Agriculture

EXTENSION SYSTEM IN INDIA

Review of Current Status, Trends and the Way Forward

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Abbreviations

ACABC	Agriculture Clinic and Agriculture Business Centres
ADF	Augmented Dickey Fuller
AES	Agriculture Extension Service
AFPRO	Action for Food Production
AgRE&XT	Aggregate Agri Expenditure on Research & Education and Extension & Training
AgXT	Expenditure on Agriculture Extension and Training
AICRP	All-India co-ordinated Research Projects
KRSP	Aga Khan Rural Support Program
ASTI	Agriculture Science and Technology Indicators
ATESC	Agriculture Technology and Extension Service Centres
ATMA	Agriculture Technology Management Agency
BAIF	Bharatiya Agro-Industries Federation
BAKORLUH	Agency for Extension Coordination
BAMETI	Bihar Agriculture Management, Extension and Training Institute
BARC	Bhabha Atomic Research Centre
BLT	Block Level Teams
CAGR	Compound Annual Growth Rate
CFPA	China Foundation for Poverty Alleviation
CPK	Choupal Pradarshan Khet
CSIR	Council of Scientific and Industrial Research
DACFW	Department of Agriculture Cooperation and Farmers' Welfare
DAFEP	Decentralized Agriculture and Forestry Extension Project
DAFF	Department of Agriculture, Forestry and Fisheries
DATER	National Rural Extension Department
EMBRAPA	Brazilian Agricultural Research Corporation
FAC	Farmer Advisory Committee
FIAC	Farm Information and Advisory Centres
FPO	Farmer Producer Organisation
GCA	Gross Cropped Area
GDP	Gross Domestic Product
GM	Genetically Modified
GSSE	General Services Support Estimate
GVOA	Gross Value of Output from Agriculture and Allied activities
GVT	Gramin Vikas Trust
HKB	Hariyali Kisan Bazaar

HVA	High Value Agriculture
ICAR	Indian Council of Agriculture Research
ICT	Information and Communication Technology
IFFCO	Indian Farmers Fertiliser Co-operative Limited
IKSL	IFFCO Kisan Sanchar Limited
IPR	Intellectual Property Right
ITD	Innovation in Technology Dissemination
KCC	Kisan Call Centres
KRIBHCO	Krishak Bharati Cooperative
KVK	Krishi Vigyan Kendras
MANAGE	National Institute of Agricultural Extension Management
MDA	Ministry of Agrarian Development
MSSRF	MS Swaminathan Research Foundation
NAARM	National Academy of Agricultural Research Management
NAMET	National Mission on Agriculture Extension and Technology
NATP	National Agricultural Technology Project
NRSA	National Remote Sensing Agency
OLS	Ordinary Least Square
OUAT	Odisha University of Agriculture and Technology
PAES	Public Agricultural Extension System
PRADAN	Professional Assistance for Development Action
RML	Reuters Market Light
R&E	Research and Education
SAMETI	State Agricultural Management and Extension Training Institute
SASAE	South African Society for Agricultural Extension
SAU	State Agricultural Universities
SFI	Syngenta Foundation India
SHG	Self-Help Groups
SMAE	Sub Mission on Agricultural Extension
SMAM	Sub Mission on Agricultural Mechanization
SMPP	Sub Mission on Plant Protection and Plant Quarantine
SMSP	Sub-Mission on Seed and Planting Material
SREP	Strategic Research Extension Plan
T&V	Training & Visiting
TTC	Trainers' Training Centres
ToT	Transfer of Technology
UGC	University Grants Commission
UPASI	United Planters Association of Southern India
USDA	United States Department of Agriculture
WPI	Wholesale Price Index
ZRS	Zonal Research Stations

Foreword

During 2004-05 to 2013-14, India experienced an overall GDP growth of 7.9 percent per annum and agri-GDP growth of 3.7 percent per annum. The targeted growth rate in agriculture was 4 percent. But during 2014-15 to 2017-18, first four years of NDA-II government, agriculture growth has collapsed to 2.4 percent. This is worrying as it has strong implications for rural poverty and malnutrition. Empirical studies show that there exists a rather strong relationship between agricultural growth, poverty and malnutrition (Gulati et.al. 2012; WDR, 2008). It is therefore important to ensure that agri-GDP growth is brought back to its targeted growth of at least 4 percent per annum, and if Prime Minister Modi's vision of doubling of farmers' income in real terms by 2022-23 is to be achieved, agriculture must grow at much faster pace than has been the case in the previous decade or more.

While agriculture growth depends on various factors ranging from rainfall at one end to investments in irrigation, agri-R&D, and prices on other, one of the critical factors is agriculture extension. It is this agri-extension that ensures that innovations in the labs are translated and implemented on the lands of peasants. The role of agriculture research and development has been studied earlier, but the role of agriculture extension *per se* has not been analysed as rigorously as is attempted in this study.

It is precisely to fill this gap that this study reviews the role of extension, evaluates various models that India adopted over time, tests its effectiveness through econometric analysis, and also looks at best practices, both in India and abroad, to ensure that Indian agriculture gets the best possible advice to put it on a sustainable and higher growth trajectory. The study is funded by Bill and Melinda Gates Foundation (BMGF), and is led by Dr. Ashok Gulati, Infosys Chair Professor for Agriculture, ICRIER and Former Chairman CACP, GoI. The study focuses on six states particularly, Punjab, Madhya Pradesh, Gujarat, Bihar, Odisha and Uttar Pradesh, besides all India analysis.

This study examines the performance of the public agricultural extension system in three high growth states as well as three comparatively moderate performing states. During the last decade, Madhya Pradesh and Gujarat have been among the best performers in terms of growth of agriculture and allied sectors, while Punjab has been a high performer during the green revolution era. The study tests if improvement in spending on agriculture research, education and extension and training has a tangible positive impact on agriculture growth.

India's agri-extension services have evolved with its agricultural strides, but the real question lies in building capacities to make sure the transfer of technology to the bottom of the pyramid is equitable and efficient to be able to reap benefits of modern day innovations.

From a focus on increasing yields via technology transfers and adoption, the extension systems have embraced a more decentralized, participatory, and a demand-driven approach. The study has also devoted a section to global practices of extension by studying China, Brazil, South Africa, Indonesia and USA. It is clear that even developed nations give importance to agricultural extension. What is unique in this study is the use of triangulation to map out the impact of extension services through both, econometric analysis and through focus group discussions with farmers. Findings of the paper bring to light constraints and challenges that impair the effectiveness of investment in technology and access to markets to deliver value to a small and marginal Indian farmers. We are sure this study will help policy makers and other stakeholders in agriculture to give due importance to agri-extension investments and models to be adopted with latest technologies.

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Preface

This study is essentially a review of the Indian agriculture extension system at the national level and in six selected states to see how agricultural research, education, and extension contribute to growth of agriculture GDP. The six states that are specifically picked up are Madhya Pradesh and Gujarat which have recently posted very high rates of growth in agri-GDP; Punjab, which registered high growth rates during green revolution days; and Uttar Pradesh, Bihar and Odisha, which have relatively experienced moderate growth rates in agriculture. The idea is to see if agriculture extension independently played an important role in high growth rate states, and if so, what lessons it offers to other states. In this process, we also look into international best practices for agri-extension in some selected countries to see if India can emulate some of those practices to have a tangible impact on agri-GDP growth rates.

This study digs out all the relevant data related to total expenditure on research & education(R&E) and extension and training for agriculture & allied sectors for India as a whole and also for the six specific states. It helps to do a comparative empirical analysis, and then with other factors, to undertake an econometric analysis of the factors driving agri-GDP growth at all India level and in six selected states. This empirical and econometric analysis is then dovetailed with the institutional analysis, supplemented by focused group discussions to evaluate the efficacy of India's agri-extension services. In doing this, the study looks at the entire spectrum of extension right from the fields of India to the global technology rich innovations in extension to capture the essence of transfer of technology by reviewing various extension systems internationally. Finally policy suggestions are given in order to prioritize government spending on agriculture R&E and extension and training services and take a step towards revolutionising the current system in place.

The study documents that India spends about 0.7 percent of its agri-GDP on agri-Research and Education and Extension and Training together, of which 0.54 percent goes for Research and Education alone while 0.16 percent is allocated to Extension and Training. Within the expenditure incurred on extension and training, almost two-thirds goes to crop husbandry and 10 percent to livestock, despite the fact that livestock sector contributed 26 percent of value of output of agriculture and allied activities in TE 2013-14. The increasing global tilt towards technology and digitization compounded with sustainability and resource management has widened the definition of extension from a traditional focus on increasing yields via technology transfers and adoption, the extension system has over the recent years embraced a more decentralized, participatory, and a demand-driven approach. Despite this, the effectiveness of the investment and efficiency of technology dissemination to deliver value to small and marginal Indian farmers is impaired by constraints and challenges in the form of capacity, accountability and quality.

Further, we review the agriculture extension system in BIICS (Brazil, Indonesia, China and South Africa) countries and USA to compare the best practices in agriculture extension. The study principally deals with the expenditure of each country on research and knowledge pertaining to agriculture including extension and what proportion of GDPA does this research hold from the years 2000-01 to 2015-16. It also looks at their institutional models to impart extensions services. Moving from a macro to a micro perspective, the analysis encompasses lessons learnt from field interactions with farmers and extension officials in the form of in-depth focus group discussions carried out in Madhya Pradesh, Uttar Pradesh, Punjab-Haryana belt. It has been inferred and backed by empirics that expenditure on research & education and extension and training, along with factors like irrigation ratio, road density, diversification and terms of trade have a strong influence on agriculture growth. There is an urgent need to re-prioritise the existing extension system to transcend from the traditional food security perspective to a more market led-extension system for a more diversified and high value agriculture.

Our paper contributes to the ongoing debate on agriculture technology-productivity-growth, with a detailed analysis of the complexities of the Indian extension system placing the farmer at the core of our study. In light of these findings, the study makes useful recommendations to bolster agriculture R&E and Extension in India and in the selected states. The prime step in this direction is to strengthen the links between research and extension by increasing cross sharing of experiences between the public, private and civil society sectors.

Authors

Acknowledgement

This paper forms a part of the study on agricultural extension, research and education in India from a macro-economic perspective with a special focus on six states viz., Uttar Pradesh, Bihar, Odisha, Madhya Pradesh, Gujarat and Punjab.

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Needless to say, the final responsibility for all information, data and analysis, conclusions and policy recommendations rests solely with the authors of this paper.

Abstract

Public spending on agriculture is one of the key policy instruments of the government to promote growth and alleviate poverty in rural areas. Amongst various types of government spending, Agricultural Research and Education (R&E) is found to be one of the most critical for promoting farm yields, which contributes towards augmenting incomes of peasantry and thus reducing rural poverty. In this paper, we look at agriculture R&E, but with a focus on extension and training system in India, with a view to examine its impact on agri-GDP growth. We look at the way entire R&E, and Extension in particular is organized, how much is being spent on this item both in absolute terms but more importantly as a percent of agri-GDP and on per hectare basis. We do this at all India level and in six special focus states, namely Uttar Pradesh, Bihar, Odisha, Madhya Pradesh, Gujarat and Punjab. While doing this, we also look at international experience, and if there are any lessons to be learnt between our focused states or across countries in search of "best practices". Based on this review and analysis, we offer some policy recommendations that can help propel growth in agriculture and reduce rural poverty faster.

It is worth noting that India spends about 0.7 per cent of its GDPA (2014-15) on aggregate agriculture research including education, extension and training (AgRE&XT) as against the recommended level of 2 per cent of agri-GDP by the World Bank (1981; p.8). Out of this 0.7 percent (AgRE&XT) of agri-GDP, agri- research and education (AgR&E) alone amounts to 0.54 percent at all India level. There are, however, considerable variations across states. Further, India's allocation of agriculture R&E is highly skewed towards crop husbandry. Sector-wise break up shows that around 70 per cent of agriculture R&E is allocated to crop-husbandry alone, while only 10 per cent is allocated to animal husbandry and dairy development. Similarly, decomposition of expenditure on agriculture extension and training (AgXT) shows that around 92 percent of this expenditure was allocated for crop husbandry and a meagre 0.9 per cent was allocated for animal husbandry and dairy. This is in contrast to the gradual transformation of the agriculture sector in India towards animal husbandry and dairy. The study also takes lessons from the field with focused group discussions carried out in Madhya Pradesh, Uttar Pradesh and the Punjab-Haryana Belt. With a current global tilt towards resource management and sustainability, there is an urgent need to re-prioritise the existing extension system to transcend from the traditional food security perspective to a more market led-extension system. Further, we show in this paper that there is a positive and significant association between public agriculture R&E and extension and training expenditure and agricultural GDPA in Bihar, Uttar Pradesh, Odisha and Madhya Pradesh using a simple OLS and Engel-Granger test of co-integration. In the light of these findings, the study makes the following recommendations to bolster agriculture R&E and Extension in India and the selected states viz., (i) strengthen links between research and extension by

increasing cross sharing of experiences between the public, private and civil society sectors; (ii) diversify agriculture R&E and extension portfolio, at the margin, away from crops and more towards animal husbandry and dairy (high value agriculture); (iii) clearer articulation and definition of the capacity of extension service providers and their quality certification through an autonomous organisation with sufficient legal powers; and (iv) designing and implementing innovation networks through digital platforms to permit free two-way flow of ideas and technologies.

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Executive Summary

Although contribution of agriculture in overall GDP of the country has come down over the years, and hovers around 17 percent currently, India is still predominantly an agrarian rural economy in terms of people living in rural areas 69 per cent (as per Census 2011) and around 47 per cent of its workforce engaged in agriculture (Labour Bureau, 2015-16). Moreover, around 270 million people in the country (22 per cent of India's population) live below the poverty line as per international definition of $1.9 per capita per day income in PPP terms, of which 80 per cent reside in rural areas. Given this huge dependency of rural households on agriculture, it has become imperative to focus on its growth in order to ensure food security and eliminate poverty in the country. However, India's agriculture growth in the 1990s and 2000s stagnated at around 3 per cent, which was lower than the targeted growth rate of 4 per cent. In developing countries such as India, public spending on agriculture is one of the most important government instruments for promoting economic growth and alleviating poverty in rural areas (Fan and Saurkar, 2006). Amongst various types of government spending for agriculture, agricultural R&D is said to be one of the most critical for promoting farm yields (Fan, Gulati and Thorat; 2007).

Keeping this background in mind, in this study, we look at agriculture R&E and extension and training system in India from a macro-economic perspective with a special focus on six states viz., Uttar Pradesh, Bihar, Odisha, Madhya Pradesh, Gujarat and Punjab. The basis for selecting these states is that, Gujarat and Madhya Pradesh have experienced rapid agricultural growth in the past decade while Punjab had achieved high growth earlier during the Green Revolution. Bihar, Odisha and Uttar Pradesh are considered moderately performing states due to their relatively lower agriculture growth and high poverty rates. The definition of agriculture research and extension used is from the combined finance and revenue accounts of the centre and states. The duality in extension is divided into extension education and extension training. 'Agriculture Research and Education'(R&E) includes extension education, while 'Extension and Training' includes frontline and field extension, both the variables together capture the total or aggregate research and extension which we call Aggregate Research and Education and Extension and Training (AgRE&XT) in our paper.

In India, public funding for agriculture R&E is contributed by both centre and state with around 55.4 per cent of the total allocation contributed by the centre and 44.6 per cent by states. Between 2000-01 and 2014-15, India's total R&E Expenditure (including only extension education) for agriculture and allied activities in real terms (2004-05 prices) has increased from Rs 31.1 billion to Rs 61.6 billion respectively, thereby recording a compound annual growth rate of 5 per cent for the period 2000-01 and 2014-15. However, as a percentage of gross domestic product from agriculture (GDPA), it amounts to about 0.54 per

cent (2014-15). Moreover, spending on agriculture R&E shows that there are considerable variations across regions. We find that excluding the north–eastern region, most of the eastern states spend less than 0.5 per cent of its GDPA on agriculture R&E, while states like Uttarakhand, Himachal Pradesh, Kerala and Tamil Nadu spend more than 0.8 per cent of its GDPA on agriculture R&E. This shows that the eastern states, which are also a few of the poorest states in the country with high dependency on agriculture and low agriculture productivity are also the states with the lowest spending on agriculture R&E. In 2010-11, the Government initiated the programme of "Bringing Green Revolution to Eastern India" in order to address the constraints limiting the productivity of rice based cropping pattern in this region. In order to improve agriculture productivity in this region, scaling up of agriculture R&E and extension funding will be critical.

In 2014-15, India allocated around Rs 18 billion for agriculture extension and training exclusively, which has grown from Rs 6.4 billion in 2000-01 thus recording a CAGR of 7.6 per cent for the given period. However, the amount spent on agriculture extension in 2014-15 was merely 0.16 per cent of GDPA vis-a-vis 0.12 per cent of GDPA in 2000-01 (current prices). Extension intensity as measured by agriculture extension expenditure per gross cropped area has also increased over the last decade, however it still remains low. Between TE 2002-03 and TE 2013-14, per hectare extension expenditure increased from Rs. 37 per hectare to Rs. 95.2 per hectare at 2004-05 constant prices, a significant two and a half times increase, though the overall levels still remain low. State-wise analysis shows that agriculture extension intensity is highest in Jammu and Kashmir (Rs 243.8 per hectare), followed by Haryana (Rs 225.5 per hectare), Tamil Nadu (Rs 223.4 per hectare), Assam (Rs 206.3 per hectare) and Himachal Pradesh (Rs 189.2 per hectare), while all of our study states namely Gujarat, Madhya Pradesh, Punjab, Uttar Pradesh, Odisha, except Bihar recorded agriculture extension intensity lower than the national average of Rs 95.2 per hectare.

In 2014-15, India allocated around Rs 18 billion for agriculture extension and training exclusively, which has grown from Rs 6.4 billion in 2000-01 thus recording a CAGR of 7.6 per cent for the given period.

Further, the paper also highlights that besides allocating less to agriculture R&E as compared to the desired level, India's allocation of agriculture R&E is also biased towards crop husbandry. Sector-wise break up shows that around 70 per cent of the total agriculture R&E budget is allocated to crop-husbandry itself, while only 10 per cent is allocated to animal husbandry and dairy development. Similarly, decomposition of extension expenditure across sectors

Besides allocating less to agriculture R&E as compared to the desired level, India's allocation of agriculture R&E is also biased towards crop husbandry

Despite the growing importance of the livestock sector, India's agriculture research and extension system has not absorbed the velocity of its growth yet.

shows that around 92 percent of total extension expenditure was allocated only for crop husbandry and only 0.9 percent was allocated to animal husbandry and dairy segment. This is in contrast to the gradual transformation of the agriculture sector in India, in which animal husbandry and dairy segment have grown in importance. As on TE 2013-14, of the total value of output from agriculture and allied activities 26 per cent was contributed by the livestock segment alone, while food-grains contributed 20 per cent and fruits and vegetables 15 per cent. Interestingly, when we calculated the sources of agriculture growth in India by deflating the current series of value of output from each segment by the WPI at 2004-05 prices, we find that, of the 5.7 percent growth in GVOA recorded during the period 2001-02 to 2013-14, 26.5 per cent was contributed by livestock, 15.4 per cent by food-grains and 13.6 per cent by fruits and vegetables. These results clearly indicate that despite the growing importance of the livestock segment, India's agriculture R&E system is skewed towards crop husbandry. In addition, sustained income growth and a fast-growing urban population are causing changes in food-consumption patterns, away from low-value staples towards high-value food commodities, implying that the agriculture production systems must change to address the growing food demand.

