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Private Investment in Agricultural Research and International Technology Transfer in India-A Theoretical Investigation.

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Abstract:*Agricultural needs in poor tropical countries differ significantly from those in temper-ate, rich countries. Yet little agricultural research is performed on products for the tropics. Privateresearch is particularly concentrated in rich countries. This is a result of significant failures in themarket for research and development (R&D), in particular, the difficulty of preventing the resale ofseed in developing countries. To encourage private R&D in tropical agriculture, traditional fundingof research may be usefully supplemented by a commitment to reward developers of specific newagricultural technologies. Rewards tied to adoption may be especially useful in increasing up-take.An illustration of how a commitment to reward developers of new agricultural technologies mightwork is provided.*
Keyword*:Agricultural research and development (R&D), private sector R&D, Technology transfer.*

I. Introduction

The present study addresses the questions of future sources of technology for increasing foodand agricultural production by considering the situation in India. This region of the worldis particularly appropriate for studying these questions because of the dynamic changesin population and incomes. How much private research is there and what is it producing?Will the private sector compensate for declining public agricultural research investmentsin India? What can governments do to stimulate private research and protect farmers fromharmful or defective technology? Agribusiness firm's R&D investments were evaluatedin selected developing countries during 1996 and 1998 and compared with data from asimilar study conducted in the mid-1980s. The largest amount of private research was inIndia where investment was about $55 million per year in the mid-1990s, followed byThailand, Malaysia, and China. China's private R&D spending represents less than oneone-hundredth of 1 percent of agricultural gross domestic product. In contrast, in Thai-land and Malaysia, firms spent about 0.1 percent. From the mid-1980s to the mid-1990s,private sector R&D grew in real terms in the countries in our sample. However, at thisrate, private research will not fill the gap needed to support rapid growth in demand foragricultural products. Foreign firms made an important contribution to private research inall of these countries. The most important policy that helped induce this growth was liberalization of industrial policy that allowed private and foreign firms to operate andexpand in agricultural input industries. A second important policy was investments inpublic research. Patents and tax incentives seem to have had little effect so far, but couldbe important in the future.

The future of Indian agriculture will be one of knowledge and technology intensive and wider disseminationof the same cannot be accomplished in isolation. Even though the share of agriculture in GDP has declined to one-fifth from one-half at the time of Independence, agriculture remains the predominant sector in terms ofemployment and livelihood provision for more than half of India's workforce engaged in it as the principaloccupation [9]. Agriculture still contributes significantly to export earnings and supplies raw materials to manyindustries. To achieve a higher rate of agricultural growth in order to meet the demands of increasing population(expected to reach 1.63 billion by 2050), technological advancement will be very critical.

The advances in biotechnology and their integration with plant breeding will pave the way for achievinghigher yield crops. In the significant advances India has made in agriculture during the past half-a-century, the roleof agricultural input industry is very significant. The expansion in the use of seed, fertilizer, agrochemicals, irrigationand agricultural machinery industry has occurred parallel with the growth in productivity of rice, wheat, cotton, corn,sunflower, soybean, sugarcane and vegetables. While the public sector R&D, extension, and seed supply has madesubstantial contributions to food and non-food crops production, agri-business companies have been working withgovernment to reach out to farmers in the supply of agricultural inputs used from sowing to harvest.

Agricultural science has always played a critical role in economic progress in both developed anddeveloping economies. Through agricultural R&D, welfare improvement has been realized in the form of lower foodprices to domestic population, improved nutrition, expansion in rural employment, agricultural

exports andenhanced level of foreign exchange, competitiveness of agricultural commodities in the world markets and stronggrowth linkages with rest of the economy. During the green revolution period, adoption of new technologies hashelped to improve the income distribution across income classes [12].

Royal Agricultural Society of England, founded during 1790s in UK, paved the way for growth ofexperimental farming. Almost 150 years have passed since US public-sector agricultural research and development(R&D) began in earnest with the establishment of the US Department of Agriculture. Subsequently, in USagriculture, Public and Private agricultural R&D played a major role in bringing about changes.

India saw the beginning of scientific farming with the establishment of Department of Agriculture in eachIndian province in 1880 under the British rule. Next step was to establish Imperial Agricultural Research Institute tofoster agricultural research and education and decentralization of agricultural developmental activities to theProvincial Governments in response to Montague–Chelmsford Reform (1919). When the country got independence,in the efforts to develop country's agriculture, promotion of agricultural R&D was considered as the most importantone. The agricultural review team chaired by Dr M.W. Parker of USDA (1963) suggested far-reaching changes inorganization and management of agricultural research in the country.

