Agriculture, Technology, Livelihoods, and Employment in India: Debates, Issues, and Concerns[1]

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Abstract
The lack of technological transformation in agriculture has drastically reduced income earning opportunities .The sector is still plagued by several challenges related to widespread rural poverty, natural resource degradation and attaining competitiveness in the increasingly globalized economy. Adoption of innovative technologies can lead to sustainable utilisation of labour, particularly in the arid and semi-arid regions, as evidenced by the paper. A holistic and system-wide approach is required in the diagnosis of constraints and opportunities for productivity improvement, employment generation, and poverty reduction.

Introduction
Agriculture in India is perennially regarded as being in a state of crisis. Farmers' suicides, frequent movements over remunerative prices, persistent high rates of poverty among peasants (especially small holders) and landless labour, relatively low rates of productivity, and the fluctuating employment potential of agriculture all seem to support the dominant notions of agrarian crisis. And yet, since the time of independence, overall agricultural production has increased and stabilized leading to national (but not household) food security, reduced dependence on food imports, and increased exports of food and non-food crops. Widespread technology adoption and technological transformation, significant crop diversification, enhanced agricultural intensification, increased access to inputs, and increases in labour productivity all partially explain the changes in total factor productivity in agriculture. However, such changes are largely restricted to pockets with better access to irrigation, stable rainfall, and better soil productivity. The semi-arid and arid regions of the country are largely characterized by subsistence peasant farming, feudal agrarian structure, low factor productivity, high rates of climatic uncertainty, price and market fluctuations, out-migration of labour, and problems of labour shortage.

In the first section of this paper, some major issues pertaining to agricultural technologies – adoption, diffusion, constraints, and impacts are briefly outlined based on a reading of the literature, and from long term field work in the semi-arid tropical regions in India, especially in the state of Maharashtra. Some focused questions regarding agricultural R&D and technological innovation are subsequently posed. The second section contextualizes the key debates that have emerged around the critique of narrow technology and productivity focused agricultural strategies in post-independence India, emphasizing in particular the importance of paying attention to issues of environmental sustainability, collective behavior and social networks, issues of social inequality (in particular gender issues), and, class and agrarian power. The final section of this

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paper uses illustrations from field work in rural Maharashtra to suggest appropriate ways of thinking about agricultural technologies, livelihoods, and employment.

The Indian economy and society has come a long way from the severe food shortages, productivity crisis, agricultural involution, and acute rural poverty of the 1950s and the first half of the 1960s. Agrarian studies as a sub-discipline has a very strong tradition in Indian social sciences, with significant contributions from economists, sociologists, and social anthropologists. The slow and gradual urban transition, adverse terms of trade between rural and urban areas, low public investment in agriculture and related infrastructure, and persistent and stubborn rural poverty in the context of the declining share of agriculture in the GDP, have kept the agrarian question boiling in a political as well as academic sense.

Policy mechanisms over the decades to address the agrarian problem have been multifarious and diverse, but have suffered from the absence of an integrated approach to livelihoods, employment, sustainability, and productivity problems. These include:

- Changes in cropping pattern, i.e. more diversified cropping system
- Agricultural intensification, i.e. bringing more land under cultivation and cultivation in more than one season
- R&D, extension, and diffusion of new technologies for addressing productivity problems as well as problems of coping with drought, water scarcity, poor soil quality, nutrition, market demand etc.
- Addressing issues of factor endowment – irrigation, labour, credit, external inputs (fertilizers, seeds, pesticides) etc.
- Increase in yields and productivity
- Improvement in household asset base
- Land and tenancy reforms
- Increase in minimum wages for agricultural workers
- Increased availability of employment throughout the year
- Reduction in indebtedness and easier availability of credit

In spite of these efforts, the agricultural sector is still plagued by several challenges related to widespread rural poverty, natural resource degradation and attaining competitiveness in the increasingly globalized economy. Much of this relates to the lack of technological change and the unfinished transformation of subsistence-oriented agriculture in marginal environments. Unless new strategies are designed and implemented, these problems not only threaten the sustainability of agriculture and future sources of growth but may also amplify the process of marginalization in agro-economic zones, which did not benefit much from the green revolution.