This study shows that empirically, there is a positive and significant effect of public expenditure on agriculture R&E and Extension on agriculture GDPA in Bihar, Uttar Pradesh, Odisha and Madhya Pradesh

In this paper we also examine the role of agricultural R&E and extension and training services in contributing to overall growth in agriculture in the study states by using an ordinary least square model and Engel-Granger test of co-integration. The econometric analysis shows that there is a positive and significant effect of public agriculture R&E and extension expenditure on agricultural GDPA in Bihar, Uttar Pradesh, Odisha and Madhya Pradesh. However, there are other factors such as irrigation, road development and price incentives which are critical variables that determine agriculture growth. Although in the case of Punjab, we are unable to establish any significant relationship between agriculture R&E or extension and training and GDPA for the period 2000-01 and 2014-15, however, historically the agriculture R&E and extension system, along with price policy and procurement support, have often been credited for ushering in the Green Revolution in Punjab in the 1960s. Additionally, we are unable to establish any relation between public agriculture R&E or extension and training expenditure and GDPA in Gujarat due to issues of multicollinearity. Despite this statistical issue, one cannot undermine the importance of agriculture R&E or extension and training service in Gujarat, specifically the role of private players. In

the 2001-02 to 2013-14, Gujarat witnessed an astounding agriculture growth of 9.7 per cent per annum, spearheaded by the cotton revolution. In 2002-03, Gujarat with three million bales produced 22 per cent of India's cotton, which rose to 11.6 million bales and a 31 per cent all-India share in 2013-14. Cotton yields grew by 131 per cent in Gujarat, way above all-India gains, over the same period. One of the most critical reasons for this expansion was the diffusion of genetically modified (GM) seeds of cotton amongst farmers through private input dealers. Of course, complementary infrastructure in terms of irrigation, roads and power also played its role, but the catalyst was the BT cotton seed promoted by private extension services. Our econometric component of the study, unfortunately, does not capture the role being played by the private sector in extension due to paucity of reliable data, but anecdotal evidence does suggest that private sector (mainly input dealers) has played quite an important role in many states, especially Gujarat.

The paper reviews the existing system of agriculture aggregate R&E and extension and training in India with a special focus on major players in the agriculture extension system. Currently, the agriculture R&E system in India is dominated by the public sector and is led by the Indian Council of Agriculture Research (ICAR). After the discontinuation of the World Bank's Training & Visiting (T&V) program in the early 1990s, the Indian Government, with the support of World Bank introduced the Agriculture Technology Management Agency (ATMA) in 1998. ATMA created a platform for convergence of human and financial resources available in the government, civil society, farm community and private sector. The ATMA society registered at the district level was mandated to coordinate all on-going extension efforts in the district and converge and share resources in a targeted fashion.

Currently, the agriculture R&E system in India is dominated by the public sector and is led by the Indian Council of Agriculture Research (ICAR).

In 2014-15, the Government of India introduced The National Mission on Agriculture Extension and Technology (NMAET) in order to take a holistic view of extension by making the system farmer-driven and increase accountability by restructuring and strengthening existing agriculture extension programmes to enable the delivery of technology and to improve the current agronomic practices of farmers under four sub missions, namely (i) Sub Mission on Agricultural Extension (SMAE), (ii) Sub-Mission on Seed and Planting Material (SMSP), (iii) Sub Mission on Agricultural Mechanization (SMAM) and (iv)Sub Mission on Plant Protection and Plant Quarantine (SMPP).

KVKs are field research units of the ICAR and are meant to test new seed varieties, agronomic practices and machinery in field conditions across different agro-climatic zones. They conduct farmer outreach programmes through on-farm demonstration and training.

Other major players providing extension services in the public sector are Krishi Vigyan Kendras (KVK), State Agricultural Universities (SAU) and ICT-led extension interventions by DACFW, Government of India. KVKs are field research units of the ICAR and are meant to test new seed varieties, agronomic practices, machinery etc. in field conditions across different agro-climatic zones before these are cleared for adoption by farmers. Additionally, they conduct farmer outreach programmes through on-farm demonstration plots, training etc. The SAUs are another important arm for promoting extension activities in the states. While their main mandate is formal degree programmes in major agricultural disciplines, they provide extension and training support through the directorate of extension and education. The information flow is mainly from the universities to the KVKs which are responsible for training farmers. An important reform undertaken in recent years by the Ministry of Agriculture at the national level has been the increasing use of modern technologies and communication strategies to help educate farmers. Since ICT has significant potential to reach large numbers of farmers in a cost-effective manner several schemes have been initiated such as Farmer's Portal, m-Kisan, Kisan Call Centre, Kisan TV channel, Agriculture Clinic and Agriculture Business Centres, Agriculture Fairs and Exhibitions and community radio stations.

Agriculture extension services by the private sector are mostly delivered by input dealers, such as those marketing seeds, fertilisers, pesticide and farm machinery. A few examples are- Hyderabad based Nuziveedu Seeds does extension related work through its programme, 'Subeej Krishi Vignan'. Fertiliser companies, such as IFFCO (Indian Farmers Fertiliser Co-operative Limited) and KRIBHCO (Krishak Bharati Cooperative), undertake extension activities by conducting farmer meetings, organizing crop seminars, arranging for soil testing facilities, adopting villages etc. Tata Chemicals initiated Tata Kisan Kendras with the objective of empowering and enabling farmers towards improved agronomic practices and higher returns. Syngenta does farmers' training programs on crop protection and how best to use pesticides etc. Nestle does it on dairy and cattle health. And like this there is a long list, but how much they actually spend on such extension programs is not collated at one place for any meaningful empirical analysis.

Additionally, NGOs, such as Professional Assistance for Development Action (PRADAN), BAIF Development Research Foundation (earlier registered as Bharatiya Agro-Industries

Federation) and Action for Food Production (AFPRO) are actively involved in promoting extension activities in more than one state. PRADAN has mainly focused on promoting livelihood of the poor in different sectors ranging from agriculture and natural resource management to micro-enterprise in rural areas across eight states in India. BAIF is also working on the development of livelihoods by engaging in livestock development, environment conservation, and water resource management across 16 states.

To substantiate the empirical study with real-time qualitative data, the paper has lessons from in-depth focus Group Discussions carried out in Madhya Pradesh, Uttar Pradesh and the Punjab-Haryana Belt. In UP, as far as Public Agriculture Extension is concerned, extension from the Horticulture Division to Small and Marginal Farmers was nearly absent. There is a pressing need to address the lack of efficient extension services given to farmers in areas which are being plagued by over-production and low prices. Traditional approach to Extension needs to be changed and focused towards market-led extension. Where as in MP, FPOs are plugging some of the weaknesses in existing extension system. Farmers who have diversified to high value agriculture for example floriculture are earning higher than soya bean producers, but with higher risks. Major Source of Extension, training and monitoring of quality of produce is done by the FPO such as crop production, seeds and fertilizer knowledge, water management and use of modern machinery. The services provided in the field on the advice of the private sector have produced good results and have been beneficial. In terms of sustainable and organic farming, farmers have tried to grow organic crops but there is still a hitch in accepting organic farming even though they hope to get a higher price for organic produce- no market, lower storage value and no trust in the market are some of the problems farmers face. Suggestions offered include first, setting up of Community Farm schools with useful demonstrations (giving knowledge on diversification towards other high value crops). Second, Community Skill Development centres to be able to absorb framers in forward and backward linkages with agriculture and not be dependent on one type of farming. Lastly, to educate farmers on and encourage community Enterprising ventures to capitalize on diverse markets.

In UP, as far as public extension is concerned, extension from the Horticulture Division to small and marginal farmers is nearly absent.

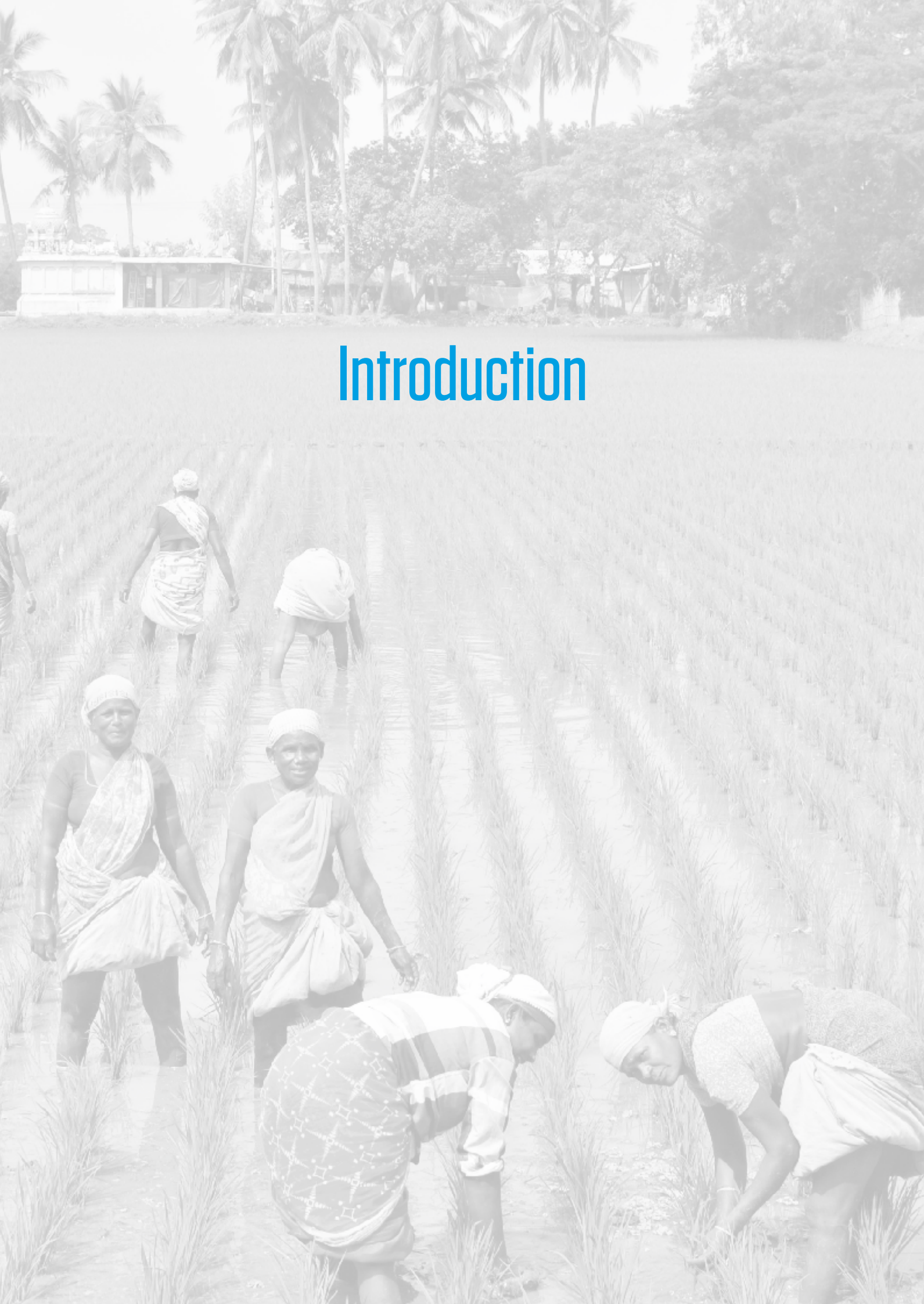
Where as in MP, FPOs are plugging some of the weaknesses in the existing extension system.

Further, we review the agriculture extension system in six different countries to compare the best practices in agriculture extension. In the recent decades there has been a global shift in the

focus of research from merely production based to more demand driven and market-led approaches with innovation at the centre of agriculture growth. The reason for selecting this pool of six countries was based on the agriculture performances of these countries starting with China being our neighbour and close competitor, moving on to Indonesia that also started off with the same structural changes as India. The Latin American experience is represented by Brazil and its fast growing livestock sector. USA is considered for the comparison by virtue of being an advanced nation and to see if some lessons could be a leap of faith for India. This chapter principally deals with the expenditure of each country on research and knowledge pertaining to agriculture including extension and what proportion of GDPA does this research hold from the years 2000-2015.

India needs to raise the bottom line of public expenditure on agri-R&E, including extension and training, to at least 1 percent of agri-GDP (from current levels of around 0.70 percent), if research and extension have to make any significant dent to performance of agriculture.

In light of the findings of this paper the following four principal recommendations are made to bolster agriculture R&E and extension and training in India in the selected states -(i) strengthen the links between research and extension by increasing cross sharing of experiences between the public, private and civil society sectors; (ii) diversify agriculture R&E and extension portfolio, at the margin, away from crops towards animal husbandry and dairy; (iii) clearer articulation and definition of the capacity of extension service providers and their quality certification through an autonomous organisation with sufficient legal powers; and (iv) designing and implementing innovation networks through digital platforms to permit free two-way flow of ideas and technologies to capture the rich data banks of local knowledge available in different parts of the country. But above all, India needs to raise the bottom line of public expenditure on agri-R&E, including extension and training, to at least 1 percent of agri-GDP (from current levels of around 0.70 percent), if research and extension have to make any significant dent to performance of agriculture. This has to be simulataneously accompanied by greater accountability for performance and delivery on the part of organizations and people involved.



Introduction

1 Introduction

Similar to most developing countries, India is observing a structural transformation with the share of agriculture sector in total Gross Domestic Product (GDP) declining and that of non-agriculture (industry and services) increasing. Between TE 1992-93 and TE 2013-14 the share of agriculture in total GDP declined from 29 per cent to 17.4 percent. Despite this decline, India continues to be predominantly an agrarian rural economy, with around 69 per cent of its population living in rural areas (Census 2011) and around 47 per cent of the workforce engaged in agriculture (Labour Bureau, 2015-16)[1]. Moreover, around 270 million people in India (22 per cent of India's population) live below the poverty line, of which 80 per cent reside in rural areas.

Given this huge dependency of rural households on agriculture, it has become imperative to focus on its growth in order to ensure food security and eliminate poverty in the country. Supporting this, there are several studies which have shown that compared to other sectors, growth in agriculture generally has the largest effect on poverty reduction (World Bank, 2008; Ravallion and Datt, 1996; Warr, 2003; Cervantes-Godoy and Dewbre, 2010 and de Janvry, 2010). However, India's agriculture growth in the 1990s and 2000s[2] hovered 3 per cent, which was lower than the targeted growth rate of 4 per cent.

In developing countries such as India, spending on agriculture is one of the most important government instruments for promoting economic growth and alleviating poverty in rural areas (Fan and Saurkar, 2006). Fan, Hazell and Thorat (2002), showed that the Green Revolution in India during the 1960s was largely due to increased government expenditure on agriculture R&E, irrigation, electricity and rural infrastructure. Amongst various types of government spending for agriculture, agricultural R&E (including extension) is said to be one of the most critical for promoting farm yields (Fan, Gulati and Thorat; 2007). In addition, several studies have shown the association of high profitability of agricultural research investment on agriculture production (Evenson, Pray and Rosegrant, 1999; Jha 2001; Pal and Byerlee, 2003).

Similar results are found in the upcoming study (Gulati and Terway, 2018) on the impact of public investment and subsidies on poverty alleviation and agricultural growth. The effect of investment and subsidies on poverty and agricultural growth is studied empirically using a multi-equation model. As a single equation would be insufficient in explaining the role of

[1] *The Census 2011 figure for employment share in agriculture stands at 55 percent for all-India.*

[2] *Average agriculture growth rate between 1990-91 and 1999-00 was 3.2 per cent and 2000-01 and 2013-14 was 3.0 per cent.*

government expenditure on poverty and agriculture growth, a system of nine equations has been developed. The linkage of the role of government expenditure on poverty and agriculture growth has been established through the development of non-farm employment and rural wages.

Marginal returns in terms of the number of people brought out of poverty, to investments in research and education, roads, education, and irrigation outweigh the benefits from input subsidies in power, fertilizer, and irrigation.

Thus, there is a need to focus on 'development' model instead of 'dole' model and focus on massive infusion of public investment.

The results of the modelling exercise reveal that the marginal returns in terms of the number of people brought out of poverty, to investments in research and education, roads, education, and irrigation outweigh the benefits from input subsidies in power, fertilizer, and irrigation. The number of people brought out of poverty per million rupees spent on fertiliser subsidy is only 26 as compared to 328 persons for agriculture research and education if an equivalent amount is spent on this item. Similarly the return on agricultural GDP per rupees spent is 0.88 for fertiliser subsidy as compared to 11.2 in agricultural research and education. Contrarily, the biggest chunk of expenditure is made on fertiliser subsidy, credit subsidy and safety net programs like food subsidy and MGNREGA. The expenditure on investment schemes like the Pradhan Mantri Gram Sadak Yojana, Pradhan Mantri Krishi SinchayeeYojana, Deen Dayal Upadhyaya Gram Jyoti Yojana, the Sub-Mission on Agri-Extension, and farm research and education continue to be meagre. The findings of the study mentioned above clearly brings out the fact that investments in agricultural research and education, roads and education are unambiguously the best instruments given their higher marginal returns to additional Rupee of investment as compared to input subsidies. Thus, there is a need to focus on 'development' model instead of 'dole' model and focus on massive infusion of public investment.

According to the theories of public economics, the public sector can supply public goods efficiently and at adequate amounts as the market tends to under-provide them due to the 'non-excludable' and 'non-rivalrous' nature of public-good i.e the provider of information may not be able to exclude other potential users from accessing information. When supplied in a cost-effective way, public goods are generally expected to generate higher returns than investments in private inputs because they create positive externalities for the economy as a whole. Feder and Slade (1986) conclude that free markets for agricultural services do not fully satisfy farmers' information needs, and the government support in provision of agricultural services is justified. As per the World Bank (1981, p8), a desirable investment target for research for many countries with poorly developed agricultural research systems is around 2 per cent of gross domestic product from agriculture.

Since the structure of the Indian agriculture R&E system is such that all state agriculture universities and national institutes of ICAR have the mandate to conduct both agricultural research (including education programmes) and extension, these two types of activities are interwoven. Therefore, they need to be viewed as complementary segments, to ensure technological innovation as well as flow of information regarding new technologies to the farm-level and skill development of farmers.

All state agriculture universities and national institutes of ICAR have the mandate to conduct both agricultural research and extension, these two activities are interwoven. Therefore, they need to be viewed as complementary segments.