The research centres across the country came under the one roof of Indian Council of AgriculturalResearch. Corresponding changes occurred at the state level with the transfer of research and education to StateAgricultural Universities (SAUs). All these efforts culminated in the development of agriculture as a modern sectoralong with rest of the economy and agriculture emerged as key sector. This paper highlights the research, confrontsfaced and the benefits that was taken place in Indian agriculture.

Research in Indian Agriculture – Confronts and Achievements

Indian agriculture faces daunting challenges. The constraints of low productivity in agriculture wererealized and thus, central and state governments emphasized the need for accelerated development of agriculture.Despite national food surpluses, wide spread poverty and hunger remain because the growth of agriculture and thenational economy have not adequately benefited the poor, policy reform alone will not be enough to increaseagricultural growth and to make it more equitable. The policy reforms must be accompanied by appropriate andefficient investments in public goods such as rural infrastructure, irrigation, agricultural research and extension,and the education and health of rural people. India has proven in the past that agricultural growth can be successfully achieved with the right public investments, even when economy wide policies were unfavourable towardsagriculture. Thus, India's promise of the future lies in combining policy reform with the right levels and kinds ofpublic investments.

Technological change has been the main engine of agricultural growth in India. Strong empirical evidenceprovides support that high levels of R&D lead to high productivity and therefore improved economic performance.R&D was found to translate into significant rates of return in primary and service sectors, registering as high as 60per cent [2]. The Total Factor Productivity (TFP) growth, which was the main driving force for the overall growth ofagricultural output during 1980s in India, has started slowing down in recent years. Various authors have estimatedgrowth in TFP of agriculture in India [3,6,7]. The growth rates range from 0.9 to 4.0. In few cases, there are negativegrowths also. The slowdown in TFP is a reflection of poor contribution by agricultural research and almost a nearnon-performance by public extension system.

Indian policymakers have created one of the largest agricultural R&D systems in the world. The knowledgeand technologies generated by investment in R&D was primarily responsible for the green revolution and achievingfood security for the huge population. Despite success of green revolution, India still houses one-fourth of theworld's hungry and poor and 40 per cent of the world's malnourished children and women [14]. The NSSO-2005survey revealed that 40 per cent of the farmers would relinquish farming if provided alternate options. This ismainly because the economic viability of farming is threatened.

Private Sector Research in Indian Agriculture

The private sector in India has also made large investments in research and development relevant toagriculture. This investment has increased rap idly over time. The amount of agricultural research and developmentin the private sector is now approximately half the amount in the public sector [3].

The national agricultural R&D system has undergone a structural transformation with the enlarged role ofprivate sector during the past two decades. One of the significant developments is the entry of MNCs making asizeable investment in research on seed, agrochemicals and agricultural machinery.

The private sector investment in agricultural R&D has been accompanied by consolidation of chemical,seed and biotechnology companies. With the decontrol of regulations, the private research expenditure increasedby 70 per cent between 1985 and 1995 [5] in India and the momentum is continuing. In the year 1991, privatesector investment on research was only of 231.7 million and by 2009, the investment got multiplied by almost 14times. The companies which have made investment in agricultural research fall in the categories of seeds,fertilizers, agrochemicals, agricultural machinery and sugar. While machinery, seeds, and agrochemicals

categorieshave shown an increasing trend in R&D investment, fertilizer and sugar companies have not raised the level ofresearch investment over the years.

The liberalization of Indian economy since early 1990s has opened up opportunities for MNCs dealing withagro-inputs, seeds and agricultural machinery to expand their activities in India and many of them have launchedjoint ventures. Thus, the private sector agricultural research has achieved a credible performance contributing toincrease in TFP in Indian agriculture. R&D on fertilizers can be categorized as one relating to fertilizer productionand the other relating to consumption.

On the production side, research comprises fertilizer production processes, product development, andmarket research and supply chain and is carried out by both public sector and private sector R&D units of therespective fertilizer manufacturing companies. Besides 9 large public sector fertilizer companies, 15 private sectorfertilizer companies have established strong in-house R&D centres. Over the years, to ensure that it is wellprepared to meet the challenges of fast-changing world and remain the market leader in the industry, the fertilizerR&D centres are involved in the in-depth surveys to understand the market demand and plan their production.These centres are spearheaded by highly qualified and experienced scientists; engineers and technologists.