The challenges mentioned above may be briefly outlined in order to contextualize the relationship between technology, livelihoods, and employment.

Rural poverty

Despite the surplus reserve of grains, food insecurity and child malnutrition in South Asia remain at unacceptably high levels. Owing to the high levels of poverty and unequal access to productive assets, the gains from productivity growth in agriculture were not sufficient to bring down the levels of food insecurity and malnutrition. Because of limited R&D investments and the harsh biophysical conditions that prevail in dryland agriculture, the incidence and depth of rural poverty is often higher in the semi-arid and arid regions. In

marginal areas the productivity of land is low and market access is limited; opportunities for non-farm employment are scarce as well, but show signs of increase in the last decade or so. The rate of productivity growth in agriculture has been much lower than in irrigated regions, with small farmers in the arid and semi-arid regions experiencing low crop yields and high costs of production being adversely affected. As land becomes scarce, some workers also migrate to cities and high production regions in search of employment. Increasing mechanization of production and adoption of less-labor intensive technologies in green revolution areas, however, limits the absorption of migrants from the marginal regions. Marginalization and poverty in arid and semi-arid regions is also associated with increasing scarcity of water, incidence of drought, and degradation of the natural resource base.

Water scarcity and resource degradation

Agriculture and livelihoods in the semi-arid tropics evolved under the influence of biotic (pest and disease incidence) and abiotic (drought) constraints. The most binding abiotic constraints are related to water scarcity and poor fertility of soils. The limited fresh water availability and seasonal variation and unreliability of rainfall particularly make agriculture in the semi-arid regions inherently risky. In rainfed systems of dryland agriculture, the constant risk of drought increases the vulnerability of livelihoods and enhances human insecurity. Since water is vital for crop growth, low and unreliable rainfall makes drought management a key strategy for agricultural development in these regions (Ryan and Spencer, 2002). Future projections indicate that water availability in the semi-arid regions is expected to decline further mainly due to population growth, depletion of aquifers and competition for non-agricultural water use associated with increased urbanization and industrial development (Seckler et al., 1998).

Apart from the tightening water scarcity constraint, degradation of soil resources (due to salinization, waterlogging, soil erosion and nutrient depletion) threatens livelihoods and sustainability of food production across India. The impressive productivity gains in cereal production achieved in the green revolution areas are now showing signs of decline or stagnation. Emerging empirical evidence shows that under intensive rice-wheat monocultures, it is difficult to sustain productivity over a long term. Low land intensification under the green revolution has been associated with buildup of salinity in drier areas and water-logging in wetter areas, depletion of groundwater reserves, soil nutrient imbalance and increased pest buildup (Pingali and Rosegrant, 2001).

Widespread poverty, water scarcity and soil degradation in the SAT, intensification-induced resource degradation problems and associated productivity decline - these necessitate a development strategy which differs from the intensive-monoculture systems of the green revolution, takes into account environmental externalities, and is compatible with the aspirations for more equitable and sustained productivity growth in agriculture. This task becomes more complex given the demands of adapting to globalization.

Globalization and marginalization

With increasing strides towards globalization through domestic market reforms that encourage integration and liberalization of import and export markets, production efficiency and competitiveness of agricultural products is becoming an important policy issue in the agricultural sector (Gulati and Kelley 1999). In the past, macroeconomic policies and R&D investments in many developing countries targeted food security and self-sufficiency in major food products. With increasing openness in the global economy, national self-sufficiency may not be a viable development strategy, as certain food products may be

cheaper to import than to produce them domestically. However, considering agriculture's role as a means of livelihoods for millions of poor people in South Asia, enhancing its competitiveness through cutting average costs of production is critical for the survival of many smallholder farmers.