Existing empirical literature reveals that extension services have a positive impacton farm productivity and farm output (Lever,1970; Harker, 1973; Moock, 1973; Patrick and Kehrberg, 1973; Hopcraft,1974; Moock, 1976; Pachico and Ashby,1976; Halim, 1976; Feder, Slade and Sundaram, 1985; Perraton, Jamison and Orivel 1983) and farm earnings (Patrick and Kehrberg, 1973; Feder, Lau and Slade, 1987; Evenson and Jha, 1973; Evenson and Kislev, 1975; Birthal et al, 2015)technology adoption (Huffman, 1974; Aklilu,1980; Jamison and Lau, 1982; Rahm and Huffman,1984; Jamison and Moock, 1984; Shakya and Flinn,1985; Cotlear,1986), technology diffusion (Feder and Slade 1986) and knowledge acquisition (Feder and Slade 1984). Most of these studies have shown a positive impact of extension services on the outcome variable. Rich empirical literature supporting the association between investment in agriculture R&E and extension service with farm productivity leaves little doubt that investing in R&E and extension can be a resounding success in India as well.

Keeping this background in mind, in this study we look at agriculture R&E and extension and training system in India from a macro-economic perspective with a special focus on six states viz., Uttar Pradesh, Bihar, Odisha, Madhya Pradesh, Gujarat and Punjab. The basis for selecting these states is that, Gujarat and Madhya Pradesh have experienced rapid agricultural growth in the past decade while Punjab had achieved high growth earlier during the Green Revolution. Bihar, Odisha and Uttar Pradesh are considered moderately performing states due to their poor agriculture growth and high poverty rates. In this paper we aim to (i) analyse the latest trends in government expenditure on agriculture research and education (R&E) and extension and training services at the all-India level and the selected six states, (ii) review the existing system of agriculture R&E and extension and training in India with a special focus on major players in the agriculture extension system, (iii) empirically examine the association between of agricultural R&E/extension services and overall growth in

agriculture in the six states, (iv) review existing extension systems in selected countries and (v) present, in the light of these results, a few policy recommendations to prioritise government spending on agriculture R&E and extension and training.

Accordingly, in section 2 we give an in-depth description of major players and models of agriculture extension services in India. We then analyse the trends in agriculture research and extension system at the national level in section 3. In section 4 we describe the status of agriculture extension system in the six focus states. Section 5 uses an econometric model to test the hypothesis if agriculture R&E or extension and training or both have a significant effect on agriculture growth in the focus states. Section 6, gives a broad international perspective on agriculture extension systems and section 7 concludes with recommendations on policy interventions to bolster India's agriculture R&E and extension and training system.

Overview of Agriculture Extension System: Major Players in India

2 Overview of Agriculture Extension System: Major Players in India

India has one of the largest agricultural research systems in the world. Currently, the public research system in India is led by the ICAR, which has 5 multidisciplinary national institutes, 45 central research institutes, 30 national research centres (NRCs), 4 bureaux, 10 project directorates, 80 all-India co-ordinated research projects (AICRPs)/networks and 16 other projects/programmes. In addition, there are 29 state agricultural universities (SAUs) and one Central Agricultural University, which operates through 313 research stations. AICRPs are the main link between the ICAR and the SAUs. The number of centres involved in the AICRPs is about 1,300, of which about 900 are based in agricultural universities and 200 in the ICAR institutes. The ICAR has also Zonal Research Stations (ZRSs) and 200 sub-stations. The National Academy of Agricultural Research Management (NAARM) is another institution under ICAR to conduct research and training in agricultural research management. The ICAR has also established 8 Trainers' Training Centres (TTCs) and 611 Krishi Vigyan Kendras at the district level as innovative institutional models for assessment, refinement and transfer of modern agricultural technologies.

In addition, there are 23 general universities under the University Grants Commission (UGC), involved in agricultural research. Several scientific organizations such as the Council of Scientific and Industrial Research (CSIR), Bhabha Atomic Research Centre (BARC), National Remote Sensing Agency (NRSA), Ministries and government departments such as Ministry of Commerce, Department of Science and Technology, Department of Biotechnology, Department of Ocean Development, and more than 100 private and voluntary organizations and more than 105 scientific societies are involved in the agricultural R&E and form the part of the national agriculture research system of India (Vision 2020, ICAR)[3]. This extensive agriculture research infrastructure not only conducts agriculture research but are also responsible for educating and providing extension services to the farmers. In the following section, we discuss the agriculture extension system in India with focus on major players providing agriculture extension services in the country. We first discuss the evolution of agriculture extension system under the public sector and the major players involved, then we briefly highlight the main players providing agriculture extension services in the private sector, NGOs and civil society.

[3] *http://www.icar.org.in/files/vision-2020.pdf*

2.1 Agriculture Extension Services by the Public Sector

Under World Bank's training & visiting programme in the 1980s agriculture extension was expected to act as a 'transmission belt' between agricultural research centres and farmers by recruiting, training and deploying large and dedicated cadre of technical workers with formal training in agriculture.

Since the early 1950s, India has witnessed a long history of planned agriculture extension service (AES) intervention. Government's Community Development Programme (1952) and National Extension Service (1953) were the first planned attempts to educate farmers about improved methods of farming. The other important area-based special programmes were Intensive Agricultural District Programme (1960), Intensive Agriculture Area Programme (1964) and High Yielding Varieties Programme (1966). In 1967, Farmers Training Centres were created to educate farmers about high yielding varieties and train them in improved methods of farming to augment the above programs (Gowda, 2012).

The extension system, along with price policy and procurement support, has often been credited for ushering in the Green Revolution in India in the 1960s. However, by the end of the 1970s, the Indian public agriculture extension system witnessed a slow decline. By this time, the system was predominantly involved in the distribution of agricultural inputs through the state agriculture depots, and in the handling of subsidies that were provided through various agricultural development programs. Consequently, the system was criticized for having become a monolith organisation without any specific goals (Babuet.al 2013).

2.1.1 World Bank's Training & Visiting (T&V) program

Due to the growing inefficiencies of the public extension service system, reforms in the system were sought. To meet this need, World Bank's Training & Visiting (T&V) program was introduced as a pilot programme in Rajasthan in 1974, and by 1977 it was scaled up to several states (Ameur,1994). Under T&V, agriculture extension was expected to act as a 'transmission belt' between agricultural research centres and farmers (Picciotto and Anderson, 1997) by recruiting, training and deploying large and dedicated cadre of technical workers with formal training in agriculture technology. Extension workers were allotted a specific area and cluster of famers to work with, with scheduled visits through the crop cycle to ensure that advice was followed. Financial support by Government of India to the states to recruit and sustain the extension workers was the major driver for the latter to participate enthusiastically in this project.

The T&V based agriculture extension system (AES) played a key role in ensuring the success of the Green Revolution in several regions of the country, notably states like Punjab, Haryana, parts of western Uttar Pradesh, as also coastal districts of Andhra Pradesh and Tamil Nadu. While the focus of the early AES was on the demonstration of high yielding varieties of seeds and agronomic practices and training farmers in adopting the same, it also played a major role in ensuring timely availability of inputs such as seeds, fertilizers and agricultural chemicals. T&V cohabited with alternative methods of diffusing technologies in many states in India.

Since this programme was funded by the World Bank, a major issue relating to the programme was the sustainability of funding. Further, high requirement and quality of staffs became other major concerns (Babu et. al, 2013; Feder and Slade 1987; Anderson and Feder, 2004). In the early 1990s, when the World Bank funding stopped, the extension system had to be maintained by central and state government funds, which resulted in the slow decay of the T&V system as it became ineffective in several States. Subsequently, there was a reduction in the extent of T&V operations after recruitment of new staff was stopped and key aspects of T&V concept (e.g. the strict schedule of visits and training and the uniform ratios of field and supervisory ranks) were abandoned (Anderson, Feder and Ganguly, 2006). This weakened the system in several parts of the country, most significantly in the central and eastern states, where agricultural growth languished for a variety of reasons through the 1990s.

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2.1.2 Agriculture Technology Management Agency (ATMA)

In 1998, the Indian Government, with the support of World Bank, introduced the Agriculture Technology Management Agency (ATMA) under the Innovation in Technology Dissemination (ITD) component of the National Agricultural Technology Project (NATP). It was first introduced in 28 districts in seven states from 1998 to 2003 under the guidance of MANAGE (National Institute of Agricultural Extension Management), an institution promoted by Ministry of Agriculture, Government of India. It was later expanded throughout the country in 2005 (Babu et al, 2013).

ATMA sought to sidestep the challenge of taking on the financial burden of a large cadre of permanent extension workers, which was left to the states to cope with. Instead, ATMA created a platform for

convergence of human and financial resources available in the government, civil society, farm community and private sector. The ATMA society registered at the district level with the Collector/District Magistrate as its head was mandated to coordinate all on-going extension efforts in the district and converge and share resources in a targeted fashion.

ATMA initiated the preparation of a strategic research extension plan (SREP) at the district level.

It also identified the research extension linkages which form the basis of the state extension work plan.

ATMA initiated the preparation of a strategic research extension plan (SREP) at the district level. The SREP listed out the existing extension programmes in the district and the gaps required to be filled. It also identified the research extension linkages which forms the basis of the state extension work plan. The ATMA Governing board at the state level set out the priorities for research and extension to be implemented in each district. After the SREP was approved, the Farm Information and Advisory Centres (FIAC) at the district level, the block level teams (BTT) and the farmer advisory committee (FAC) were responsible for the extension activities in the district. Existing extension staff (with legacy gaps) still formed the backbone of the ATMA approach. Some additional resources were made available to support innovative approaches, pilots by NGOs, private sector etc. At the state level, an apex planning and training body, the State Agricultural Management and Extension Training Institute (SAMETI) was established, with the aim of training various levels of extension staff in the convergence-led approach of ATMA.

The main goal of ATMA was to bring together different agencies involved in extension activities on one platform. However, it struggled from the very beginning with issues of planning, execution and monitoring capacity at the district level as well as inadequate funding. There were also gaps in the autonomy of the district level bodies, approach towards high value sectors and engagement with non-government bodies. This led to serious divergence in the promise and performance of ATMA across most states. Though small and isolated examples of success were noted (Swanson, 2008) the majority of evaluation studies have concluded that ATMA failed to make any notable impact on the quality of extension services or add significantly to resources at the district level to upgrade the quality of AES (Sulaiman and Hall, 2008; AFC, 2010).

Government of India responded to this feedback by revamping ATMA in 2010. While the basic concept was retained, several new elements were added to make the programme more effective in achieving convergence and mopping up various resources

available at the district level. The primary challenge of providing additional human resources to support extension was sought to be addressed through additional contractual technical staff at the block level. The new guidelines also brought in the concept of a Farmer's Friend for every two villages. This part-time functionary is meant to be selected from among the farming community, building on the assumption that he will enjoy greater local connect and knowledge of the local ecosystem.

The number of subject matter specialists, both at the district and state level, was also increased. Farmer Advisory Committees were mobilized to tap the functional expertise of progressive farmers. Farm Schools were to be formed in every crop season to promote lateral sharing of knowledge between farmers themselves. KrishiVigyan Kendra (KVK), primarily tasked with research and trial of locally suitable crop varieties was roped in for direct farmer outreach, demonstrations and training. Collaboration with the private sector and NGOs was made simpler, with more powers and resources delegated to State level authorities. Early assessment of the revamped programme does not suggest that these changes could rescue ATMA from the several challenges in which it was mired since its launch. (Gladenning, Babu 2011 & Gladdenning, Babu 2013).

The concept of a Farmer's Friend for every two villages was introduced after revamping of ATMA in 2010, this part-time functionary is meant to be selected from among the farming community, building on the assumption that he/she will enjoy greater local connect and knowledge of the local ecosystem.

2.1.3 National Mission on Agriculture Extension and Technology (NMAET)

The feedback on the performance of ATMA through various evaluation studies and the observations of the working group on extension set up by the Planning Commission to prepare for the Twelfth Five Year Plan paved the way a comprehensive new national scheme to address extension services. The National Mission on Agriculture Extension and Technology (NMAET) was launched by the Department of Agriculture and Farmers' Welfare (DACFW) in 2014-15 and takes a holistic view of extension by embedding components for technical support and training in four major sub-schemes. It aims to make the system farmer-driven and accountable by restructuring and strengthening existing agriculture extension programmes to enable the delivery of technology and to improve the current agronomic practices of farmers. NMAET consists of 4 Sub Missions:

- Sub Mission on Agricultural Extension (SMAE)
- Sub-Mission on Seed and Planting Material (SMSP)

The National Mission on Agriculture Extension and Technology (NMAET) aims to make the system farmer-driven and accountable by restructuring and strengthening existing agriculture extension programmes to enable the delivery of technology and to improve the current agronomic practices of farmers.

- Sub Mission on Agricultural Mechanization (SMAM)
- Sub Mission on Plant Protection and Plant Quarantine (SMPP)

Sub-Mission on Agricultural Extension (SMAE) aims to focus on creating awareness about the latest technologies to be used by the agriculture and allied sectors. There will be increased training of personnel under agriculture clinics and agriculture business centres. A lot of emphasis has been placed on use of ICT interventions like pico projectors, low cost films, handheld devices, mobile based services, Kisan Call Centres (KCCs) etc. to speed up dissemination of information, good practices etc.

The guidelines for NMAET were issued well into the financial year 2015-16 and it is too early to say if the new approach has made a significant impact on the ground. It is also pertinent to point out that Government of India has significantly altered the funding pattern in 2015, reducing the Central share from 90 per cent to 10 per cent. However, we will return to the overall assessment of the public sector expenditure patterns to extension the subsequent section.

2.1.4 Public Agriculture Extension system: Other Players

a) KrishiVigyanKendras

Krishi Vigyan Kendras (KVK) are the field research units of the national agricultural research system (the Indian Council for Agricultural Research-ICAR) and are meant to test new seed varieties, agronomic practices, machinery etc. in field conditions across different agro-climatic zones before these are cleared for adoption by farmers. The KVK initiative was launched in 1974 and has grown into 611 centres by the end of 2011, ensuring at least one KVK in each district of the country. Besides research, these institutions also conduct farmer outreach programmes through on-farm demonstration plots, training etc. However, despite their impressive network, KVKs are seen as underperformers in terms of reaching out to large numbers of farmers and have faced severe challenges of capacity, performance standards and accountability.

Despite their impressive network, KVKs are seen as underperformers in terms of reaching out to a large number of farmers and have faced severe challenges of capacity, performance standards and accountability.

b) State Agricultural Universities

The State Agricultural Universities (SAU) are another important arm for promoting extension activities in the States. While their main mandate is formal degree programmes in major agricultural disciplines, they provide extension and training support through the directorate of extension and education. The information flow is

mainly from the universities to the KVKs which are responsible for training farmers. The information flow is largely linear, with little scope for feedback from famers. Another criticism is that the information flow largely reflects centralised agendas rather than catering to local needs, with the major focus being on transfer of technology. A holistic approach at support to the entire production chain, including post-harvest management is missing.

c) ICT (Information and Communication Technology) led Extension

An important reform undertaken in recent years by the Ministry of Agriculture at the national level has been the increasing use of modern technologies and communication strategies to help educate farmers. ICT has significant potential to reach large numbers of farmers in a cost-effective manner. It can also facilitate two way information flows between farmers and the extension agencies. Here we focus on some of the schemes launched in the past three years:

ICT has significant potential to reach a large number of farmers in a cost-effective manner. It can also facilitate two way information flows between farmers and the extension agencies Farmer portals and Kisan Call Centres

- **Farmers Portal:** Farmers Portal is a platform where farmers can access information on crop insurance, storage, crop advisories, extension activities, seeds, pesticides, farm machinery, fertilizers, market prices etc. Farmers can download a handbook which provides details of schemes and guidelines of various schemes and programmes.

- **mKisan:** mkisan is an SMS portal that enables authorities at the central and state level to give information to farmers in the local language. There are several free, mobile based applications (or apps as they are commonly referred to), such as KisanSuvidha, PusaKrishi, Agricultural Market, Bhuvan Hailstorm etc. providing various types of information to farmer through mobile phones.

- **Kisan Call Centre:** These toll-free, phone based agricultural advisory services in local languages are operational in most States with financial assistance provided Government of India. A single number is offered to farmers for seeking information and advice on a range of agriculture related issues. Subject matter specialists are available at these centres to respond to calls, in case the queries require specialist consultation, a call-back facility is also operational. In several States, the KCC has achieved fairly impressive levels of penetration.

- **Kisan TV Channel:** A dedicated 24 hour television channel on agriculture was launched by the national broadcaster,

Doordarshan in 2015. Delivering content in several major regional languages, besides Hindi, the Kisan Channel provides real time information on inputs, farming techniques, water conservation etc. to the farmers. The dedicated channel replaced a daily hour (KrishiDarshan) set aside by the national broadcaster on its terrestrial network of regional centres which produced (in-house developed) programme content on agriculture. Despite criticism by experts for the lack of innovation and attractive production values, KrishiDarshan was listed among the major sources of agricultural advice by farmers (NSSO 70th Round). The majority of those who watched this programme also found the content useful. Government of India seems to have built on this feedback by dedicating a separate channel to agriculture. While initial teething troubles are to be expected, the success of the channel in reaching out to farmers in diverse agro-climatic zones to address their technical needs for a range of crops and emerging HVA sub-sectors could be a major factor in influencing growth in the sector.

- **Agriculture Clinic and Agriculture Business Centres (ACABC):** The ACABC scheme was launched in 2002 and was targeted at young rural agriculture graduates who wanted to turn entrepreneurs seeking to provide fee-based agriculture services to farmers. The scheme involves mandatory training and subsidy to set up a rural service centre, often supported by a bank loan. ACABCs were to provide a range of services, including sale of inputs, agriculture advice, marketing support etc. A mandatory two month training at the National Institute of Agricultural Extension Management (MANAGE), at Hyderabad was designed to instil the basis of business management among aspiring agriculture entrepreneurs. As of November 2013, a total of 34,883 graduates were trained under the scheme, 13603 of whom went on to set up agriculture clinics (MANAGE,http://www.manage.gov.in/). However, problems of raising capital and access to institutional finance have proved to be the bane of this programme. The experience so far does not suggest that the intervention is a game changer in the sector and could address the gaps in AES which opened up after the collapse of T&V in many States. During the Twelfth Plan, the scheme was further liberalized in terms of outlays but the impact of these measures can only be assessed after further evaluation.

Agriculture Clinic and Agriculture Business Centres targeted young rural agriculture graduates who wanted to turn entrepreneurs seeking to provide fee-based agriculture services to farmers. The scheme involves mandatory training and subsidy to set up a rural service centre.

- **Agriculture Fairs and Exhibitions:** These events have become a common feature in most States and are often effective in demonstrating new technologies and products. Some States, like Gujarat, organize an elaborate fortnight long KrishiMahotsav (which literally means "festival of agriculture"), where mobile vans fitted with video screens and field staff move along a pre-announced route, showing films, holding discussions, selling inputs etc. These fairs also provide an opportunity for exchange of ideas as well as knowledge and experience among farmers.