Now the emphasis of private sector R&D units of fertilizer companies is on creativity and ingenuity todevelop products most suitable for the end-users. They are also seeking the recognition by the Department ofScientific and Industrial Research, Govt. of India and look for obtaining patents and allow the researchers to publishscientific papers. R&D in micro irrigation is getting priority in investment. Private companies having known the hugemarket ahead for micro irrigation are investing sizeable quantum of funds on R&D in micro irrigation.

Ideas to Innovation and Management of Technology: Changing Face of Indian Agriculture

As the world agriculture and agri-business havebecome more technology reliant, there is anincreasing need for actively monitoring thetechnology requirements, technology innovations andmapping technologies. Technology change potentiallyhas implications for all businesses including agri-business. In case of agriculture and agri-business, theadvances in technologies for increasing input-useefficiency, climate-resilient agriculture, efficient farmmachineries, biotechnology etc., and improvements insupply-chain and value chain make drastic andsignificant changes in terms of business gain as wellas customer satisfaction. The uncertainties in climate,which in turn affect the ability of the land to producefood for increasing populations is a major challengeto the developing countries. In this context,technology management with reliable forecastingoptions can provide information with obvious andimmediate applicability and with significant costimplications. A reliable technology managementsystem will aid a firm that sells products vulnerable tothe effects of technology change to develop a newproduct and set up production lines in accordancewith the change in technology landscape.

Technology management, which inter alia aims atplanning and developing the technological capabilitiesof an organization or a nation, has now occupied thecentre stage of decision-making in many strategicareas. It embraces several interconnected issues suchas: technology policy; technological forecasting andassessment; technology strategy; technology transfer;technology-induced as well as market-oriented R&D;process and product technology and their continuingimprovement; human resource management in termsof innovative capabilities, flexibility and contribution;and technology project management. The management,mapping, transferring and forecasting of technologieswith respect to food, water, energy and theenvironment have attained centre stage in view ofemerging issues on climate change, carbon footprinting, greenhouse gas emission, deterioration inenvironment and water, poverty related livelihood andsocial issues, etc.

Agriculture is and will continue to be the maindriver of India's economic growth. India's agriculturedid extremely well and was on the ascendancy till themid-nineties but after that the growth slowed down.The eighth five year plan period showed a growth rateof 4.8 per cent for agricultural GDP.[17] But since then(1996-97), the growth rate of agricultural GDP hasbeen, on an average, 1.8 per cent per year.[16] On theother hand the farmer has been facing rising inputcosts, declining returns, an uncertain market, threatfrom multinational players and market giants andblurring of distinction between the domestic marketand the international market. Indian agriculture hasalso pulled backwards due to many contradictingconstraints like lack of infrastructure, investment andinfrastructure facilities, fragmented lands, largenumber of intermediaries, lack of suitable supply orvalue chain mechanisms, less scale of value additionand many more. To assist the farmer in thesechanging contexts, new strategies and innovativesolutions are urgently required which in turn willrequire strong technological support. The technologydevelopment process in agricultural sector should notonly be responsive to farmer's needs, but also supportthe rapid changes in global innovations. Hence, theagricultural research system which generatestechnologies has to conduct the business ofagricultural research in an innovative way withstronger measures for collaborative and participatoryresearch and streamlining of the activities with globalchanges.

Apart from generating innovativetechnologies, effort should also be taken to protectand manage these IP/ technologies and ensuremaximum return to the inventors or farmers bytechnology commercialization. Scouting, cataloguing,conserving and protecting indigenous plant varietiesand rural technologies are also important. One of thepre-requisite for achieving these goals is creatingawareness among farmers, rural innovators,researchers, academia and students about thechanging perspective of IP regime and also about itsbenefits as well as necessary precautions.

The constant change in landscape of Indian agro-industries in the dynamic IP regime also needs amention along with the changes in research and ruralinnovations. While Indian industry has beenincreasingly realizing the importance and benefits ofIP creation and protection, the Indian Government hasbeen doing its best in creating a conduciveenvironment by upgrading infrastructure and bringingin policy level initiatives in the country resulting insweeping changes in the IP culture and administrationin the country. However, there is a lack of an enablingenvironment for the corporate sector to work with theacademic sector on joint research/commercialization,largely due to factors as articulated in the report from Indian industry organizations.[13] Some of these are:

(i) Absence of a clear IPR regime governing theownership of intellectual property created throughgovernment funded projects.