Investments in small scale irrigation to boost yields and reduce production risk, extension services, and supply of credit facilities and required inputs at the right time are essential for competitiveness of production. In their absence, there is a real risk that globalization may lead to further marginalization and poverty (World Bank, 2002b). Similarly, without adequate investment in productivity-enhancing technologies and basic infrastructure and human resources, arid and semi-arid regions poorly serviced in the past in terms of these investments, may lose out even further as agricultural markets become more liberalized and competitive. Thus globalization and increased market liberalization could further marginalize these areas, potentially leading to worsening poverty and environmental degradation.

Past empirical evidence in agricultural technology development and infrastructural investments in South Asia lends support to this process of marginalization in resource scarce regions. Fan and Hazell (1999) show that adoption of improved varieties, road density, market access (number of rural markets per 1000 km^{-2}), and intensity of fertilizer use are consistently lower in rainfed than in more-favored irrigated districts. The high transaction costs and low productivity of rainfed dryland agriculture affect the relative competitiveness of smallholder crop-livestock production activities in these areas. It will also influence farm-household decision behavior in terms of crop and technology choice and ability to hedge risk, both from the market and from the adverse biophysical environment.

The basic question then is how agriculture in India can be organized or diversified to overcome complex challenges and capture emerging opportunities in such a way that the forces of globalization, and technology, policy and institutional innovations can be harnessed to reduce poverty and resource degradation, and generate employment rather than lead to further marginalization.

Agricultural technology and impacts: critical issues

The gains from the green revolution in agriculture were substantial but had long term adverse ecological consequences, were socially disruptive, confined to a few regions with favourable factors of production, and benefited only a small (upper) section of the peasantry. Studies indicated unequal distribution of benefits from the diffusion of green revolution innovation, related in part to problems of scale neutrality, but also arising from the nature of the factor endowments required to benefit from technology adoption. There were also implications for labour - decreased employment for some sections (especially women), and, increased employment opportunities for men in certain pockets of the country. What explains differences in scale and quality in gaining from an innovation? Does inequality necessarily increase with adoption of an innovation, or does it do so under specific social conditions? Why is there a differential flow of benefits to small, medium and large farmers, and to male and female headed households from adoption of technologies or innovations? Such questions have been raised and resolutions attempted through empirical studies across the Indian sub-continent especially following the classic green revolution studies of the 1970s.

Such questions have also been raised regarding intra-family distributional aspects of technological gains, particularly food and nutrition security for women and children. Gender sensitive technologies are observed to contribute to equitable distribution of benefits within the

household (Kolli and Bantilan 1997). At the household level, factors that facilitate uptake of innovations may be different from those facilitating impact. These in turn might be separate from institutional and community level intervening conditions, which expedite adoption and impact. A comprehension of the typology of households based on access to resources and institutions, and possession of assets is usually lacking both in R&D and technology diffusion strategies. A consideration of household typologies would establish whether poverty impacts and labour are differentiated by types of households or social category, and identify its implications for providing access to technology, and creating enabling conditions for deriving benefits from technology adoption.

Of related interest is the issue of labour use and labour absorption. Some studies indicate that poverty alleviation and food security among the rural poor are enhanced if technology adoption leads to increased labour absorption. What is the impact of adoption on agricultural labourers, who are often the poorest of the poor, and most come from lower caste or *adivasi* backgrounds? Do benefits of technology induced productivity increase trickle down to them? Do skills levels, capabilities and entitlements of agricultural labour go up in response to technology adoption? Do overall employment levels decline or grow? Do technologies reduce drudgery especially for women?

There is increasing evidence to show that the rural poor subsisting on agriculture based livelihoods have been marginalized with reference to state policies, R & D efforts, market and infrastructure development, and provision of other basic social and financial services. With subsistence oriented livelihoods, low levels of resource availability and access, and domination by markets forces, limited social engineering efforts in the form of welfare measures, public distribution of food, employment guarantee schemes, affirmative action programs, and special legal provisions have had little effects. Access to and management of productive water, land and forest resources, livelihood diversification, market linkages and gender equity are key areas which have been ignored by many of the technological interventions. These groups and the regions inhabited by them are at further risk of marginalization and continuing exclusion if left to market forces alone, as current critiques of globalization and agrarian crisis show. This is essentially due to their vulnerability arising from higher exposure to drought conditions, continuing displacement, and risks emanating from other external shocks, as also due to continuing state failure and the constraints of a hierarchical agrarian structure.