- **Community Radio Stations:** Community radio stations are narrow broadcast channels which seek to generate locally relevant content and advice within a small area (typically about a few hundred villages). They are an effective means of dissemination of local knowledge and good practices, help to showcase success stories and mix entertainment, news and other non-technical content along with their core mandate of agriculture extension. While there was much expectation from this medium about a decade ago, the promise seems did not materialize into replicable, scalable models. Perhaps the fact that the bulk of community radio licenses were issued to universities and academic institutions made the content too heavily dependent on experts and academics. The participatory, local nature of community radio could never evolve for this reason. In the interim, more economical means of reaching content to individual farmers (through phones, internet etc.) overtook radio broadcast technology and the initiative seems to have joined the list of sub-optimal performers in the AES pantheon.

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2.2 Agriculture Extension Services by the Private Sector, NGOs and Civil Society

At present, extension services are being provided mainly by the public sector through a two tier system. As mentioned earlier, at the central level, Indian Council of Agriculture Research (ICAR) is the nodal institute for agriculture research and extension; while at the state level, the State Agricultural Universities (SAU) facilitate agriculture extension via the KrishiVigyan Kendra (KVKs) and Agriculture Technology Management Agency (ATMA) at the district level. Besides the existing public extension service system, there are several private players, civil-society organisations including farmer-based organisations and NGOs that play a major

role in financing and providing extension services (Birner and Anderson, 2007)

2.2.1 Agriculture Extension System by Private Players

Major complaint against input dealers is that they indulge in "product advisory" instead of "technical advice" which is brand agnostic.

AES in private sector are mostly delivered by input dealers, such as those marketing seeds, fertilisers, pesticide and farm machinery. There are about 2.80 lakh input dealers across the country, compared to approximately 1.42 lakh sanctioned posts of extension workers (of which on an average 30 per cent remain unmanned). This gives an idea of the reach and importance of the input dealer as a source of technical advice to farmers. A major complaint against input dealers is that they indulge in "product advisory" instead of "technical advice" which is brand agnostic. Even the Government of India has recognized the leverage of this category of extension support to farmers and offers a course at MANAGE specifically targeting input dealers who wish to brush up on the latest technical knowledge in various sub-sectors of agriculture.

Some private sector agribusiness and input manufacturing companies also undertake direct extension activities. Hyderabad based Nuziveedu Seeds has done a lot of extension related work through its programme, 'SubeejKrishiVignan'. These extension activities are in support of their product brand and seek to help the famer realize higher production (and thus returns) through necessary pre-sowing preparation, optimum seed rate, correct agronomic practices, application of nutrients and harvesting techniques.

In the case of fertiliser companies, especially large cooperatives like IFFCO (Indian Farmers Fertiliser Co-operative Limited) and KRIBHCO (KrishakBharati Cooperative), extension activities include a wider range of interventions, such as conducting farmer meetings, organizing crop seminars, arranging for soil testing facilities, adopting villages etc.

Tata Chemicals initiated Tata KisanKendras with the objective of empowering and enabling farmers towards improved agronomic practices and higher returns. DCM Shriram, which also produces seeds and fertilizers, established HariyaliKisan Bazaar (HKB), a chain of agriculture input retail stores which also offered marketing support for select produce. Farmers could also access technical information, information on agri-inputs and banking and farm credit facilities through the HKBs. AGROCEL an agro-chemical company, provided inputs and necessary technical guidance to

farmers through its "Agrocel Service Centres" in many states. The commercial model adopted by both Tata and DCM Shriram proved unsustainable, leading to closure of the majority of centres initially launched. A similar fate awaited Mahindra ShubhLabh, which was closely modelled on the Tata centres.

ITC, another agribusiness major, launched its e-Chaupal initiative in extension over a decade ago. A VSAT-enabled internet connection at the village level allowed farmers to check prices in the local mandis before they moved their produce for sale. This helped to reduce information asymmetry to a great extent and forced the mandis to adopt fairer price discovery processes. ITC also purchased small quantities of select commodities at these centres for its own trading and processing needs. The e-choupal also provided access to information about weather and innovative farming practices to the farmers. Other initiatives taken by ITC include the "ChoupalSaagars" and "ChoupalPradarshanKhet" (CPK). ChoupalSaagars mainly comprise of collection and storage facilities which create a hypermarket in rural areas that serves multiple services under one roof. ChoupalPradarshanKhet is a demonstration plot which helps farmers to learn best agronomic practices to enhance their farm productivity.

e-Chaupal initiative allowed farmers to check prices in the local mandis before they moved their produce for sale. This helped to reduce information asymmetry to a great extent and forced the mandis to adopt fairer price discovery processes.

Companies like Pepsico and Heritage Foods, which undertake contract farming of potato and vegetables respectively, also work closely with farmers to provide inputs, technical advice and marketing services. (Sulaiman, 2012). None of these models, however, operate at a scale of over a few thousand farmers at the limit, thereby restricting the scope of impact that they make on the wider farming ecosystem.

The growing importance of private sector in both research and extension in India gives rise to an important aspect that has special relevance to the incentives for agriculture research, is that of intellectual property rights (IPRs). A lack of well-defined IPRs weakens incentives for privately funded research.

2.2.2 Agriculture Extension System by Non-Governmental or voluntary organisations (NGOs)

In India about 15,000-20,000 NGOs are actively involved in development of rural areas. Their grassroots orientation and proclivity to work in rain-fed and tribal regions has naturally oriented them towards land based livelihoods, hence the essential component of extension in their intervention.

NGO-led extension services are characterized by a focus on contextual relevance, fostering local innovations and participatory approaches, which sets them apart from the traditional top-down approach of larger institutional players.

Some NGOs, such as Professional Assistance for Development Action (PRADAN), Bharatiya Agro-Industries Federation (BAIF) and Action for Food Production (AFPRO) are actively involved in promoting extension activities in more than one state. PRADAN has mainly focused on promoting livelihood of the poor in different sectors ranging from agriculture and natural resource management to microenterprise in rural areas across 8 states in India. BAIF is also working on the development of livelihoods by engaging in livestock development, environment conservation, water resource management across 16 states. Syngenta foundation, India (SFI) has been instrumental in helping marginalized farmers adopt high quality production technology for better productivity and improved incomes through unique models of agriculture extension. During 2005-09, three extension-driven projects were launched in targeted disadvantaged regions in the country which included high performing seeds, improved agronomic practices and new pest control technologies. From 2009 to 2013, extension was synonymous with 'market-led extension' especially in the case of vegetables. The idea was to 'produce together and sell together' with fewer intermediaries. In 2014, SFI introduced its flagship initiative of the Agri-Entrepreneur (AE) Model which brought together unemployed youth with an aptitude for entrepreneurial activity to take the role of agri-entrepreneurs. The critical role of an AE is to bring together credit and market linkage, access to high-quality input and crop advisory for a 'cluster' of farmers. The AEs must also come from the villages in the cluster they support. Financial support comes from IDBI bank, moreover the AEs are closely monitored and supervised by SFI and partner NGOs to make sure they do not act in self-interest alone. The model is successfully running across six states including three of our study states: Bihar, Madhya Pradesh and Odisha with a network of 40,000 farmers as beneficiaries and a total of 309 AEs as of December, 2017. KRIBHCO, the fertilizer cooperative, launched a not-for-profit entity, called "GraminVikas Trust" (GVT), which promotes holistic rural development activities. This organisation is working across 8 states and specializes in the field of agriculture, watershed development, natural resource management, livelihood improvement, women empowerment, institutional development etc. (Sulaiman, 2012).

2.2.3 Agriculture Extension System through Farmer Interest Groups/ Farmer producer Groups/ Women farmer Groups etc

Organized user groups such as commodity groups, farmer interest groups, farmer clubs, women farmer groups, special interest groups etc. also play small but important roles in extension in niche regions and areas. One of the most successful farmer organisations in Maharashtra, MAHAGRAPE (Grape Growers Association of

Maharashtra) has organised itself to support members to achieve higher yield, quality and returns. It conducts training, seminars, group discussions, publishes leaflets and also undertakes R&E and other activities to benefit its members. In South India, the United Planters Association of Southern India (UPASI) which is the apex body of tea, coffee, rubber and cardamom growers is involved in leadership, research and extension services for the plantation industry.

Due to the important role played by farmer groups, both informal and formal, in supporting extension activities, many state governments have taken a keen interest in promoting farmer self-help groups (SHGs). Producer co-operatives and farmer producer organisations have in many instances provided extension service to their members. (Sulaiman, 2012). However, like other non-institutional players, none of these models offer scale and replicability.

2.2.4 Agriculture Extension System through Media and ICT

Due to widespread availability of ICTs such as mobile phones, internet, television etc. digital technology has shown a tremendous potential to disseminate information to the farmers and promote extension. Several experiments of varying scale are observed across the country. MS Swaminathan Research Foundation (MSSRF) in Pondicherry has taken up the use of ICTs to disseminate information on ecology, livelihoods, socio-economic and gender aspects. Several web portals (ikisan.com, krishivihar.com, agriwatch.com and commodityindia.com) offer internet-connected farmers a variety of information and advice. The increasing growth in the use of smartphones suggests that this source of information will expand significantly in coming years. An IT app called e-sagu provides farm specific expert advice to farmers throughout the crop duration. Agencies such as IFFCO Kisan Sanchar Limited (IKSL), Reuters Market Light (RML) and Tata m-Krishi are similar examples of knowledge dissemination to farmers through mobile phones. Sulaiman et al. (2011) found that ICT in general didn't contribute effectively in putting new knowledge into use as it mimics the traditional approach of information transfer and training of the farmers and also has limited reach. (Sulaiman,2012). None of the initiatives listed reaches out to more than a few thousand farmers, mostly in short periods. A scalable intervention leveraging ICT has yet to emerge.

Most initiatives listed reach out to only a few thousand farmers, mostly in short periods. A scalable intervention leveraging ICT has yet to emerge. Even the early promise of the 'Digital India' campaign of Government of India (seeking to deploy ICT on a large scale to enhance citizens' access to services) appears to have run out of steam, with no visible breakthrough at least in the agricultural sector.

Broad observations on national level extension efforts

The following broad conclusions may be drawn from the foregoing review of public, private and civil society led extension interventions in the country:

i) Agriculture extension services in India are predominantly centred around crop husbandry with a pronounced tilt towards terms of trade. The approach of public sector extension is to offer a one-size-fits-all product to all farmers. In a country with over 86% of farmers categorized as small and marginal, this is a self-limiting approach as the huge variations in resource endowment, agro-climatic conditions and legal exigencies are not factored into the model of agriculture extension being followed either by the government.

ii) While NGO-led extension models offer far more variety and display sensitivity to local priorities and conditions, they do not have the capacity or scale to make a significant impact across large regions. They are also seriously hampered in scaling up due to paucity of resources, as public sector extension agencies rarely explore synergies or cooperation and donor support continues to be project-driven and episodic.

iii) In recent years, the growth in the High Value Agriculture (HVA) sector has been twice or sometimes even thrice that of the crop husbandry sector. Yet agri extension services for HVA sectors remain weak and disorganized.

iv) The above analysis also suggests that the government, private sector, NGOs and others providing agriculture extension services are working in isolated silos with little or no functional coordination at the field level. This leads to restriction of good practices generated in each of these sectors and an opportunity for wider application is lost.

v) Lastly, it may be concluded that the large number of players in the agriculture extension arena function without any standards or certification of quality. This leaves questions of accountability up in the air as the majority of farmers are not in a position to pursue legal remedies in case of erroneous or even harmful advice.

An increasing number of players in the agriculture extension arena function without any standards or certification of quality. This leaves questions of accountability up in the air as the majority of farmers are not in a position to pursue legal remedies in case of erroneous or even harmful advice.

2.3 Agriculture Extension and Doubling Farmers' Incomes

It is imperative to consider the recently released report of the **Dalwai Committee on Doubling Farmers' Income** (vol XI) on "Empowering the Farmers through Extension and Knowledge Dissemination".DFI Committee defines Agricultural Extension as the "empowering system of sharing information, knowledge,

technology, skills, risk & farm management practices, across agricultural sub-sectors, all along the agricultural value chain, so as to enable the farmers to realise higher net income from their enterprise on a sustainable basis". The report stresses on the dichotomy between knowledge and skill- a large number of farmers are aware of knowledge pertaining to production; however it is the skill to convert that knowledge into tangible output that is missing. The report has addressed the importance of extension in bridging the knowledge gap among farmers. Targeting incomes requires an increase in productivity as a pre-requisite which can only be improved with better technology, motivation and institutional structures to facilitate research and extension.

There is a growing concern about the focus of extension primarily towards production technology, only recently has there been a recognition of the extended role of extension as 'extension of extension' to include market-led and market oriented information in the conceptual paradigm. The DFI approach proposes to promote agriculture extension as a value system that would help farmers produce for the markets and generate a sustainable growth in income.

The analysis raises two important questions; first does the public extension system have adequate and technically competent manpower to empower farmers? The heterogeneous nature of the farming communities in India in terms of socio-economic, cultural and agro-climatic backgrounds makes it necessary to have specific extension. The competition among private players has made the extension market vast and diversified with a confusing range of choices for farmers, sometimes even the wrong piece of information. Aggressive marketing strategies followed by agri-businesses, input dealers and fertilizer companies are often product based not productivity based. Public extension's role is limited to advisory services while input is provided by private sector. The concern raised is sometimes despite getting the right information, framers purchase wrong products and hamper their gains. The other concern is of course the lack of skills and accuracy of information by technical manpower transferred to farmers.

The second question is about the comprehensiveness of the system- is Public Extension designed to be result-based or outcome-oriented at all? The public extension delivery system has functioned more as targeted activity based rather than targeted outcomes based mechanism. The quality concerns raised are tremendous, along with a tendency for repetition and limited

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knowledge base from procedural bottlenecks. The targeted outcome must result in profitability enhancement for the farmer, which would need to address aspects such as climate change based crop alignment, productivity gains, post-harvest information and marketing and risk negotiation in the agriculture value system. Over the years, the linkages of extension have weakened since the T&V programme by the World Bank leading to extension not serving its entire supply chain. The breaks in the chain arise from the strained contact farmers have with the market which ultimately lowers their bargaining power. Extension advice and information on post-harvest management and marketing is almost missing today

The report also overstates the role of ATMA. In its initial stages, ATMA was thought to be an integrating body which would coordinate the efforts of all extension institutions, however with time its strength diluted. One of the major problems was routing funds through state treasuries to ATMA causing major delays. SAMETIs were placed under the control of State governments further diluting their autonomy. It is important to note that ATMA itself suffered from inherent flaws, for instance the committee itself accepted that funds identified for 'Extension & Training' activities under various flagship schemes (both Centre and State) were spent without the required convergence which resulted in duplication of efforts at the field level. Certain guiding principles of ATMA which have not been deliberated upon are worth noting, especially the promotion of Public-Private Partnerships under it. A minimum of 10 per cent of fund of ATMA are already earmarked for PPP initiatives.

The need of the hour is to teach farmers to capture a larger share of the consumer spend, this would involve educating them on activities that create greater value in other terms-diversification. The DFI committee (DFI Vol IV) proposes that farmers need to be effectively educated to take advantage of services of primary rural agri-markets (PRAMs). Extension functionaries themselves need to be trained in these areas to be able to motivate farmers to add value to their production.

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A critical precondition to doubling farmers' incomes is to treat agriculture as profitable and as a business with fundamentals like right cost, book keeping, finance and resource management. Agri-enterprises have aimed at providing income generating opportunities either in agriculture or in allied services such as nurseries, custom hiring, vermi-composting, bee-keeping, agri-tourism, milk chilling and spawn production (for mushrooms) to

name a few. All these investments require skills and market linkages- which are currently the two weakest links in the public extension system. This mutual incentive structure contributes significantly to doubling farmers' incomes.

Another crucial dimension of knowledge dissemination has been attended to pertains to the importance of the extension system in identifying a distressed individual and providing necessary advise to overcome this distress. Often, distress is related to a number of psychological and socio-economic factors which are overall underpinned by instability of income. Extension needs to streamline advise on the basis of guidance on actions that can mitigate distress and this type of counseling is proposed to be a part of extension advisory services. Researchers in Punjab Agricultural University, Telangana State Agricultural University and Marathwada Krish Vidyapeeth are working on an index called 'stress index' which captures distress symptoms for farmers. They are also developing a training module for village level officials to counsel vulnerable farmers. Sensitive counseling is critical in the extension system and such advice can help farmers in stressful agrarian crisis.

Researchers in Punjab Agricultural University, Telangana State Agricultural University and Marathwada Krish Vidyapeeth are working on an index called 'stress index' which captures distress symptoms for farmers.

Markets for wrong and biased information:

As much as the right type of information makes a huge difference to farmers, the wrong kind of information has serious harmful consequences. The negative impact of imperfect knowledge has proven to be a major problem especially in the private sector. Spurious markets for pesticides and fertilizers exist in different parts of the country. FICCI's data showed that the market for spurious pesticides was worth Rs 3,200 crore in 2013. This amount made up about 25 per cent by value and 30 per cent by volume of the domestic pesticide industry. Iyengar (2010) has pointed out that fake pesticides lead to annual crop loss of Rs 6000 crore.

Status of Manpower in Public Extension

There is a major scarcity of extension staff at various levels. As per the report, in 2012-13 one extension functionary served 1162 operational holdings (broadly, sectoral variations exist). The DFI committees of the opinion that the minimum ratio of extension service provider to farming family that is recommended is as follows:

(i) Hilly areas – 1:400

(ii) Irrigated areas – 1:750

(iii) Rainfed areas- 1:1000

A total of 27,937 positions were sanctioned depending on the strength and eligibility of each state. As on 15/4/2017, only 13,672 positions were filled and 14,265 positions were vacant. If these ATMA vacancies are filled up then the ratio would improve from 1162 farmers per officer to 1037 farmers per officer.

Another recommendation in this area is the introduction of Performance linked incentives for field functionaries. Three key developments are proposed:

First, remuneration benefits in line with percentage increase in productivity in a designated area. Second, reduction in percentage gap between productivity in lab conditions and the subsequent productivity conditions in the field. Lastly, the net income generated per unit area.

Moreover, to involve women in the income generating process, it is suggested that 50 per cent of the farmer field friends (currently 3.25 lac) should be reserved for women. Women will potentially play a major role in the livestock sector.

Moreover, to involve women in the income generating process, it is suggested that 50 per cent of the farmer field friends (currently 3.25 lacs) should be reserved for women. Women will play a major role in the livestock sector. At the same time, with the increased importance and enhanced responsibility of 'farmer friends', it is recommended that their remuneration be doubled (from 500 to 1000 per month per farmer friend)

Changing role of universities

In recent years universities have taken the role of 'concept nurseries and think tanks' along with the traditional role in mainstream extension. Universities are required to disseminate not only their own technology but all other technology related to the specific area from different corners, this, however has not been happening. At present there are about 1.2 lac extension functionaries in the country. ICAR organizations, Agricultural Universities and KVKs have the largest manpower serving the agriculture sector but at least 15 per cent of the positions in extension are held by supervisory and administration officers which are not active field level staff.

Real Time Extension with risk management

With the advent of global warming, farmers are in need of real time information related to weather conditions, natural calamities, and fire and pest attacks. The delivery system in this case has been weak in India while most countries have efficient early-warning

systems. The capacity for weather related information and disaster management preparedness has to increase.