(ii) Limited incentives for academic institutions/academicians to partner with corporate bodies andvice-versa.

(iii) Lack of concrete structured processes and systemsfor academic institutions to partner with corporatebodies, leading to an ad-hoc approach and poorvisibility of outcomes.

These challenges can only be overcome by makingways for stronger and vivid IP policies similar to theBayh-Dole Act of USA and proper management oftechnologies. The Bayh-Dole Act introduced in 1980provided impetus to university licensing offices to usestart-up companies to commercialize early stageinventions.[8]The introduction of 'The Protection andUtilization of Public Funded Intellectual PropertyBill, 2008' (Public Funded IP Bill) in the upper houseof Indian Parliament could be a major paradigm shiftin the way the outcome is expected of the publicfunds by researchers in a university or an institute ofhigher education. The bill makes it mandatory forsuch grant recipients for time-bound disclosure and IPprotection of all R&D supported with public funding.[10] However, given the current innovationenvironment in India, it is argued that the Bill wouldlikely be premature. The R&D infrastructure inuniversities, R&D ethos in several R&D institutions,absorptive capacity of its domestic industry,availability of seed capital for entrepreneurship aswell as the overall awareness about IPRs need to bestrengthened considerably before a system asenvisaged under the proposed Bill could have a realimpact.[11] The Bill was shelved in 2011 due toincreasing criticisms and sustained campaign formany amendments. Some thinkers suggest that theGovernment can pursue the objective of the Bill byamending the General Finance Rules (GFR), 2005 bymaking it mandatory for government funding agenciesto permit recipient institutions to protect, own andlicense IP resulting from government funded projects.

IP and Technology Management Framework in Indian NARS

Technological assets of ICAR include a number ofhigh yielding and resilient crop varieties, animal andpoultry breeds and fish strains, packages of improvedcrop and animal husbandry practices, naturalresources management technologies, improved tools,equipment and farm machinery, improved, dairy,poultry and fisheries technologies, post-harvesttechnology, computer software and data sets, andseveral other processes and products of agricultureand allied sectors. Over the years, many innovativetools and techniques have been developed to improvestrategic planning and management process withrespect to agricultural and rural technologies. Recent,advanced and sustainable technologies on agriculture,veterinary, food, water, energy and environment arebeing scouted, catalogued and mapped by ICAR.[18] Subsequently methodology/tools have been developedto link the acquisition of technology to strategicobjectives and associated business and market drivers,enabling effective technology investment decisions.Apart from these, systematic attempts are being madeto anticipate and understand potential direction, rate,characteristics and effects of technological change,innovation, adoption and application in identifiedareas. The institutionalization of IP management inthe ICAR institutes has been able to create the desiredawareness of IP issues and a minimum level of in-house expertise. This needs to be nurtured with theaim to generate an environment in which researcherscome forward with ideas and create an effectiveinnovation system.

All IP related issues within ICAR are managed bya team headed by Assistant Director General (IPR)positioned at New Delhi under the governance of theDirector General, ICAR. Policy support in the areas ofagriculture related IPR and technology management isgiven by its constituent institutes like NationalAcademy of Agricultural Research Management (NAARM)[1], National Centre for AgriculturalEconomics and Policy Research (NCAP)[19] and alsoacademic bodies like National Academy of Agricultural Sciences (NAAS)[20]. As part of policyinitiatives for Intellectual Property Management and Technology Transfer and

Commercialization[21]undertaken by the ICAR and Department ofAgricultural Research and Education (DARE) towardsencouraging agricultural innovations and furthermanagement and commercializing of the technologies,there is now a framework in place.