State strategies regarding agricultural technologies have not seriously considered the problem of the commons; attention to issues of natural resource governance, and access to resources have been limited, downright hostile, or ill-conceived. Similarly R&D strategies as well as overall agricultural policies have in general failed to take into account the socio-economic characteristics of the rural poor, and the agro-ecological conditions in which they eke out their livelihoods; these become important if agricultural innovations are to be appropriate and relevant, enhancing the possibility of wider adoption and diffusion, and better impacts.

Technology adoption studies and impact analysis in India, have not (unlike in the case of some other countries) attempted to gain insights into broader farming system level changes and their consequences. Such insights are useful if agricultural innovations are to directly address natural resource constraints and problems of degradation in already marginal areas. Establishing the nature and types of impact of agricultural technology adoption hence assumes centrality in research, even as issues of risk reduction and increasing yield and

income stability in the harsh, marginal environments of arid and semi-arid regions become vital R&D priorities.

The foregoing analysis underscores the need to seek out new opportunities, and address old challenges in tackling agrarian crisis in India. The lack of technological transformation in agriculture has drastically reduced income earning opportunities, forcing farmers and agricultural laborers to migrate to urban centers and distant places in search of livelihood opportunities. Frequent recurrence of droughts, depleting water tables and soil degradation are reducing the importance of farming as a source of income and employment. Without strategic intervention, the future of rainfed farmers in the arid and semi-arid regions of India appears limited. So far, neither the crop production technologies nor the resource management technologies were able to make an impact on the rainfed areas, at least on an extent comparable to the one that was witnessed in irrigated areas.

In light of old and emerging issues, research needs to examine and understand limiting factors (technology, policy, market, institutional, structural, etc) and identify future development strategies, which would help identify a R&D role for poverty alleviation and sustainable intensification for rainfed agriculture, along with enhanced employment potential. Dryland agriculture is not a homogenous system; future sources of growth and development opportunities will likely vary across typologies of dryland agricultural and ecological systems. This requires a holistic and system-wide approach in the diagnosis of constraints and opportunities for productivity improvement, employment generation, and poverty reduction. Monitoring changes at different levels (household, community, district, etc) in cropping patterns, in diversification of income-earning opportunities, in the levels of poverty, in livelihood strategies, investment opportunities (including incentives for productivity enhancing and resource conserving investments), and understanding factors that drive these changes is crucial for identification of more sustainable options.

Technology, Agrarian Structure and Agricultural Transformation: Key Problems and Prospects

Technology and productivity focused agricultural strategies in post-independence India have experienced measured success in selected pockets in India as revealed by many studies. Their consequences for employment and livelihoods have been mixed. Overall, such strategies have not been sustainable in ecological and yield terms, and have not displayed the potential to be transferred to other regions due to problems of agrarian power and social structure, inappropriate R&D and extension, and differences in factor endowments. Critics from an environmental perspective have pointed to the severe consequences of green revolution techniques for soil degradation, water depletion and water conflicts, genetic loss, health effects, and ecosystem problems. Gains for labour and employment were limited and adverse for women agricultural workers. Problems of scale neutrality expanded gaps between peasants and farmers with different land holdings. The green revolution being the single largest source of rapid technological transformation in agriculture, studies yielded many insights into the relationship between agrarian power and technology adoption. While certain sections of entrepreneurial peasants adopted such technologies on a large scale, initial optimism about large scale technological transformation of Indian agriculture were belied. This applies whether one looks at conventional technologies or those that are more sustainable, appropriate, and beneficial to small peasants in dryland agriculture.