Integrated & Inclusive Extension

While there has been a mention of the importance of women self-help groups and women centric extension services, most schemes are underfunded in allocation areas involving women in agriculture. Their medium of help is limited to NGOs and self-help groups. There is a dearth of women agri-entrepreneurs. Secondly, out various schemes (55 schemes under 7 broad missions) of the DAC&FW, only about 14 schemes have specific allocations for women. Feminization of agriculture is still a far-fetched dream. The committee also acknowledges that the lack of special schemes exclusively for women farmers and their challenges is rather disappointing.

Agricultural value chain extension with ICT

Extension should not be seen in isolation. With various links that extension has with the entire value chain of agricultural activities, DFI recommends that co-opting and converging the multiplicity of public, private and not-for profit extension efforts. This could be done best by bringing out a database on the number of extension workers, their roles, approaches adopted by them and their impact. Such an approach would help in linking diverse product value chains, in various agro-climatic zones.

ICT is an imperative tool to link value chains in agriculture. With digitization taking the lead, they have the potential of creating a large virtual extension web available to farmers 24 hrs, at any place at the fastest and cheapest rate. Mass media has helped reach out to a large number of farmers, however the frequency and access needs to be increased along with quality checks on the content.

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Kissan Call centres have proved to be important and reliable arm disseminating information and addressing queries. Every week more than 1.9 crore crop advisories reach out to farmers. Mobile Apps, TV channels and periodic journals have benefitted e-friendly farmers in a massive way.

Digital technologies have a crucial role to play in knowledge gains but if not implemented equitably, can exacerbate the gap between illiterate and illiterate farmers. This is a critical outcome of ICT based extension where in, depending only on ICT might not be the way to go, farmers who are incapable of modern technologies need to be integrated in the digitized system first.

Increasing the farmers' share in the consumer rupee will depend on eliminating third parties that take advantage of the room for arbitrage created due to high price differentials between primary rural and final wholesale markets.

Primary Rural Agri-Markets

Increasing the farmers' share in the consumer rupee will depend on eliminating third parties that take advantage of the room for arbitrage created due to high price differentials between primary rural and final wholesale markets. It is recommended (DFI vol, IV) that the periodical rural markets be developed into retail cum logistics hub named Primary Agri-Rural Markets (PRAMs) which include facilities for aggregating produce, grading, price discovery and increasing the bargaining power of farmers. The forward linkages from here on to large demand centres can be done by interconnecting PRAMs via a virtual network under the e-NAM program.

One of the key recommendations worth noting is the concept of a sharing arrangement between KVK and Agri-preneurs. This income generating endeavour in the vicinity of KVKs is a form of demonstration in itself. Activities such as custom hiring, milk chilling units, nurseries, bio-fertilizers, honey processing and fish fingerlings production could be tried on a PPP basis within the geographical areas of KVKs. A suggestion has been made to start this initiative on a pilot basis in 50 KVKs across the States including Andaman and Nicobar Islands and ATARI zones, which will later be scaled up.

Trends in Public Agriculture Research and Extension Expenditure in India

3 Trends in Public Agriculture Research and Extension Expenditure in India

In this section, we analyse the trends in agriculture R&E and extension and training expenditure by the public sector in India for the time period 2000-01 and 2014-15[4]. We have collated data on agriculture R&E and extension and training expenditure by the public sector from several issues of the 'Combined Finance and Revenue Accounts of the Union and State Governments in India' provided by the Comptroller and Auditor General of India. Since all state agriculture universities and national institutes of ICAR have the mandate to conduct both agricultural research (and education) and extension these two types of activities are interwoven (Jha and Pal, 2007). Therefore, the definition of agriculture R&E expenditure used in this paper includes expenditure on agriculture R&E ie, education and all extension services pertaining to Extension education. The duality in extension is divided into extension education and extension training. 'Agriculture Research and Education' (R&E) includes extension education, while 'Extension and Training' includes frontline and field extension, both the variables together capture the total or aggregate research and extension which we call Aggregate Research and Education and Extension and Training (AgRE&XT) in our paper. In the first part of this section we discuss the allocation of financial resources towards agriculture R&E and extension and training in India. In the second part we analyse trends in research intensity such as agriculture R&E expenditure as a percentage of GDPA and per hectare agriculture R&E expenditure at the all-India level in order to gauge the amount of investment compared to the size of the sector. In the third part we discuss the sector-wise allocation of agriculture R&E and extension and training resources vis a vis the changing composition of the agriculture sector.

3.1 Financial Resources Allocated for Agriculture R&E and Extension & Training

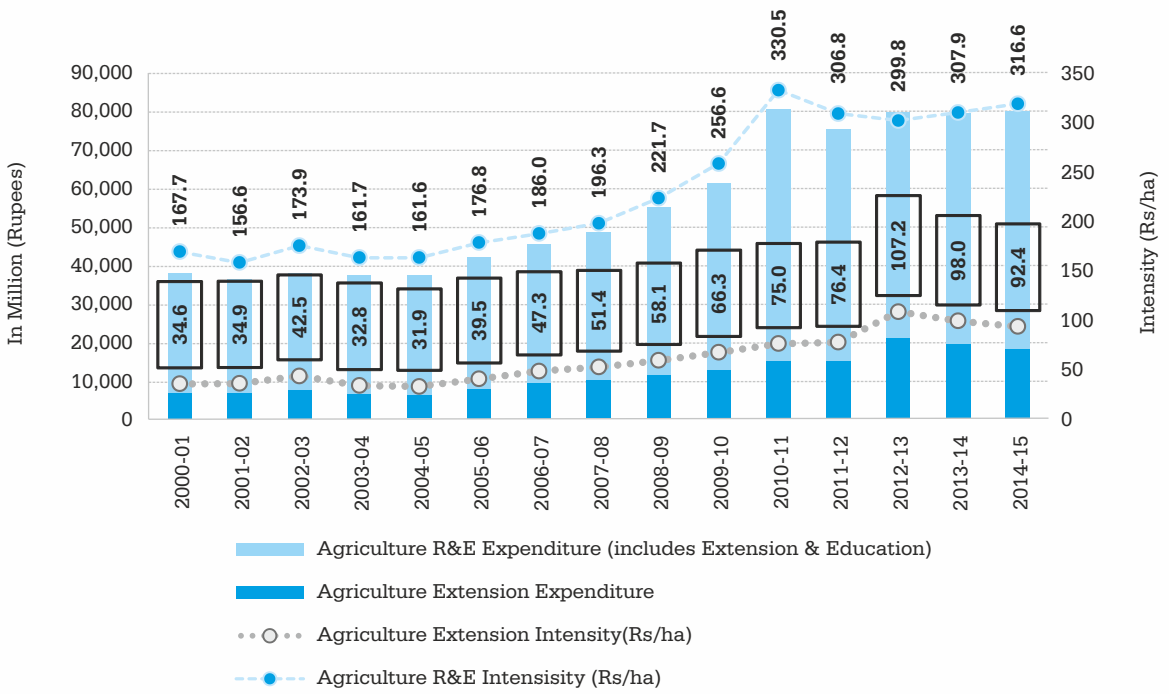
In India, public funding for agriculture R&E is contributed by both centre and state with around 55 per cent of the total allocation contributed by the centre and 45 per cent by states. The total R&E expenditure for agriculture and allied activities in real terms (2004-05 prices) has increased from Rs 31,073 million in 2000-01 to Rs 61,552 million 2014-15, thereby recording a compound annual growth rate of 5 per cent for the period 2000-01 and 2014-15 (Figure 1).

[4] *For certain calculations 2013-14 data has been used due to paucity of data for 2014-15.*

An important component of agriculture R&E is provisioning of funds for extension services to ensure diffusion of new innovations in the field. Around 82 per cent of total extension[5] allocation is funded by the state government and around 18 per cent is allocated by the centre. In 2014-15, India allocated around for Rs 17956 million for agriculture extension and training exclusively, which has grown from Rs 6,407 million in 2000-01 therefore recording a CAGR of 7.6 per cent for the given period. (Figure 1)

"*Extension throughout the text and in figures refers to Extension and Training, unless specified otherwise*"

Figure 1: Agriculture R&E and Extension and Training Expenditure in India (2004-05 prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and DES.

3.2 Research Intensity Indicators

3.2.1 Agriculture R&E expenditure as a percentage of GDPA

Agriculture R&E expenditure as a percentage of GDPA gives a holistic picture of the amount spent on the sector relative to its size. Historically, India spent a very small proportion of agriculture gross domestic product (GDPA) on research and development, it was at 0.32 per cent for TE 1971, and two decades later it rose marginally to 0.45 per cent (TE 1991). Between TE 1999-00 and TE 2014-15, agriculture R&E expenditure as a share of GDPA increased from 0.50 per cent to 0.54 per cent (Table 1).

[5] "*Extension throughout the text and in figures refers to Extension and Training, unless specified otherwise*"

Table 1: Public Expenditure on Agricultural Research and Education in India

	Agriculture R&E Expenditure (includes Extension Education)	Research Intensity Indicators
	In Million Rs	Expenditure (% of GDPA)
TE 1971	6,073	0.32%
TE 1981	8,007	0.40%
TE 1991	13,528	0.45%
TE 2000	20,773	0.50%
TE 2015 (Current Price)	111,533	0.54%

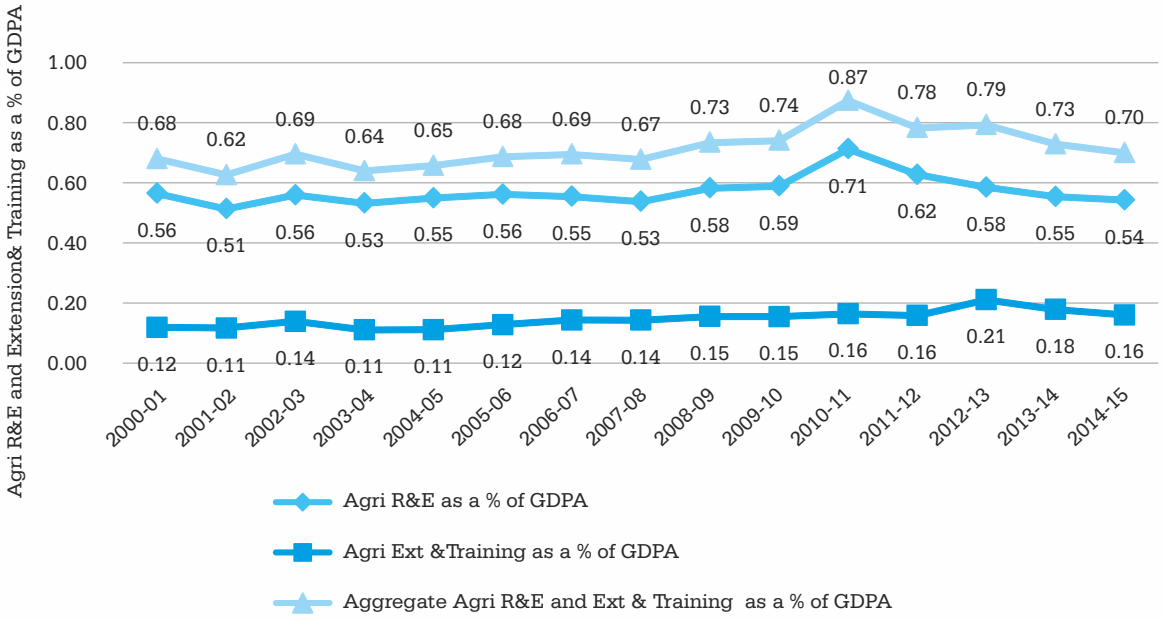
Source: TE 1971, TE 1981, TE 1991 and TE 2000 data taken from Jha and Pal, in Dragon and the Elephant: Agriculture and Rural Reforms in China and India (2007). Data for TE 2015 taken from Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO.

From Figure 2, it is observed that agriculture R&E expenditure as a percentage of GDPA remained steady since 2000-01 at 0.5 per cent till 2007-08, post which it rose significantly reaching 0.7 per cent of GDPA in 2010-11 and finally settling down at 0.54 per cent in 2014-15. We also use an Aggregate measure combining total R&E and Extension and Training expenditure of the public sector as a percentage of GDPA. This aggregate (R&E and E&T) stand at 0.7% of GDPA for the year 2014-15. Other estimates such as Agriculture Science and Technology indicators (ASTI) estimates that in 2014-15[6], India spent around 0.3 per cent of GDPA on agriculture R&D. The difference in the estimates given in this paper and ASTI is mainly because ASTI's definition of agriculture R&D excludes the amount spent on education and extension. It has deciphered how much actual expenditure is on R&D based on interviews from some selected universities. In our analysis we have used data from the 'Combined Finance and Revenue Accounts of the Union and State Governments in India' provided by the Comptroller and Auditor General of India. According to the definition presented in these reports, agriculture R&E includes both education and some part of extension because it is often difficult to isolate the effect of extension from R&E itself as resources allocated for R&E and extension are often interwoven. 'Agriculture Research and Education'(R&E) includes extension education, while 'Extension and Training' includes frontline and field extension, both the variables together capture the total or aggregate research and extension which we call Aggregate Research and Education and Extension and Training (AgRE&XT) in our paper.

In Figure 2 we have also presented the data of agriculture research and education and we also analyse the trend in funds allocated for extension and training alone. It is observed that extension expenditure alone as a percent of GDPA has remained almost stagnant, only 0.16 percent of GDPA (2014-15) is spent on agriculture extension vis a vis 0.12 percent of GDPA in 2000-01. As on TE 2014-15, around 82 per cent of the total agriculture extension and training funding was contributed by the state and only 18 per cent by the centre.

[6] *https://www.asti.cgiar.org/india*

Figure 2: Agriculture R&E and Extension & Training as a percentage of GDPA (Current prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO.

Although at the national level India spent about 0.54 per cent of its GDPA on agriculture R&E, there are considerable variations across states. From Table 2 it can be seen that excluding the north–eastern region, most of the eastern states spend less than 0.5 per cent of its GDPA on agriculture R&E, while states like Uttarakhand, Himachal Pradesh, Kerala and Tamil Nadu spend more than 0.8 per cent of its GDPA on agriculture R&E. This shows that the eastern states, which are also few of the poorest states in the country with high dependency on agriculture, are also the states with the lowest spending on agriculture R&E. In 2010-11, the Government initiated the programme of "Bringing Green Revolution to Eastern India" in order to address the constraints limiting the productivity of rice based cropping pattern in this region. In order to improve agriculture productivity in this region, scaling up of agriculture R&E and extension funding will be critical. We discuss in details about the status of agriculture R&E and extension in Uttar Pradesh, Bihar and Odisha later in the paper.

Table 2: State-wise Agriculture R&E expenditure as a percentage of GDPA (TE 2013-14)

Agriculture R&E Expenditure as a percentage of GDPA	State-wise spending (TE 2013-14)
Above 1 %	Uttarakhand (1.1%)
Between 1 to 0.6%	Himachal Pradesh (0.9%); Kerela (0.9%); Tamil Nadu (0.8%); Maharashtra (0.6%); Andhra Pradesh (0.6%); Assam (0.6%); Gujarat (0.6%); Karnataka (0.6%);
Less than or equal to 0.5%	Bihar (0.5%);Punjab (0.4%); Jharkhand (0.3%); Chhattisgarh (0.3%); Odisha (0.2%); Uttar Pradesh (0.2%); Madhya Pradesh (0.1%); West Bengal (0.1%); Rajasthan (0.1%)

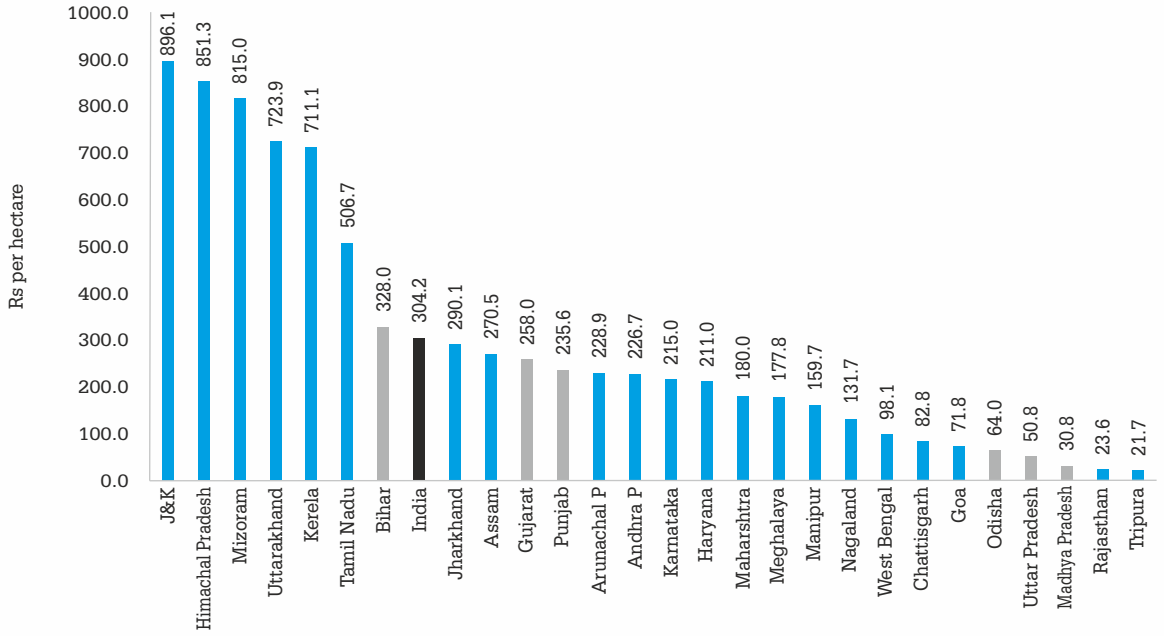
Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO

3.2.2 *Agriculture R&E Expenditure per Gross Cropped Area (GCA)*

Another way of measuring agriculture R&E intensity is agriculture R&E expenditure per gross cropped area (GCA), which gives an idea of how much India is spending on agriculture R&E relative to its gross cropped area. From Figure 1, it can be observed the gradual increase in per hectare expenditure on agriculture R&E. In TE 2002-03, India spent around Rs. 166 per hectare, which has more than doubled to around Rs. 304.2 per hectare in TE 2014-15 at constant prices. Similarly, extension intensity as measured by agriculture extension expenditure per gross cropped area has also increased over the last decade, however it still remains low. Between TE 2002-03 and TE 2014-15, per hectare extension expenditure increased from Rs. 37 per hectare to Rs. 94 per hectare. An increase of about two and a half times, although the absolute levels are still very low.

Further, if we disaggregate the all-India figure, we observe considerable differences across states in terms of R&E and extension intensity. In Figure 3 and Figure 4, we present the state-wise agriculture R&E intensity and agriculture extension intensity, respectively. From Figure 3, it is observed that in TE 2014-15, Jammu and Kashmir had the highest agriculture R&E intensity (Rs 896 per hectare), followed by Himachal Pradesh (Rs 851 per hectare), Mizoram (Rs 815 per hectare), Uttarakhand (Rs 723 per hectare) and Kerela (Rs 711 per hectare).