ITMU, ZTMU and BPD Units

Since the implementation of the XI Plan Scheme,a three-tier IP management mechanism has beenestablished in ICAR. Accordingly, InstituteTechnology Management Units (ITMUs) wereestablished in its 100 institutes as a single-windowmechanism to showcase the intellectual assets ofthe institute and pursue matters related toIP management and transfer/commercialization.Five Zonal Technology Management (ZTM) andBusiness Planning and Development (BPD) unitswere established at the middle-tier, in synergywith the ITMUs, in their respective zones. Twelvenew BPD units have been initiated in 2013-14to promote business incubation and technologycommercialization.36 The IP&TM Unit at the ICARheadquarters performs a key facilitation/coordinationrole and monitors functions for the implementation ofthe scheme as stipulated in the ICAR Guidelines forIntellectual Property Management and TechnologyTransfer/Commercialization[22], 2006.The initiatives of establishing agri-incubators havebegun being instrumental in formulating businesspolicy, plan and developing models for technologycommercialization not only for the institutes wherethey are located, but also for the identified institutesin the respective zone.[22] These efforts by ICAR havebeen successful in creating an institutional mechanismfor commercialization of agriculture researchproducts/technologies generated from public researchinstitutions. The ZTM & BPD units have beensupported to provide the physical infrastructurenecessary for technology incubation and to launchnew business, including laboratory space, and sharedresources such as specialized equipment and technicalsupport services. Appropriate capacity building interms of human resource has also been undertaken byengaging/contracting professional help and providingrequired training to the existing inter-disciplinaryprofessionals in the area of technology managementand enterprise creation. This has led to enhancedproduction, diffusion and use of new andeconomically useful knowledge and provides desiredcredence for further scaling up these components.[21]

National Agricultural Innovation Project (NAIP)

The World Bank funded National AgriculturalInnovation Project (NAIP) with a total budget ofUS$ 250 million has been undertaken by the ICARsince 2007 to pilot and accelerate agricultural andrural innovations in agricultural research. The projectis expected to be complete by the year 2014. One ofthe basic objectives of the project is to give theagricultural research and technology developmentsystem an explicit development and businessperspective through innovative models.[22] Oncompletion of the project, the agricultural researchsystem should be able to support agriculture as abusiness venture and also as a means of securelivelihood of the rural Indian while maintainingexcellence in science.

Agri Innovate India Ltd

Agri Innovate India Limited, a registered companyunder the Companies Act, 1956 is owned by DARE,Government of India. It aims to work on the strengthsof ICAR, which is under DARE and promote thedevelopment and spread of R&D outcomes through IPresource protection, commercialization and forgingpartnerships both nationally and internationally.The company has been set up with an authorizedshare capital of Rs 1000 million with an initial paidup capital of Rs 500 million. The company is anextended independent commercial outfit, whichcapitalises on the vast network of ICAR institutes,where the researchers innovate and harness science toprovide access to food, nutrition, livelihood andincome security for all engaged in agriculture and itsallied sectors. The company through a corporateframework should add to the availability of suchquality products and services in the market and takeinitiatives for global brand building. The majorobjective of the company is protection andmanagement of IP generated in the system and itscommercialization/ distribution for public benefit.

Other Initiatives from ICAR

The ICAR has more recently focused on demandbased research and technology developmentwith creation of its own innovation systems. Thisis because, the general focus on strengthenedresearch systems while increasing the supply ofnew knowledge and technology, may not necessarilyimprove the capacity of in-house innovationmechanism. The research activities that takeplace within NARS albeit within the context ofits external linkages and government policies arejust one component of the innovative systemand therefore there is a need to revisit them time-to-time based on the global changes in market,technologies and innovations. In general, theadvantages of any innovation system are based onthe ability of an organization to (a) successfullydefine its scope, (b) manage and coordinatetechnology within the organization as well asin relation to stakeholders, and (c) be aware ofmarket demand characteristics and respond to themappropriately. In this context, apart from frequentfarmer interfaces, the ICAR has initiated comprehensiveconsultations with other

stakeholders throughICAR industry meets, interaction meets withNGOs and farm entrepreneurs and agri-tech investor meets, etc.[18,21]

New Initiatives and Processes in IP Resource and Technology Management in India

Apart from ICAR, many other governmentalagencies and departments, professional societiesand NGOs have taken up initiatives in IP andtechnology management both in national as well as inregional perspective.

Technology Information, Forecasting and Assessment Council (TIFAC)

The Technology Information, Forecasting andAssessment Council is an autonomous organizationset up in 1988 under the Department of Science &Technology (DST), Government of India to lookahead in technologies, assess technology trajectories,and support innovation by network actions in selectedtechnology areas of national importance. TIFAC[23]embarked upon the task of formulating a technologyvision for the country in emerging technology areas.The Women Scientists Scholarship Scheme (WOS-C)of TIFAC42 is a progressive step towards trainingwomen having qualifications in science/ engineering /medicine or allied areas in the area of IPR and theirmanagement for a period of one year.