The classic work of Desai, Rudolph and Rudra on agrarian power and productivity drew attention to the social and political constraints to technology led productivity, labour, and agrarian

transformation in rural India. Likewise the 'mode of production in agriculture' debate (Patnaik 1990) raised larger issues of forced commercialization, adverse terms of trade, and the conditions under which actual agrarian transformation were taking place. More recently, hopes of a MGNREGA led transformation of labour market dynamics have been belied by evidence of rich peasants opting to go for a crop holiday rather than raise agricultural wages (Vakulabharanam and Prasad 2011). It is clear that the existing agrarian structure, enmeshed in deeply hierarchical caste and class inequalities and exploitation, strongly resists change. Technologies, - even unsustainable ones – can be disruptive, and the rural dominant class would promote change only on its own terms.

The expansion of non-farm employment in rural areas puts further pressure to open up agrarian labour markets, but studies are again inconclusive on the long term dynamics of this change, on the nature of non-farm employment, its actual potential to usher in change, and on the reasons for fluctuations in employment potential of this sector (Thomas 2012 and 2014). Political changes are pushing dependent lower castes to seek labour outside of their regions putting further pressure on the labour market, creating labour shortages, but unable to force more favourable conditions for rural labour. On the whole these processes create a situation of flux which require further research, and which complicates the process of strategizing and policy-making for employment generation in agriculture. The large scale fluctuations in women's employment is especially to be noted, and needs explanation (Thomas 2012). Given the feminization of agriculture and rural poverty, the gender dynamics of the labour market and of households are fundamental to any strategy for poverty reduction and women's empowerment, as well as the success of agricultural transformation initiatives.

In addition, gender dynamics and feminization of agriculture also have implications for technology adoption, and the choice of techniques for enhancing productivity and income. Critics of agricultural biotechnology and genetic engineering have tended to suggest that such strategies would disempower farmers and peasants by making them dependent on corporate seed companies, would have deep ecological consequences affecting already fragile agricultural systems, make them passive recipients of inappropriate technologies, and would especially affect women who have traditionally played an important role in the genetic perpetuation and experimentation of crop varieties. Constant learning and innovation are of crucial importance for farmers in developing countries. Women in farm households produce food and other commodities, but also develop knowledge and technology with reference to improving, storing and exchanging seed, and conserving and managing natural resources.

It is in such situations that some activists and scholars working on gender issues in agriculture argue that biotechnology has the promise and potential for rural women. Omvedt and Kelkar (1995) and Mitter (1995) among others argue that biotechnology can contribute to low external input sustainable agriculture and help women contest male domination of technology, as well as support the entry of women into high-tech fields. New options are seen to build on the existing knowledge base and enhance technical skills and knowledge, in the process empowering women. Feminist scholars have argued that a focus on indigenous or traditional knowledge "give women the task of preserving the traditions that oppress them" (Omvedt and Kelkar, 1995) whereas new technologies have the capacity to give them rights and capabilities to overcome their situation. However technologies can be empowering only when women are able to or allowed to use them. Will the advent of modern biotechnology tools and techniques automatically ensure their entry into women's hands? While social institutions play a role in this, technology design is also of significance. What is also important is to focus on those crops that are of importance to women in

managing their households, rather than develop crops which simply yield more cash income from market sales which may be taken away by male household members.

Studies on the role of women in agriculture provided a better understanding of the increasingly complex challenges of food production, farm structure, and rural development, and present women as productive partners, producers of food, traders and family care-takers. Information of this kind, along with concrete data on women's labour potential and availability will help in better design and development of appropriate technologies, cognizant of the role of women in increasing food production and improving the general standard of living of the average peasant household.

Women could achieve much more in food production, provision, and utilization if agricultural researchers, plant scientists, extension agents and policy makers would level the agricultural playing field. Women face an uphill struggle as a result of weak land tenure rights, exclusion from an active role in seed development and selection, neglect by agricultural extension services, and barriers to access complementary inputs such as fertilizer, improved seed, and credit. These impediments are likely to result in foregone agricultural growth through lower crop yields, delayed adoption of new technology and plant varieties, and environmental degradation.