Figure 3: Agriculture R&E Intensity State-wise (TE 2014-15)

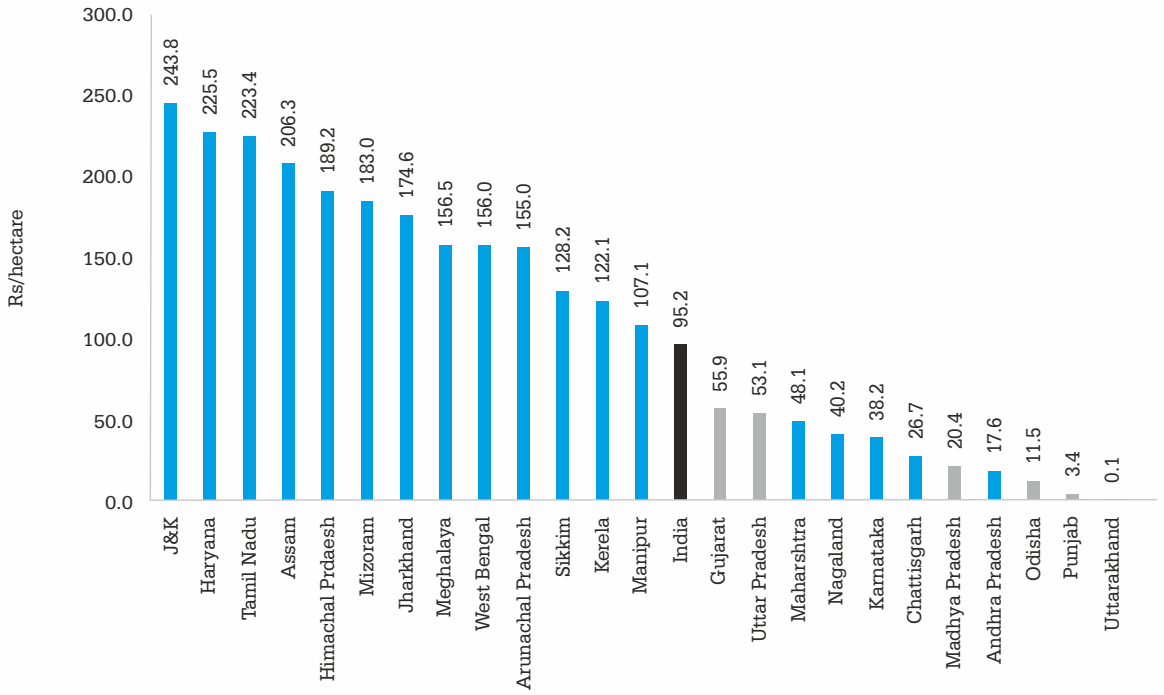


Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and DES.

Further, from Figure 4, it is observed that in TE 2013-14, agriculture extension intensity is highest in Jammu and Kashmir (Rs 243.8 per hectare), followed by Haryana (Rs 225.5 per hectare), Tamil Nadu (Rs 223.4 per hectare), Assam (Rs 206.3 per hectare) and Himachal Pradesh (Rs 189.2 per hectare), while all of our study states namely Gujarat, Madhya Pradesh, Punjab, Uttar Pradesh, Odisha, except Bihar recorded agriculture extension

intensity lower than the national average of Rs 95.2 per hectare. The data for agriculture extension expenditure in Bihar given in the "Combined Finance and Revenue Accounts of the Union and State Governments in India" appears to be erroneous as the amount spent on agriculture extension expenditure is higher than agriculture R&E for the years 2000-01, 2001-02 and 2002-03. And therefore we do not analyse the expenditure incurred in extension services in Bihar here.

Figure 4: Agriculture Extension Intensity State-wise (TE 2013-14)



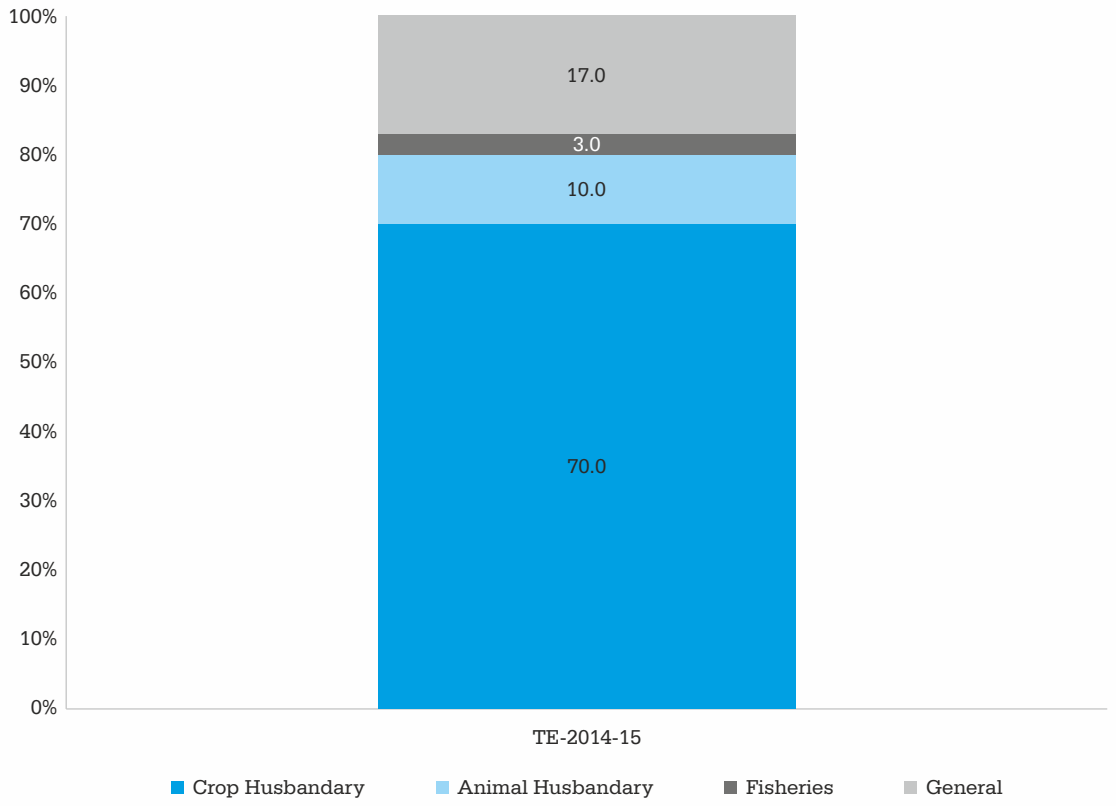
Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and DES.

3.2.3 Sector-wise Decomposition of Agriculture R&E and Extension and Training Expenditure

In this section we analyse the composition of agriculture R&E in order to understand the relative priorities placed across various sectors in terms of research. Figure 5 represents the sector-wise allocation of agriculture R&E expenditure for TE 2014-15. It is observed that around 70 percent of the total agriculture R&E budget is allocated to crop-husbandry itself, while only 10 percent is allocated to animal husbandry and dairy development. Similarly, decomposition of extension expenditure across sectors shows that around 92 percent of total extension expenditure was allocated only for crop husbandry and only 0.9 percent was allocated to animal husbandry and dairy segment. This is in contrast to the gradual transformation of the agriculture sector in India, in which animal husbandry and dairy segment have grown in importance. Figure 6 presents the share of value of output from different segments as a percentage of the gross value of output from agriculture and allied activities (GVOA) at current prices. It can be seen that the share of food-grains (cereals and pulses) has declined from around 24 percent in TE 2002-03 to 20 percent in TE 2013-14, while

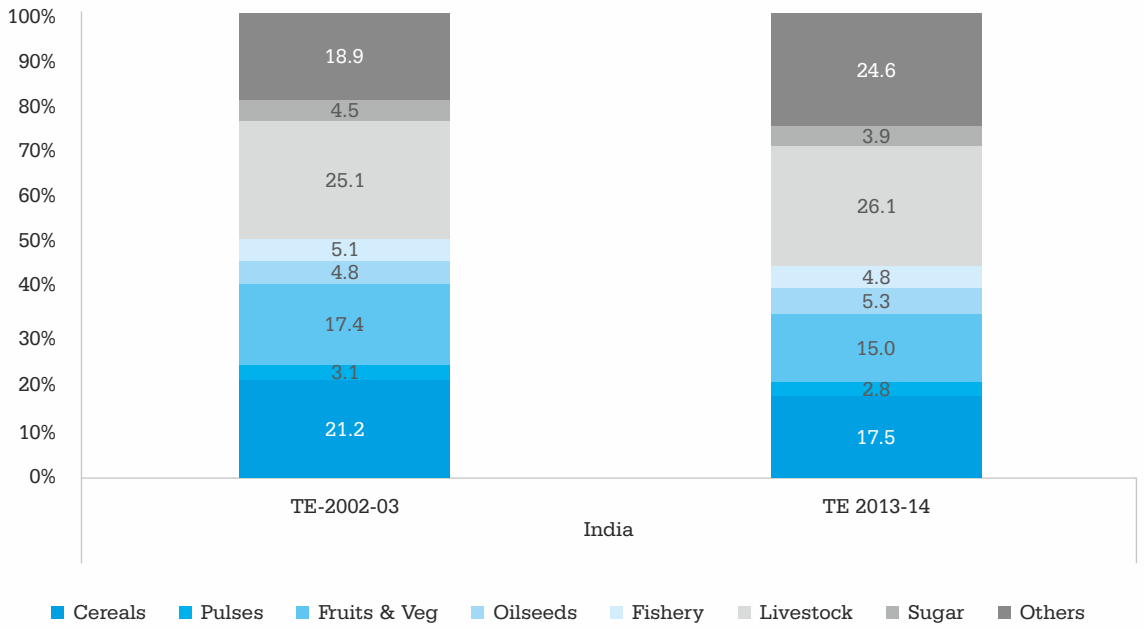
the share of fruits and vegetables has declined from 17 percent to 15 percent in the same period, while the share of livestock (dairy and animal husbandry) has marginally increased from 25 percent to 26 percent.

Figure 5: Sector-wise allocation of Agriculture R&E Expenditure (%) TE 2014-15



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser

Figure 6: Percentage of GVOA in India (current prices)



Source: Government of India, State-wise Estimates of Value of Output from Agriculture and Allied Activities

Further, we have calculated the sources of agriculture growth in India (Table 3) by deflating the current series of each segment by the WPI at 2004-05 prices and then we have decomposed the year-on-year growth in GVOA by taking the absolute year-on-year difference in GVOA from each segment as a proportion of the previous year's GVOA. We find from Table 3 that, of the 5.7 percent growth in GVOA between 2001-02 and 2013-14, 26.3 per cent was contributed by livestock, 15.7 per cent by food-grains and 14 per cent by fruits and vegetables.

Issues of food-security and under nutrition have kept the focus of agriculture R&E on crop husbandry. But from the above discussion it is clear that there is a growing importance of the livestock segment (which includes animal husbandry and dairy), and India may need to rethink about the allocation of agriculture R&E and increases allocation towards livestock sector.In addition, sustained income growth and a fast-growing urban population are causing changes in food-consumption patterns, away from low-value staples towards high-value food commodities, implying that the agriculture production systems must change to address the growing food demand and changing consumer preferences for diversified and safe food (Birthal et al, 2015). Therefore, to augment the change required in the agri-food production system, India needs to increase financial resources for agriculture R&E and extension in horticulture crops and animal husbandry and dairy.

Table 3: Sector-wise composition of growth in GVOA (2001-02 to 2013-14)

	Food-grains	Fruits & Veg	Oilseeds	Livestock	Fibre	Sugar	Fishery	GVOA
2001-02	1.6	0.8	0.6	0.5	-0.1	-0.2	0.2	4.2
2002-03	-4.1	0.0	-0.4	0.3	-0.1	-0.4	0.3	-4.9
2003-04	3.3	-0.6	2.8	0.1	1.0	-0.6	0.0	7.3
2004-05	-1.7	-0.3	-0.7	0.9	0.0	0.6	-0.2	3.9
2005-06	1.6	1.9	0.3	0.7	0.2	0.7	0.5	7.7
2006-07	2.1	0.8	-0.3	1.0	0.2	0.0	0.2	5.6
2007-08	3.5	0.8	1.6	2.2	0.6	-0.2	0.2	8.6
2008-09	1.4	0.1	-0.8	2.2	-0.1	0.4	0.2	4.6
2009-10	0.1	2.1	0.2	3.4	0.3	1.2	0.4	10.5
2010-11	1.3	1.3	1.5	1.4	1.8	0.1	0.2	9.1
2011-12	0.3	-0.2	-0.1	2.8	0.3	0.1	0.4	5.5
2012-13	1.3	1.4	0.0	1.8	-0.7	0.1	0.4	4.7
2013-14	0.7	2.0	0.0	2.2	0.5	0.1	0.7	7.2
Average growth (2001-02 to 2013-14)	0.9%	0.8%	0.4%	1.5%	0.3%	0.1%	0.3%	5.7%
Share of each segment in total growth in GVO	15.7%	14.0%	7.0%	26.3%	5.2%	1.75%	5.2%	

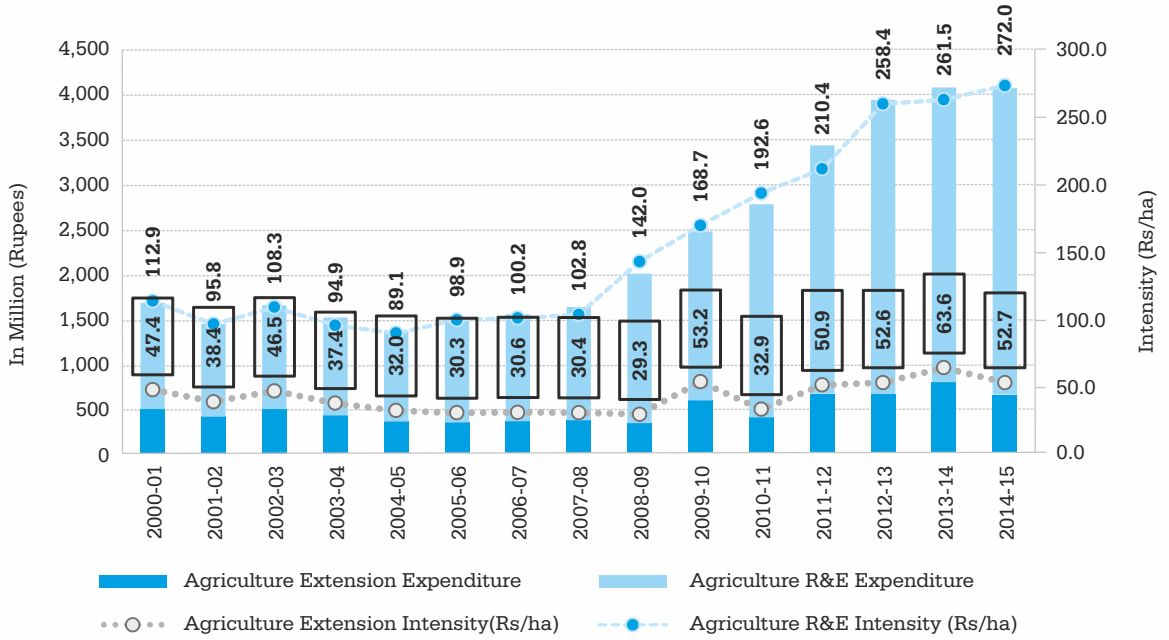
Source: Computed by Authors

Overview of Agriculture Extension System in Focus States

4 Overview of Agriculture Extension System in Focus States

4.1 Agriculture R&E and Extension & Training System in Gujarat

Figure 7: Agriculture R&E and Extension & Training Expenditure in Gujarat (2004-05 prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and DES.

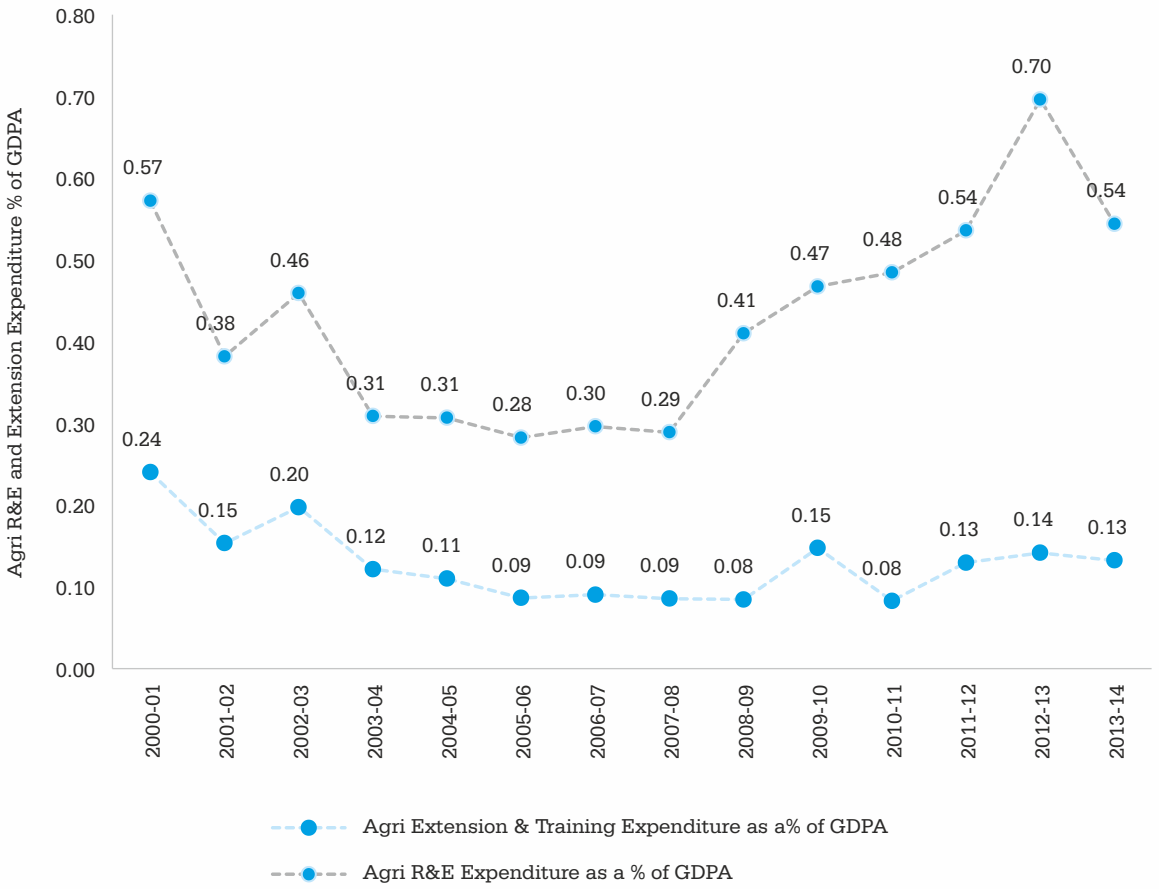
In the past decade, total R&E expenditure on agriculture in real terms has steadily increased from Rs 1,179 million in 2000-01 to Rs 3,378 million in 2014-15 in Gujarat. During this period the CAGR was around 7.4 percent in the state as compared to the national average of 5 percent. Agriculture R&E expenditure as a proportion of GDPA has increased from 0.47 per cent in TE 2002-03 to 0.59 percent of GDPA in TE 2013-14.(Figure 3).R&E intensity defined as R&E expenditure (in 2004-05 prices) as a proportion of GCA has also recorded an upward trend.