IP Facilitation Centre (IPFC) for MSME

The Confederation of Indian Industry (CII) inassociation with the Ministry of Micro Small &Medium Enterprise (Mo-MSME) has established anIntellectual Property Rights Facilitation Centre (IPFC)in three cities of India. This is the first of its kind tobe launched with a primary objective to 'boost IPculture' which would enhance the intellectual capitalthat is vital for the economic development of the state.

India IP Owners Forum

The India Intellectual Property (IIP) Forum acts assingle window service for all those who are interestedin protecting their IP. The portal will serve as aplatform where members would get to voice theirconcerns and issues. It facilitates interaction and actsas a knowledge networking gateway for all IP users.

National Science & Technology Management Information System (NSTMIS)

The National Science and TechnologyManagement Information System, a division of DST,Government of India has been entrusted with the taskof building an information base on resources devotedto scientific and technological activities for policyplanning in the country on a continuous basis. It isalso responsible for collection, collation, analysis anddissemination of information with respect to S&Tactivities in the country.

Society for Technology Management (STEM)

The Society for Technology Management is a not-for-profit organization, which provides a facilitativeenvironment for successful technology transferprocesses and promotes best practices in technologymanagement. It provides a supportive environment forentrepreneurship and networks with referral links forinformation and other resources. It contributes to theprofessional development of technology managementprofessionals and provides proper guidance andassistance to inventors and corporations in matters ofintellectual property.The efforts of these agencies led to awarenesscreation among institutions and stakeholders, linkagebetween service providers and clients and voicing ofemerging issues and constraints of the stakeholdersand figuring out appropriate strategies. If theseagencies regularly come together to establish acommon platform for sharing experiences and expertise,such initiative may facilitate arriving at a roadmap foreffective technology management in agriculture.

Global Perspective of Agricultural Technology Management and IPR Education: Emerging Opportunities and Challenges

Intellectual property rights could play a significantrole in encouraging innovation, product developmentand technical change. Developing countries like Indiatends to have IPR systems that favour informationdiffusion through low-cost imitation of foreignproducts and technologies. This policy stancesuggests that prospects for domestic invention andinnovation are insufficiently developed to warrantprotection. However, an inadequate IPR system couldstifle technical change even at low levels of economicdevelopment.[13] This is because much invention andproduct innovation are aimed at local markets andcould benefit from domestic protection of patents,utility models, and trade secrets. Moreover, IPRsystems could help reward creativity and risk-takingamong new enterprises and entrepreneurs. Countriesthat retain weak standards could remain dependent ontechnologically inefficient firms that rely oncounterfeiting and imitation. It is therefore necessarythat a development oriented country like India musthave strong IPR legislation and policies and strive tocreate awareness among industry, academia, students,farmers and public on the IP regime and precautionsto

be taken to protect their intellectual assets. India isrich in its indigenous technical knowledge andtherefore, the avenues to cash upon the traditionalwisdom should be opened to the grass root innovatorsand farmers. A general awareness of the globalscenario and clear understanding of the modalitiesunder the IPR is inevitable to the above mentionedstakeholders and it can be cultivated only througheducational programmes at the degree level and aboveespecially to the students of agriculture, law,engineering and management.