On the issue of agricultural extension, studies and overviews have revealed that public sector extension has had a narrow focus, and has tended to ignore issues of gender, caste, and other forms of inequality. Despite significant innovations and the trying out of different approaches, the link between agricultural R&D and extension has historically been quite weak, and this is more so in dryland, subsistence agriculture, with marginalized peasants and small holders affected the most. Since women, marginal peasants, and agricultural labour already suffer from various forms of exploitation and subordination, and the state's policies on agricultural transformation have not adequately addressed their needs, developing a strategy that address all or many of the above concerns in raising productivity while simultaneously addressing livelihoods and employment issues in a sustainable manner is a huge challenge, but not an insurmountable one. The final section of this paper will briefly showcase a few illustrations which have been elaborated elsewhere. It is hoped that these cases will demonstrate how innovative and imaginative approaches that are collaboratively designed can yield positive solutions to the problems of agricultural livelihoods and employment at the grassroots level.

Agriculture, Technological Change, and Enhancing Livelihood / Employment potential

Stories of agrarian crisis, out-migration of labour, farmers' suicides, and struggles over remunerative price dominate media reports and academic discussion of the rural situation today. However the overall agricultural production scenario itself is not grim, pointing to important contradictions between the state of the agricultural economy, and its consequences for peasant and farm households. Many of the radical critiques of the agrarian crisis tend to be too vague or general, or assume a direct link between globalization of the Indian economy and the nature of the crisis (Parthasarathy 2013). Issues related to agrarian class structure, relations of dependency, labour market dynamics, production relations, and cropping systems are not adequately addressed in these critiques. These studies have gone out of fashion, and studies focusing on adoption and impact of technologies tend to be too narrowly focuses on economic factors and causes / consequences. In this section three case studies are presented which provide insights into the possibilities for a kind of agrarian transformation that can enhance livelihood security and employment potential in agriculture. Institutional transformations, policy support, and

collaborative research, as well as local level cooperative behavior are identified as factors which have contributed to these results[2].

A. Participatory breeding, climate adaptation and farm livelihoods in western Rajasthan

As an arid, dryland area, with frequent droughts, little rainfall and sandy soils, farmers in Western Rajasthan eke out difficult livelihoods. In the early 1990s, an innovative collaborative experiment in farmer participatory breeding of improved pearl millet (*Bajra*) cultivars was started by the International Crops Research Institute for the Semi-Arid Tropics along with the Rajasthan Agricultural University, a local NGO, and farmers in selected villages in Barmer and Ajmer districts. Hybrids varieties of *bajra* were found to be risky and performing poorly given the agro-climatic conditions and unstable weather patterns. Traditional cultivars or landraces performed better in terms of stability of yields, though the yields were lower. The collaborating teams worked with farmers using on-farm breeding and varietal valuation to enable them to breed and select varieties appropriate for the agro-climatic conditions. Several varieties were selected through multiple-year trials. Bureaucratic apathy and the disinterest of the private seed companies resulted in the delay of release and except for one variety, most of these were never officially released. However a study carried out ten years (Parthasarathy and Chopde 2000) after this experimentation revealed significant positive outcomes. Village farm households, especially women, had worked out mechanisms to save seeds year after year such that they had access to an improved choice of varieties to suit the unpredictable climate; as such, households were able to better manage risk through the availability of varieties of different duration to suit the rainfall and temperature pattern. It was observed thatrisk reduction led to greater stability of the cropping system; farmers were able to plan better in advance and take optimal decisions regarding the cropping pattern. More importantly, stability led to yield gains, and especially enabled building up of grain stock for lean years. Decreased risk and higher yields changed the cropping pattern. Farmers chose an optimum mix of cash and subsistence crops, to harvest grain yield for consumption, and cash crops for purchasing other necessities, and investing in factors that lead to higher yields and productivity. Problems of out-migration and labour shortage were addressed by the tradition of labour sharing prevalent in the area. During times of peak labour demand, the *adola* or cooperative labour sharing arrangements between small and medium farmers, involving short-term agricultural working parties, was one way of obtaining large amounts of labour for a short time.

Overall, the sustainability of the farming system was enhanced since *bajra* was an appropriate dryland crop suited to the local soil and climate, requiring less water, and resulted in better utilization of idle labour during drought years.