The agriculture extension model adopted by Gujarat is built around the ATMA funding pipeline created by the central government. As in many other states, ATMA supports a wide range of AES in Gujarat. One of the reasons for the increase in agriculture extension expenditure in Gujarat is the introduction of the fortnightly flagship initiative 'KrushiMahotsav' by the state government in 2005 which involves mobilization of the entire

machinery of the Agriculture Department in a mass contact programme with famers. Vehicles equipped with video equipment, accompanied by technical experts, input suppliers etc. traverse a pre-announced route, covering several villages every day in each district. Screening of films on crop technology, discussions with experts, sale of inputs etc. are a part of each stop of this caravan.

Although in absolute terms, agriculture extension expenditure has increased during the decade, but agriculture extension expenditure as a percentage of GDPA has declined from around 0.20 percent in TE 2002-03 to 0.13 percent in TE 2013-14 (Figure 8), which implies that the amount spent on agriculture extension by the public sector compared to its size of the sector has been falling in Gujarat. Agriculture extension intensity, on the other hand increased from Rs 44.1 per hectare in TE 2002-03 to Rs 55.7 per hectare in TE 2013-14. However, it is much lower than the national average of Rs 93.9 per hectare and states like Jammu and Kashmir (Rs 243.8 per hectare), Haryana (Rs 225.5 per hectare) and Tamil Nadu (Rs 223.4 per hectare) (Figure 4).

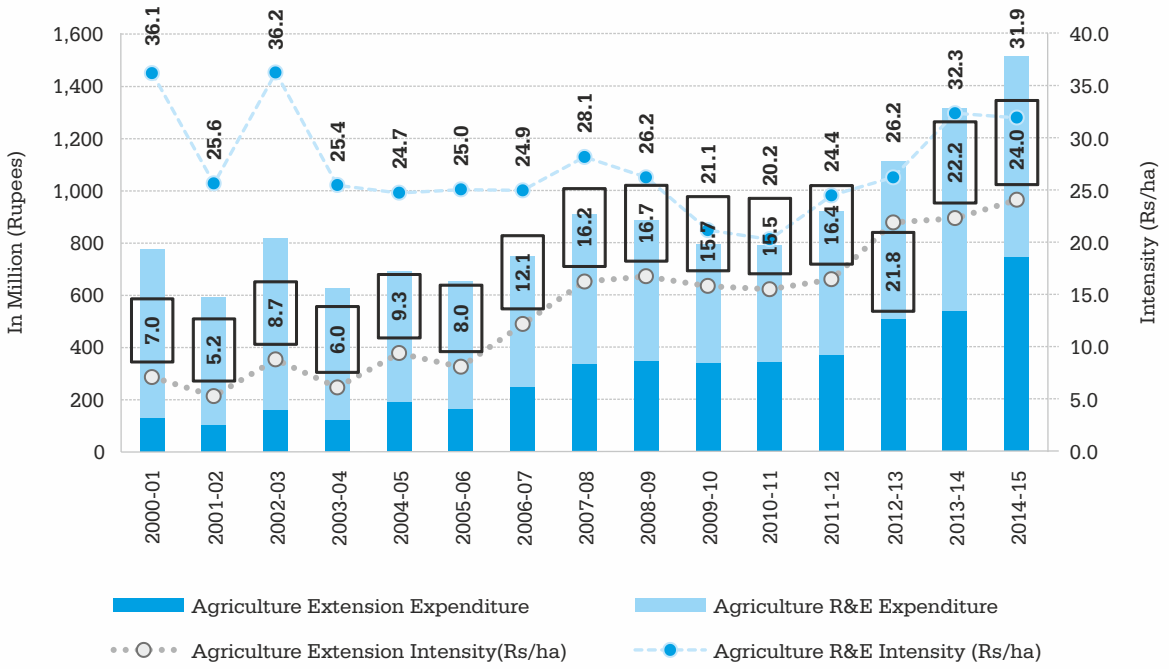
Figure 8: Agriculture R&E and Extension and Training Expenditure as a Percentage of GDPA in Gujarat (2004-05 Prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO.

4.2 Agriculture R&E and Extension and Training System in Madhya Pradesh

Figure 9: Agriculture R&E and Extension & Training Expenditure in MP (2004-05 prices)

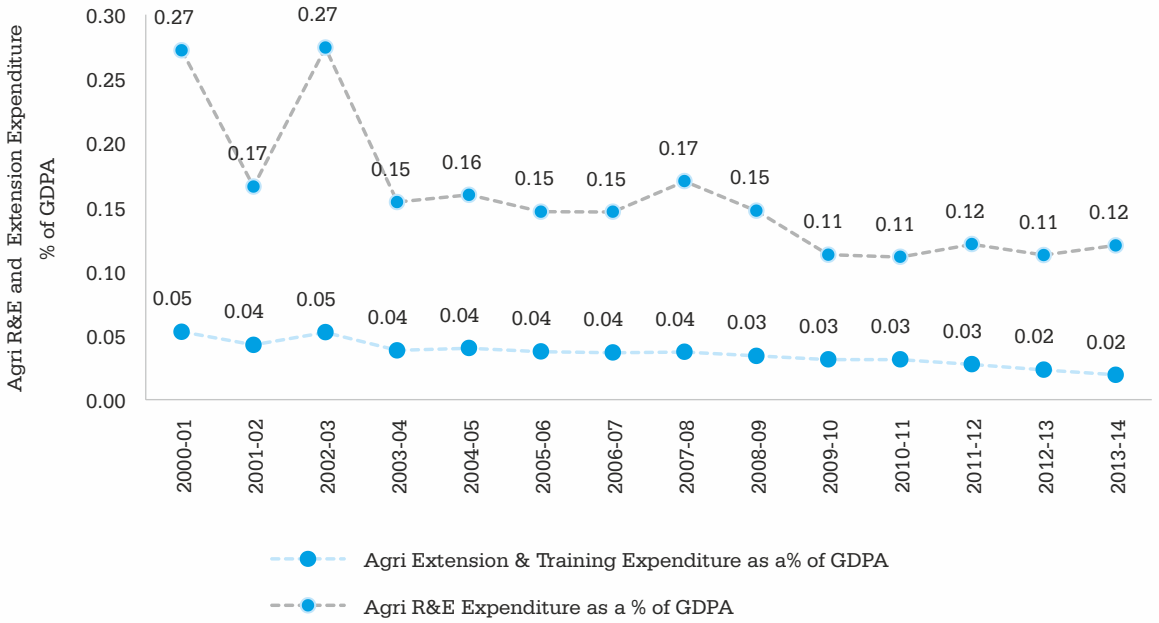


Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and DES.

In MP, agriculture extension system essentially consists of implementing the nationally funded schemes, with a few local innovations. Between 2000-01 and 2014-15 MP witnessed a steady rise in annual allocation and expenditure levels under the ATMA scheme. Agriculture extension expenditure increased from Rs 125.7 million in 2000-01 to Rs 744 million in 2014-15 thereby recording a CAGR of 13.6 per cent as compared to the national average growth of 7 percent in the given period. Consequently, agriculture extension intensity increased from Rs 7 per hectare in TE 2002-03 to Rs 22.7 per hectare in TE 2013-14 but it is still way below the national average of Rs 93.9 per hectare. MP spends only around 0.02 per cent of GDPA on agriculture extension as compared to the national average of 0.16 per cent in 2014-15 (current Prices[7])

[7] *All Agri R&E and Extension as a% of GDPA are in Current prices for all states and for all India levels unless specified.*

Figure 10: Agriculture Extension & Training and R&E Expenditure as a Percentage of GDPA: Madhya Pradesh (2004-05 Prices)



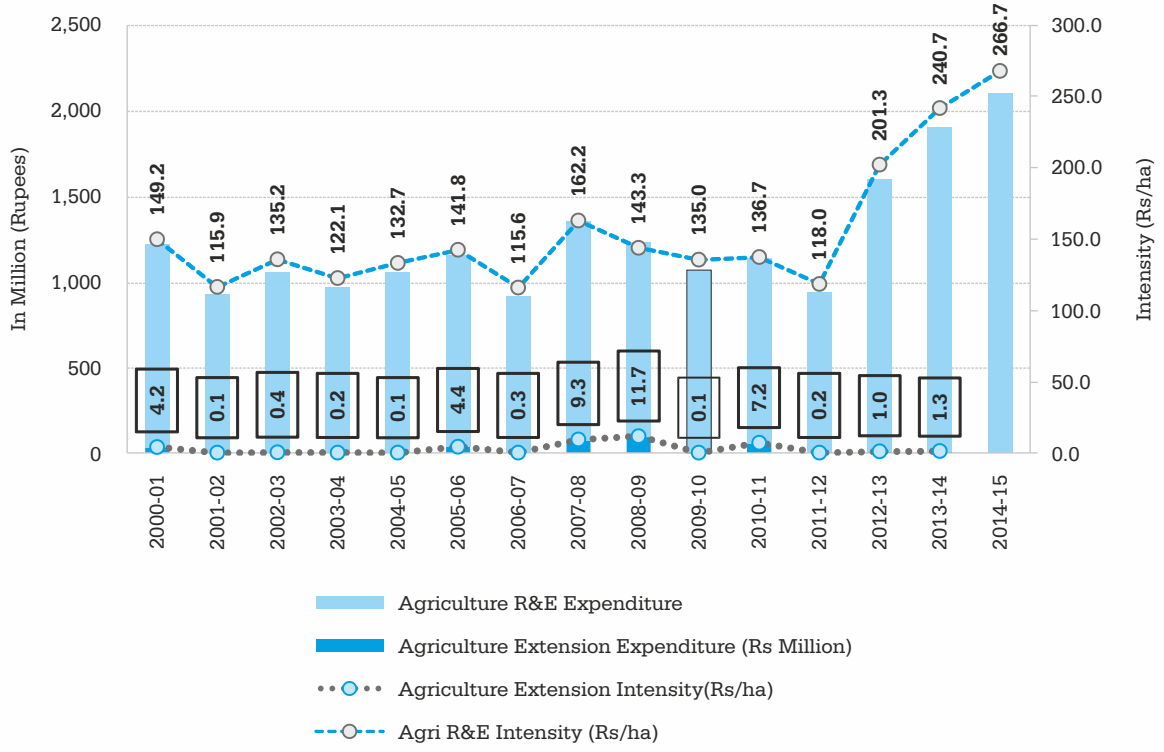
Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO.

4.3 Agriculture R&E and Extension& Training System in Punjab

Often called the cradle of the Green Revolution, Punjab till a few years ago boasted the classical model of the original T&V model of agriculture extension system. The entire lab-to-land linkage model was successfully created and ran efficiently for almost two decades before weakening in the 1990s.

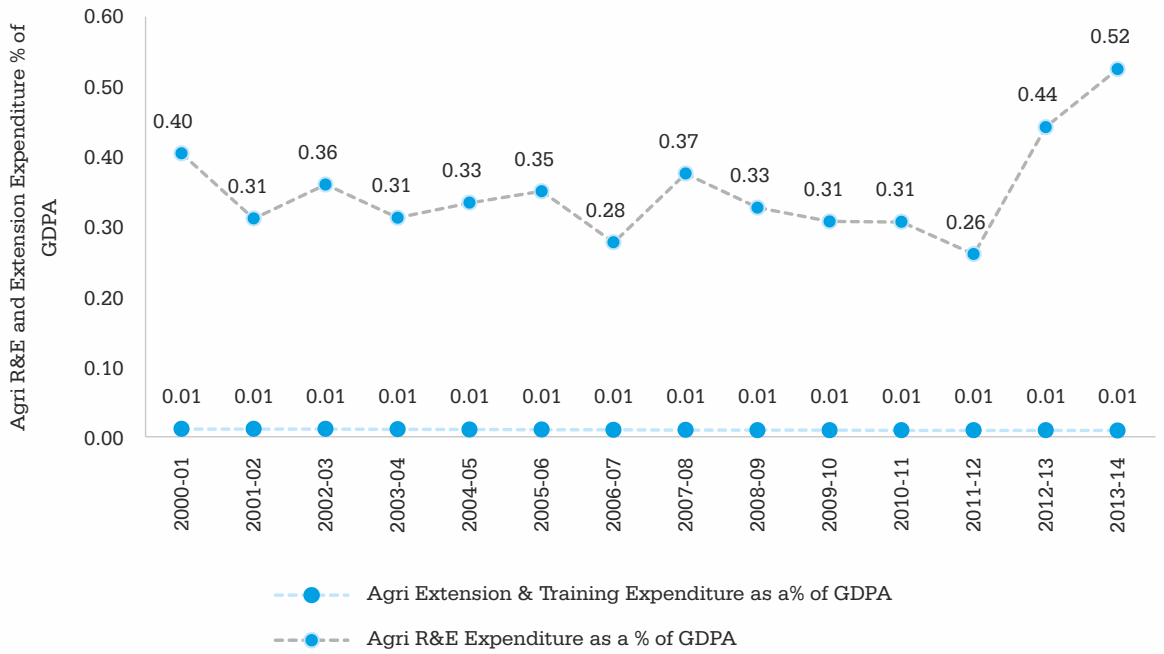
Between 2000-01 and 2014-15, agriculture extension expenditure as a percentage of GDPA averaged around 0.01 per cent and agriculture R&E expenditure as a per cent of GDPA averaged around 0.35 per cent in Punjab while the corresponding all-India average was around 0.16 per cent and 0.54 per cent respectively. Even in its present form the Punjab agriculture R&E and extension system is stronger than many other States. The Agriculture Information Wing of Department of Agriculture plays a major role in transmitting the latest farm technology to the farmers through farmers training camps and literature/print media in the state. A total 12 Farmer Training Centres are housed in the state, including at the Punjab Agriculture University (PAU), Ludhiana and Khalsa College, Amritsar. Approximately 3 lakh farmers are imparted training every year, including specialized training courses in agriculture and other allied subjects

Figure 11: Agriculture R&E and Extension & Training Expenditure in Punjab (2004-05 prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and DES.

Figure 12: Agriculture Extension & Training and R&E Expenditure as a Percentage of GDPA: Punjab (2004-05 Prices)

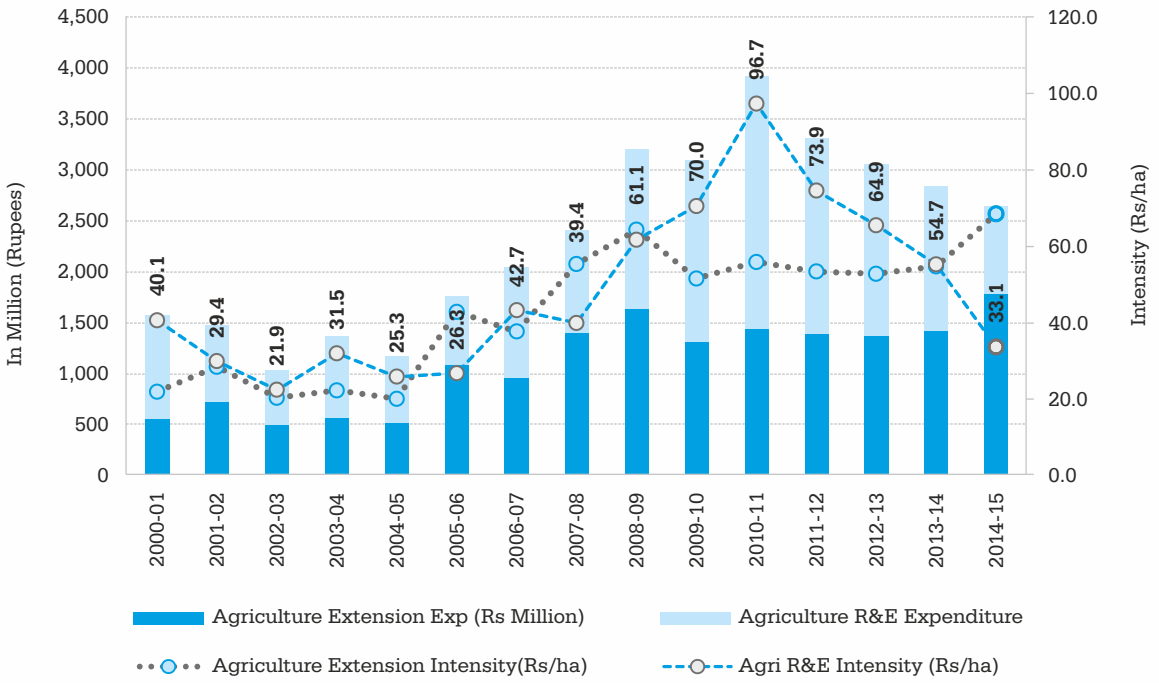


Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO.

4.4 Agriculture R&E and Extension& Training System in Uttar Pradesh

The state's funding towards agriculture R&E recorded a decrease of CAGR of -1.2 percent between 2000-01 and 2014-15. In absolute terms, it increased from 1,015 million rupees in 2000-01 to 856.7 million rupees (2004-05 prices) in 2013-14. The increase was steady and more uniform post 2005-06, with the highest recorded expenditure in 2010-11 of Rs 2,477 million, a declining trend was seen thereafter till 2013-14 with the total falling to Rs 1,416 million.

Figure 13: Agriculture R&E and Extension& Training Expenditure in UP (2004-05 prices)

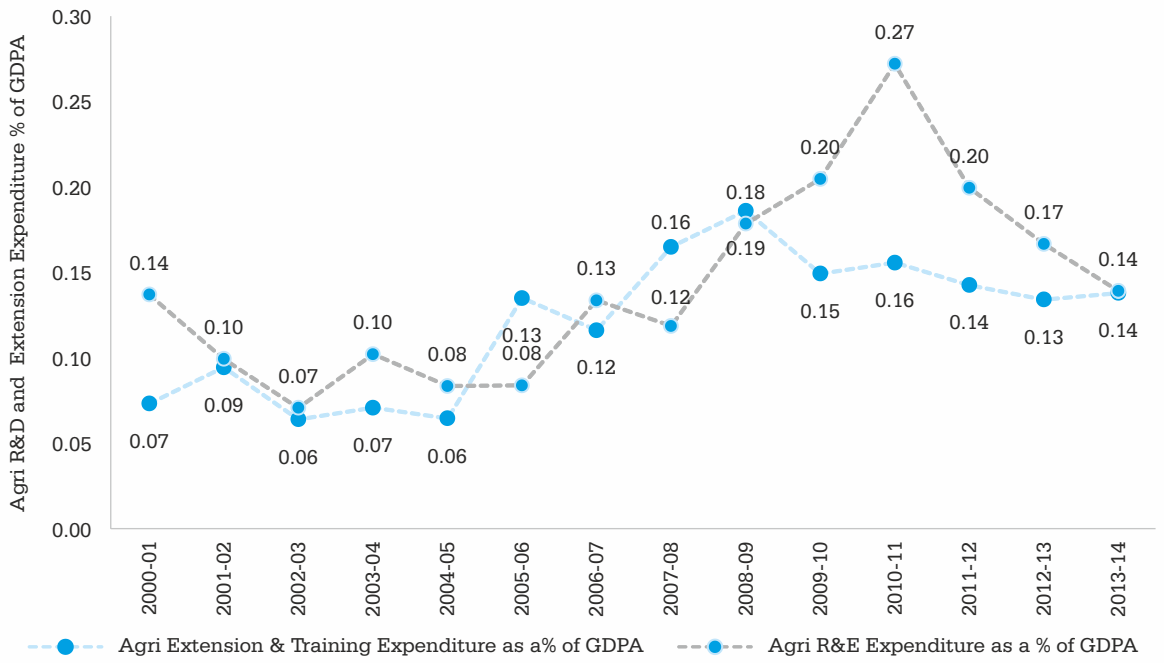


Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and DES.

