

At the national level, currently the most important rural development programme is Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), serving as a key social protection measure for the poor and vulnerable rural people. MGNREGA has multiple aims such as to create durable assets in rural areas, strengthen the natural resource base, improve farm productivity through better management of soil and water resources, and improve asset base of the rural community. Though some controversies are emerging with implementation of MNREGA such as labour scarcity affecting agriculture, nevertheless it is serving the cause of rural development. The impact of MGNREGS on red gram, jowar and groundnut was assessed by D. Kumaraswamy and C.V. Hanumanthaiah in Karimnagar district of Andhra Pradesh. A sample of 128 farmers was selected comprising equal number of farmers from high and low MGNREGS implemented in mandals of district with equal number of beneficiaries and non-beneficiaries. The results revealed that irrespective of the level of MNREGA expenditure, area under selected crops on sample farms were low. The beneficiaries derived higher proportion of income from livestock than non-beneficiaries. However, the study failed to bring out the tangible and intangible benefits accrued due to implementation of MNREGA in the region by using robust methodologies.

The study by Mruthyunjay Swain has analysed the role of institutional support system in drought management in Western Odisha. The results of the paper reveal that though the institutional support systems have been strengthened over time, the institutional performance in terms of allocating resources and implementing the
development programmes has been dismal, influenced by several factors including the political economy issues. The proportion of households benefitted by different programmes was hardly 12 per cent. The watershed programmes under different schemes implemented did not generate the desired impact in terms of increased cropping intensity and or changes in crop pattern. Though a large number of developmental programmes have been implemented in the drought prone regions, they failed to sustain the benefits due to lack of long term vision.

Though the small WHS have proved to be economically feasible, poverty and low economic status of farmers constrained to invest on WHS. Further, lack of marketing facilities coupled with the problem of credit availability and shortage of power supply for lifting groundwater precluded cultivation of dry land commercial crops like cotton.

An attempt has been made by M.M. Rajpoot et al. to study the agrisilvopastoral farming systems for optimising forage and energy resources in rainfed areas of Bundelkhand region of Uttar Pradesh. The agrisilvopastoral systems involve croplands, forests and animal husbandry with interdependence on each other involving flow of products for sustaining productivity and human welfare. The paper provided more of technical/cultural details than empirical details and lacks rigorous economic analysis in order to recommend the most economically viable farming system. However, based on review studies it is quoted that for establishing a silvipastural system with a considering a time horizon of 10 years, the discounted B:C ratio was 2.56 with an IRR of 34 per cent.

Considering the focus of the papers submitted for the conference including the summaries, the following issues have been drawn up for discussion in the session.

1. Economic feasibility of dry land agriculture areas focusing on the variants *inter alia* size of holdings, crops, integrated farming systems, technologies adopted, governmental support, governance, levels of adoption of technologies, off farm employment, wage rates, in the period of post economic liberalisation will reflect the predicament of economic viability of marginal and small farmers in agriculture.

2. Hard rock areas (HRA) are fraught with negative externality in groundwater irrigation due to cumulative interference of irrigation wells. As comprehensive studies in different parts of HRA considering both scientific measurement of groundwater extracted across variants *inter alia* in levels of use of energy (electricity/diesel), well depths, HP of pumps, externalities, size group of holdings, crop patterns, well failure probabilities, urban periurban influence, water requirement of crops, technologies in water use (drip/sprinkler/flow) market forces (demand - supply factors), levels of availability of electricity, economic scarcity of labor, transaction costs of metering and meter reading, (gender) equity and efficiency considerations, and the relative comparison with appropriate variants in use of surface water for irrigation, are lacking, there are no compelling reasons to accept the
hypothesis that marginal cost of water/electricity/diesel will bring efficiency in groundwater use in irrigation.

3. Methodological issues especially in sampling for drawing contrasts are crucial determinants of the use of methods analysis. For instance the caveats in using limited independent variable models (logit/probit) for predrawn sampling criteria needs attention of the researchers.

4. Issues in the use and interpretation of intercept and slope dummy variables in econometric analysis reflecting the contributions of natural resources as well as the technologies in their use, focusing on water, the most scarce resource in dry land areas need focus.

5. Economic appraisal of investment on deepening bore-wells/additional bore-wells and depleting groundwater versus investing on micro-irrigation technologies and conserving water and energy is crucial. Estimating the rate of returns to the lifesaving/stress relieving irrigations in the case of dry land crops provides crucial information on water use efficiency.

6. How to attribute the incremental benefits accrued after MI adoption entirely to the technology, or the risk farmers are willing to take by adopting a new crop. Why the MI technologies have been spreading very fast in some regions and not in other regions. Whether large scale adoption of MI for cash crops, will lead to decline in area under coarse cereals leading to regional food insecurity?

7. Trade-offs analysis of augmenting productivity in dry land crops through natural resource conservation with incentives through price and market support vs enhancing productivity through input and resource intensification.

8. The size of investments on institutional and infrastructural interventions vs rate of returns to such interventions for dry land crops.

9. Increasing farm income in dry lands vs stabilising farm incomes.

10. Implications of groundwater scarcity, labour scarcity, pricing of water and energy on farm economy.

REFERENCES