B. Adoption of short duration pigeonpea (*tur* or *arhar*) in Western Maharashtra

Pigeonpea (*tur* or arhar) has been a staple of subsistence farming in much of peninsular India. While it was historically a long duration crop (160-200 days), efforts have been ongoing since the early 1970s to develop new varieties of shorter duration to fit into cropping systems with more two or more crops per year. These efforts bore fruit with the development of several new short duration pigeonpea (SDP) varieties by the early 1980s. One of these was ICPL 87 - a SDP cultivar (120-130 days duration). It was collaboratively developed by ICRISAT with international scientists and local agricultural universities. After trials in the All India Coordinated Pulses Improvement Project in the early 1980s, the variety was initially

[2] I wish to thak V.K.chopde, Valentine Gandhi, Padmaja, and Lakshmi for assisting me in these research projects.

targeted for release in northern India, for cultivation in rotation with wheat, where due to a mismatch of agro-climatic conditions, it proved unsuitable and not appropriate for the cropping systems of the region. Around 1983, a decision was taken to test it for possible release in peninsular India. ICPL 87 was first introduced during the mid-1980s in the Vidharbha and Marathwada regions in eastern Maharashtra, regions which constitute one of the main pigeonpea-growing areas in India. These areas were targeted by the LEGOFTEN (Legumes On-farm Testing and Nursery) technology transfer program—a part of the Government of India's Technology Mission on Pulses. However this variety was found unsuitable for their cropping system due to agronomic and agro-climatic reasons. Nevertheless, the variety soon spread to the western part of the state due to further efforts of local research and extension networks from around 1990. With the launch of one of the few public programmes for pulses in the country – the NPDP (National Pulses Development Programme), ICPL 87 was one of the varieties recommended under this scheme. As farmers in the irrigated tracts of western Maharashtra cultivating sugarcane and banana were facing problems of sustainability, they began to try a rotation of ICPL 87 along with irrigated crops. Due to several advantages including enhancing soil nutrition, adaptation to drought stress, and shorter duration, it was rapidly adopted across all districts of western Maharashtra by the mid-1990s. Seed production to match demand was a problem despite the official release and seed production by the state owned MSSC. Several of the local cooperatives began participating in seed production in association with MSSC, thus assuring themselves of good returns, as well as meeting their needs in terms of a sustainable crop rotation option. Significant yield and income increases as a result of adoption of the variety were observed. Sustainability gains were also observed in form of improved soil nutrition, leading to significant savings in expenditure on land preparation and fertilizer inputs for the subsequent crop in the plot where pigeonpea was grown (Bantilan and Parthasarathy 1999).

C. Groundnut Production Technology in Umra village, Maharashtra

Groundnut Production Technology (GPT), is a package of practices for dryland cultivation of groundnuts. As a natural resource management (NRM) innovation, the GPT was specifically developed for cultivation of groundnuts in dry areas, to promote cultivation in summer using an improved package of practices which included improved cultivars, as well as soil, water, and nutrient management options. The GPT was collaboratively developed as part of the Government of India’s Oilseeds Technology Mission, and introduced in Umra village of Nanded district in Maharashtra (along with other villages in the groundnut growing districts of the state), as part of LEGOFTEN, an initiative supported by Government of India, the Government of Maharashtra, and agricultural research institutions in the late 1980s. The package had the following objectives:

- Increase the adoption of improved varieties
- Optimize use of fertilizers and encourage the use of micronutrients
- Minimize the need for pesticides and herbicides
- Increase the efficient use of soil moisture, and
- Minimize drudgery for labour, especially women