Inventive firms in developed economies tend toorient their research programmes toward products andtechnologies for which they expect a large globaldemand and that may be protected by IPR. Thismeans that a disproportionately small amount ofglobal R&D is focused on the needs of developingeconomies with low incomes and weak IPRprotection. The efforts to strengthen IP protection indeveloping countries like India could induce greaterR&D aimed at meeting the particular needs of thecountry. The evidences suggest that IPR protectioncould generate more international economic activityand greater indigenous innovation [4], but such effectswould be conditional on circumstances. Thesecircumstances vary widely across countries and thepositive impacts of IPR should be stronger incountries with appropriate complementary endowmentsand policies. Countries face the challenge of ensuringthat their new policy regimes become pro-activemechanisms for promoting beneficial technicalchange, innovation, and consumer gains. Educatingall stake holders along with policy makers on thedynamic environment of the IPR regime is a vitalpre-requisite for conceiving and enforcing strongIP legislations. Apart from encouraging theirinnovativeness and accelerating returns forre-investments, the stakeholders should also be taughtto extract profit from their innovations on traditionalor modern technologies using the means providedunder IPR by commercializing them through licensingor similar agreements on an international arena.The lack of formal IP education makes futureagriculture professionals incompetent in the face ofglobal business and technological challenges andtherefore, a well-structured and comprehensiveacademic programme in IP and technologymanagement should be included as part of curriculumat the university level. The future global economieswill largely be governed by climate change/GHGemission approach, carbon trading, environmentalissues and sustainable livelihood based foodand water policies. Hence IPR and technologymanagement educational programmes should alsobe directed towards these issues and relatedsocio-economic factors. The factors such as changesin global and local businesses, dynamics of supplyand value chain systems, advances in technologymanagement protocols, change in preferenceof consumers and industry should be consideredwhile formulating education policies with respect toIPR in agriculture.

II. Conclusion

The future of Indian agriculture will be one of knowledge and technology intensive and wider dissemination of the same cannot be accomplished in isolation. All categories of players, viz. public and private, and large and small must be involved in promoting the technologies. The agro-input industry has to closely work with government to realize the objectives. Policy environment must ensure a continuous encouragement to the private sector forattracting more investment. Mechanisms can be evolved for accreditation of private R&D, MOU for forging functional relationships and protocols for transferring/sharing technologies, materials and unique facilities. There is ample scope for intensifying human resource development through initiation of fellowships and professorial chairs by the private sector in focused areas of research. Private sector has a good amount of expertise which can be used in agricultural management process within NARS.

India has begun to see some positive results asawareness of the need for greater IP protection hasincreased. But these results are only the first steps onthe path to full development of India's knowledgebased economy. When examining potentialinvestment sites, investors in the knowledge industrieswill look at the IPR regimes of various countries andchoose those countries that offer the greatestprotection for their investments. In this context, thecountry must continue to improve its IPR protection,or risk being left behind as other countries in thedeveloping world implement protection and buildtheir own knowledge based economies.Educating all the stakeholders from farmers toinnovators to industry players is vital for achievingthe benefits of IP regime as well as for standingstrong among global competing players. Being acountry rich in its biodiversity and traditionalknowledge base, India should take extra steps forensuring due benefit and recognition to actual stakeholders while making use of them. The followingmeasures will prove helpful towards cultivating an IPfriendly community among farmers and agriculturalprofessionals in the country:

(i) Education in IP should start at least from the postgraduate level in all agricultural and managementschools/ universities in the country.

(ii) More importance should be given to creatingIP enabled business environment and macro-and micro-level technology management inagri-business management courses offered inSAUs and other organizations across the countryto ensure competitive advantage and aid instrategic decision making process.

(iii) The current system of offering non-credit coursesmay be upgraded to credit courses on IPmanagement which will promote budding of IPprofessionals rather than just giving away basicawareness.

(iv) Training programmes to progressive farmers onIP management, plant variety protection and TKmanagement and its potential benefits may beconducted through the KVK system and othertraining institutes under NARS.
(v) A coordinated effort should be in place forintegrating the various IP related activitiesinitiated by institutions under different agenciessuch as research and academic institutions, NGOsand government departments. A national levelagency or a consortium in this regard may beconstituted. It can support the innovators, farmersand communities who want to preserveinnovation, biodiversity and TK for IP filing,protection and benefit sharing process.
(vi) The Government of India can either bring thePublic Funded IP Bill in a new form or amendthe GFR incorporating the provisions to protect,own and license IP resulting from governmentfunded projects
Early implementation of a strong patent regimeincludes a comprehensive IP education plan thatwould strengthen India's agricultural research anddevelopment sector, attract more foreign investment,and provide a basis for Indian firms to begin tacklingshortcomings and problems that seriously affect thecountry. As India's knowledge based economy grows,it will benefit not only India, but the rest of the worldas well, especially the developing world it leads.The country's IP specialised manpower can supportglobal industries and business houses and itsIP friendly community will attract more foreigndirect investment into India. As Indian agriculture isreaching to new vistas of development and business isbecoming increasingly global and also in view of thecountry's mammoth consumer market, it is time for'new and fresh think' to prevail in the IPR debate bycreating much more awareness through formaleducation on this aspects among academia, policymakers and the public.

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