Early studies revealed significant changes with respect to the gender issue, especially the intra-household distribution of benefits, and changes in access to and control over different post-harvest products (Kolli and Bantilan 1997). Significant impacts on a number of indicators, to diverse social groups were evident during the further research carried out in the late 1990s, ten years after the technology was first introduced in the region (Parthasarathy and Chopde 2000). Adoption of GNPT were seen to have contributed directly to increase in income and yields, and greater stability of the cropping system was achieved. Indirectly, it

enhanced food availability, improved nutrition, and led to crop diversification. Also assets acquired for GNPT in the form of farm equipment and tools were being used for other crops, and have enabled cultivation in other seasons. The increased stability of the farming system expanded choices i.e. increased the freedom of farm housholds to take decisions regarding the cropping pattern (cash vs. subsistence crops or market vs. subsistence orientation, investing in production vs. investing in education, housing, household assets etc.). There were been positive changes in the condition of agricultural labour. Out-migration of labour was replaced by in-migration of labour due to the higher labour intensiveness of the technology package. Employment opportunities for women went up, since many of the operations were done by women as part of the gender division of agricultural labour. It can be seen from the above that a stream of benefits have flowed due to changes resulting from adoption of the GPT package. In carrying out an informal survey to assess impacts, in attempting to find causal relations between technology traits and the perceived impacts, and in the process of unearthing the reasons for lack of impact during an earlier study, research identified the role of collective action in successful adoption and impact in the village. The importance of collective action and of forging unity with members of other social categories was also felt because of the complexity of the technology in terms of more number of operations to be performed and supervised, and hence more dependence on labour. The landowning households therefore consciously attempted to improve relations with the agricultural labour community who were mainly *adivasis*.

This is perhaps a classic case of interdependence arising out of modernization and specialization leading to greater social solidarity, typified as 'organic' solidarity by the classical sociologist Emile Durkheim. For the *lambada* labour households, secure work throughout the year, and employment for more members of each family enabled them to fulfil certain social and community social obligations. Initially, seeds for groundnut as well as for pulses such as chickpeas and pigeonpea were given to the farmers of the village under the LEGOFTEN extension programme. Subsequently seed supply for some of the varieties have been erratic while seeds for some varieties are not available at all since they were not officially released. However, farmers in the village propagated and distributed seeds among themselves, perceiving them to be superior to other varieties.

Conclusion

Agriculture in the fragile, semi-arid tropics faces a vastly changing landscape in a globally competitive environment. Technology is an integral part of agriculture, and will remain a key factor for agriculture in the future. It is recognized that sustained agricultural research and technological improvements are critical in ensuring food security, and reducing poverty and hunger, without irreversible degradation of the natural resource base. The task therefore is to improve productivity and to diversify agriculture and the rural economy in order to create employment and income opportunities that alleviate poverty and deprivation.

With respect to livelihood asset endowments, land and labour are key. Scarcity of land and abundance of labour may result in adoption of labour intensive and land augmenting technologies, and increased intensity of land use. Technology has a key role here in supporting such strategies. These would encourage adoption of improved technologies, and undertaking of yield increasing and resource conserving investments. Increased access to markets would open up more opportunities in the non-farm sector, thus leading to livelihood diversification. In the absence of market access, off farm employment, or scope for out-migration, farmers may be forced to expand and exploit fragile and marginal environments.

The results would include degradation of the commons, encroachment of forest land, and decline in soil fertility levels. Further marginalization of small and marginal farmers is likely.

Choice of livelihood strategies is based on assessment of comparative advantages as determined by the natural resource and livelihood asset endowments of farm households, and prevailing socio-economic, policy and institutional environment. Hence there is a need to understand adaptive responses and changes in livelihood strategies. For this, household decision behaviour under conditions of risk and uncertainty must be understood and explained, which requires longitudinal studies with panel data. Decisions are made on the basis of resource trends, group dynamics, changing institutional norms, policy mechanisms, and broader economic changes including changes resulting from globalization and market liberalization. Decisions regarding livelihood strategies are therefore different for people with differential resource endowments, resource and market access, household characteristics, ability to cope and adapt, and technology availability. The above case studies hopefully show that a collaborative, locally adapted, and appropriate strategy is required to address issues of development, poverty, and employment in Indian agriculture. While a macro-level understanding offers strategies for national agricultural planning, and a better comprehension of broader trends, sustained increases in livelihood stability and employment generation in rural areas require strategies that are locally adapted to address conditions of risk, vulnerability, insecurity, and relations of dominance.

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