The total agriculture extension expenditure in real terms (2004-05 prices) grew only marginally between 2000-01 and 2003-04 but doubled from Rs 500 million in 2004-05 to Rs 1,070 million in 2005-06 and then continued to rise. After peaking at Rs 1,624 million in 2008-09, the total dipped marginally to Rs 1,404 million in 2013-14. Agriculture extension intensity has witnessed a gradual increase from Rs 23.1 per hectare in TE 2002-03 to Rs 53.1 per hectare in TE 2013-14 in Uttar Pradesh[8]

[8] *TE 2013-14 used for UP*

Figure 14: Agriculture Extension & Training and R&E Expenditure as a Percentage of GDPA in Uttar Pradesh (2004-05 Prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO

4.5 Agriculture R&E and Extension & Training System in Odisha

In 2014-15 in current terms, Odisha spent around 0.17 per cent of its GDPA on agriculture R&E. The state has witnessed a gradual increase in the amount of money allocated for research and education in real terms from Rs 187 million in 2000-01 to Rs 554 million in 2014-15, thereby recording a CAGR of 8 per cent, which is higher than the national average of 5per cent CAGR in agriculture R&E expenditure. Consequently agriculture R&E intensity has increased from Rs 23.7 per hectare in 2000-01 to Rs 64 per hectare in 2014-15.

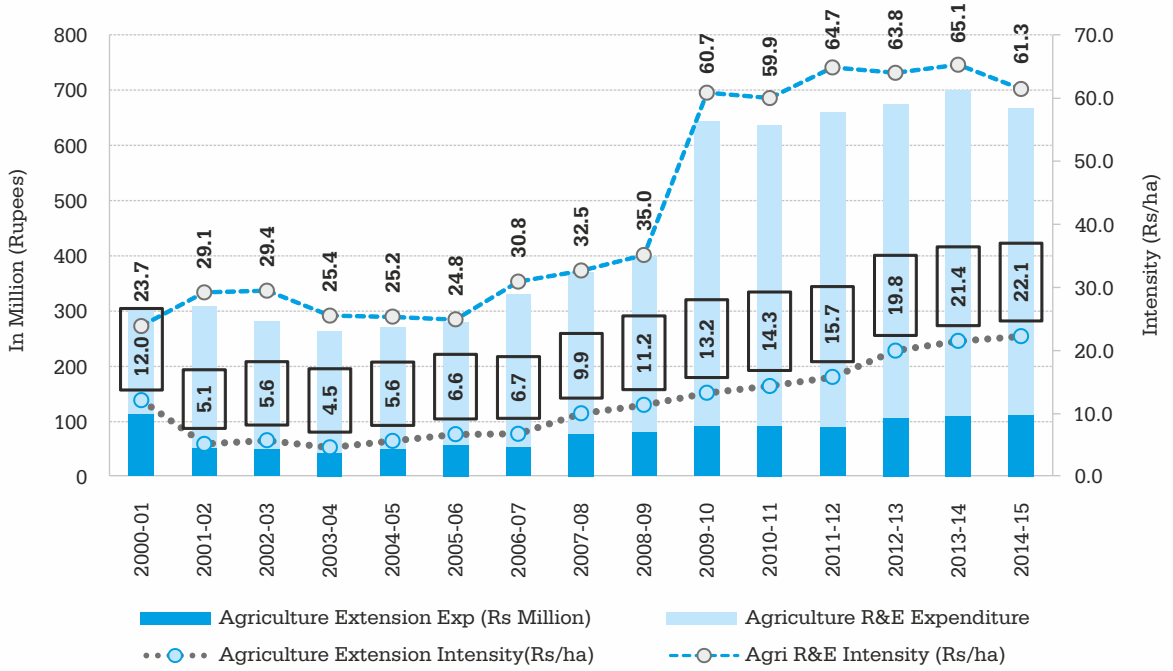
In 2014-15, Odisha spent around 110 million rupees on agriculture extension. As a percentage of GDPA, Odisha spends only 0.03 per cent, which is much lower than the national average of 0.16 per cent. Further agriculture extension intensity in Odisha is one of the lowest in the country standing at Rs 19.1 per hectare as compared to the national average of Rs 95.2 per hectare.

Applied and adaptive agriculture research and development (including extension) in the state is primarily undertaken by Odisha University of Agriculture and Technology (OUAT). The objective of OUAT is to develop location specific technologies to increase production and productivity of agriculture and allied activities through 8 regional research technology, 4 sub-stations, 7 commodity research stations and 13 adaptive research stations covering all 10 agro-climatic zones of the state. Currently, there are 51 all-India coordinated research project and 49 ad hoc research projects in operation via OUAT. OUAT receives funding from ICAR, the central Government, state Government and other external funding agencies.

OUAT has released 140 high yielding varieties of crops, out of which 59 are for rice, 22 are of oilseeds, 8 each of Pulses and spices, 15 of vegetables and 28 other crops. The university farms produces breeder seeds, foundation seeds, certified seeds, vegetable seedlings, mango grafts, forest and medicinal plants, sugarcane planting material, fish spawn and fry. The university has also developed equipment such as paddy thresher, groundnut decorticator, low volume sprayer, OUAT puddler, a zero energy cool chamber for storage of fruits and vegetables, a package of power tiller operated implements for plantation of horticultural crops.

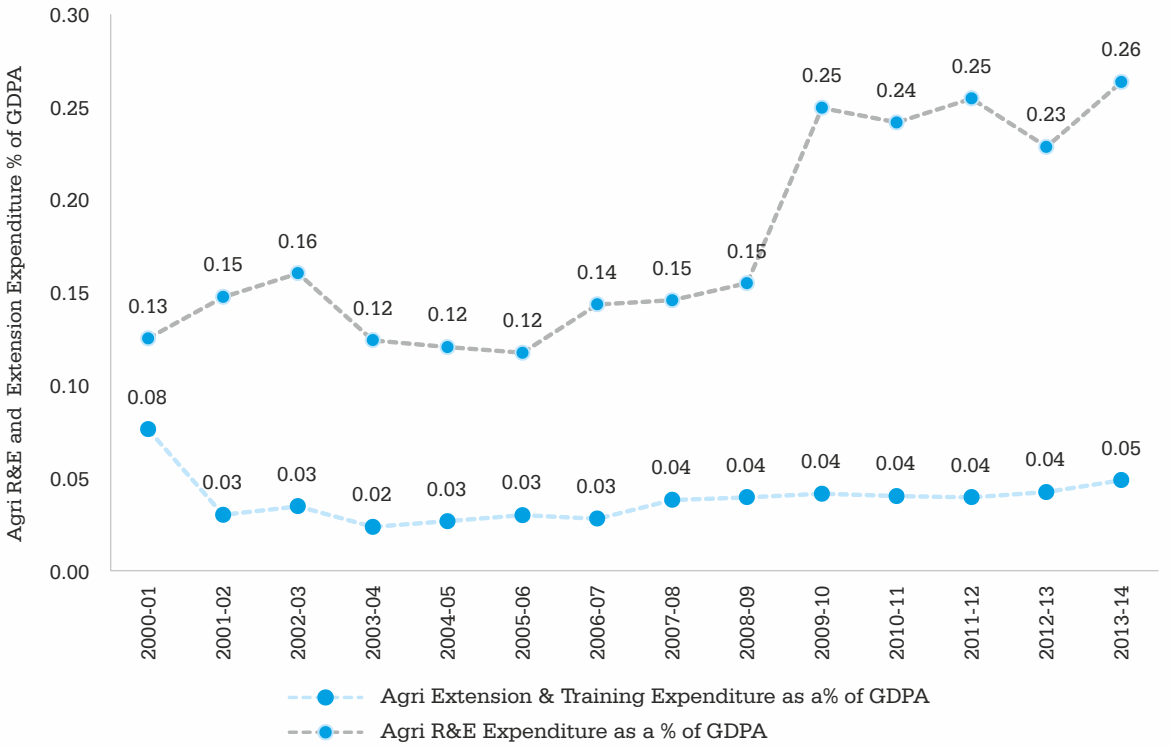
Agriculture extension on the other hand is funded through ATMA, like in many other states. A sample of the activities supported under ATMA in Odisha is provided in Table 2 in Annexure.

Figure 15: Agriculture R&E and Extension & Training Expenditure in Odisha (2004-05 prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO

Figure 16: Agriculture Extension & Training and R&E Expenditure as a Percentage of GDPA in Odisha (2004-05 Prices)

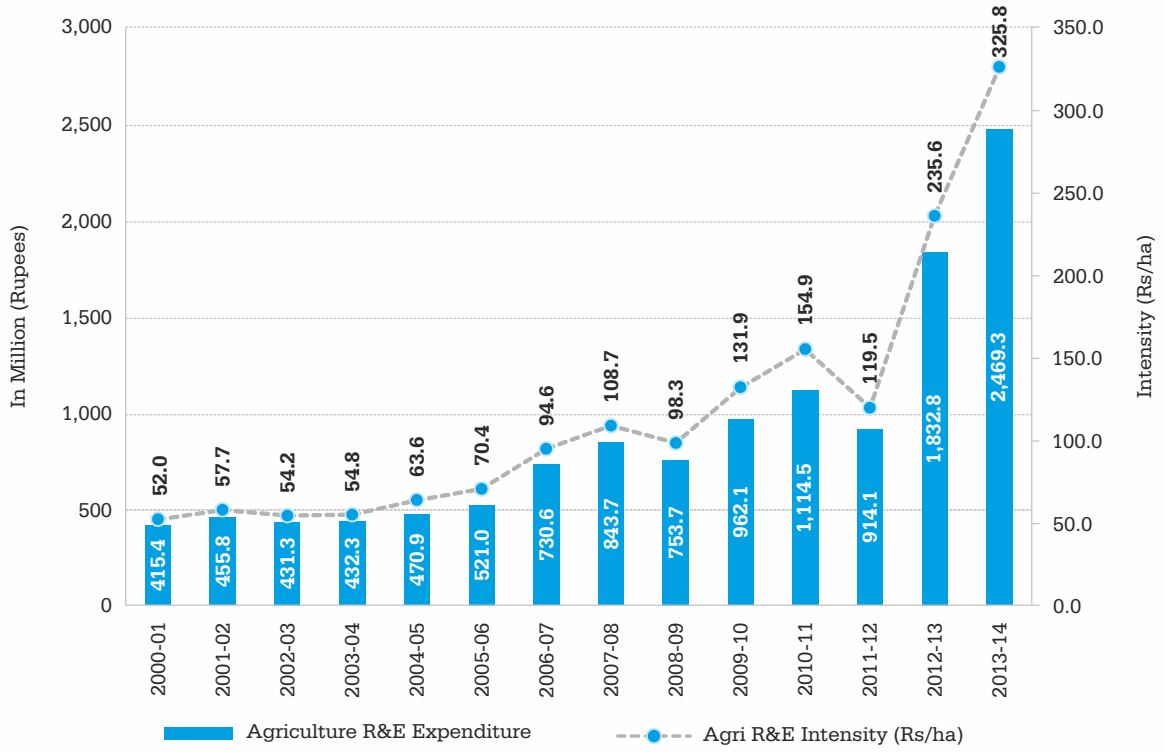


Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO

4.6 Agriculture R&E and Extension & Training System in Bihar

In Bihar[9], the total agriculture R&E expenditure remained uniform between 2000-01 (415.4 million) and 2004-05 (470.9 million) in constant prices. It increased post 2005-06 to reach 1,116 million in 2010-11, which was higher than most of our study states except Uttar Pradesh and Gujarat. The most phenomenal leap recorded for Bihar were in the years 2012-13 and 2013-14 with the value of total agriculture R&E expenditure rising to 1,833 million and 2,469 million respectively.

Figure 17: Agriculture R&E Expenditure in Bihar (2004-05 prices)



Source: Combined Finance and Revenue Accounts of the Union and State Governments in India (Several issues) and Office of the Economic Adviser and CSO

Agriculture R&E intensity at constant prices followed the same trend as total agriculture R&E expenditure. While it remained low as compared to the all-India levels for the initial period, it increased exceptionally for the last two study years almost coinciding with all-India figures. In TE 2013-14, on an average the all-India value for agriculture R&E intensity was Rs 304.8 million per hectare, Bihar stood very close to this value at Rs 227.0 Million per hectare. Similarly, Bihar previously spent a very small proportion of GDPA on Agriculture R&E. It was as low as 0.16 % of GDPA in 2000-01 and gradually increased to 0.37% of GDPA only in 2009-10. After which it plummeted to 0.5% in 2012-13.

Bihar has in place two state agriculture universities, five agricultural colleges, one horticulture, engineering and one dairy technology college. All 38 districts have KrishiVigyanKendras that provide crop diagnostic services to farmers within the district. In addition, the KVKs use a significant portion of their lands to multiply seeds of improved

Note: The data for agriculture extension expenditure in Bihar given in the "Combined Finance and Revenue Accounts of the Union and State Governments in India" appears to be erroneous as the amount spent on agriculture extension expenditure is higher than agriculture R&E for the years 2000-01, 2001-02 and 2002-03. And therefore we do not analyse the expenditure incurred in extension services in Bihar in this paper.

[9] *Only till 2013-14*

varieties and propagate planting material to sell to farmers as a means of partially supporting their operations. Despite a strong institutional set-up, the output for Bihar is disappointing due to slow adoption of technology and the efficiency in the transfer of new technology to farmers. Furthermore, the risk aversion of farmers to adopt new technology, low credit availability and a historical dominance of cereals in Bihar's cropping pattern reflect the poor performance of agriculture R&E and extension in the state.

Presently, the State has put in strong effort to improve the prevailing conditions, for instance The Bihar Agriculture Management, Extension and Training Institute (BAMETI), supported through ATMA funding, serves as a financial support and coordinating body for extension training and communication capacity-building activities within the state. BAMETI is the nodal agency responsible for the implementation of ATMA in the state of Bihar. Several NGOs are also active in small pockets of State providing AES as part of their larger livelihood projects. One such example is PRADAN which promotes the System of Rice Intensification (SRI) through its field programs. Some of the other NGOs promoting technology demonstrations and disseminations are Aga Khan Rural Support Program (AKRSP) and Digital Green which are working closely with the government.

Table 4: Comparative table for six states

	Comparative table for six states						
Time period (2000-01 to 2014-15)	India (National average)	Gujarat	Madhya Pradesh	Punjab	Uttar Pradesh	Odisha	Bihar
Total R&E Expenditure	Rs 31,073 million in Rs 61,552 million	Rs 1,179 mil to Rs 3,378 million	Marginally from Rs 645 mil to Rs 766.6 mil	Rs 149 mil to Rs 249 mil	increased from Rs 1,015 mil in to Rs 856.7 mil	Rs 187 million to Rs 554 million	Rs 415 to Rs 2469 mil
CAGR	5%	7.4 %	1.2%	4.1%	-1.2%	8%	14.7%
[10]R&E as a % of GDPA	0.54% (in 2014-15 current Prices)	Increased from 0.47% in to 0.59%	0.12% fallen from 0.24%	Increased 0.36% to 0.41%	Increased 0.10 to 0.14%	Increased 0.14 to 0.22%	Increased 0.16% to 0.5%
R&E intensity (as a proportion of GCA)	Rs. 166 per ha to Rs. 304.2 per ha (TE 2002-03 & TE 2014-15)	Rs 264 per ha	fell from Rs 32.6 per hectare in TE 2002-03 to Rs 30.1 per hectare	Rs 133 to Rs 236 per ha	Rs 30 per ha to Rs 50 Per ha	Rs 23.7 per ha Rs 64 per ha	Rs 54.6 to Rs 227mil per ha
Total Extension Expenditure	Increased from Rs 6,407 mil to Rs 17956 mil	Rs 494.7 million in 2000-01 to Rs 657.5 million in 2014-15	Rs 125.7 million in 2000-01 to Rs 744 million in 2014-15	Rs 33 Mil to Rs 59 Mil	Rs 542 to Rs 1758 mil	Rs 113mil to 110 mil	***[11]
CAGR	7.6%	2.05%	13.6%	Fallen	8.8%	-0.2%	
Ext as a % of GDPA	0.16% (in 2014-15, Current Prices)	Fallen from 0.2% to 0.13%	0.07% fallen from 0.13% (current Prices)	0.01%	0.08 to 0.14%	0.05% to 0.04%	
Ext intensity	Rs. 37 per ha to Rs. 94 per ha. (TE 2002-03 & 2013-14)	Increased from 44.1 to 55.7 per ha	Rs 7 per hectare in TE 2002-03 to Rs 22.7 per hectare in TE 2013-14	1.6 to 0.8 per ha	Rs 23.1 per hectare in TE 2002-03 to Rs 53.1	Rs 7 to Rs 21.6 per ha	

[10] *All India levels in 2014 current prices, all other states in constant prices between TE 2002-02 & TE2014-15*

[11] *The data for agriculture extension expenditure in Bihar given in the "Combined Finance and Revenue Accounts of the Union and State Governments in India" appears to be erroneous as the amount spent on agriculture extension expenditure is higher than agriculture R&E for the years 2000-01, 2001-02 and 2002-03. And therefore we do not analyse the expenditure incurred in extension services in this table.*

Econometric Analysis

5 Econometric Analysis

Agricultural growth is influenced by a number of supply-side factors. A priori, we would expect (i) technology (agriculture extension services, agriculture research, seed replacement rate, irrigation, fertiliser use, farm mechanisation, etc), (ii) incentives (terms of trade), (iii) infrastructure (electricity, roads), and (iv) weather conditions to drive agriculture growth. However, it is difficult to analyse the effect of all variables in a single framework, since many of these variables can be correlated. Therefore, we use a parsimonious model to test the hypothesis if agriculture R&E (including extension) has a significant positive effect on agriculture growth in our study states, namely Odisha, Uttar Pradesh, Bihar, Madhya Pradesh, Gujarat and Punjab.

(I) Data and Methodology

The study has used time-series secondary data for the period 2000-01 to 2014-15 compiled from various published sources by the Government of India and the respective state governments of our focus states. Data on agriculture R&E and agriculture extension and training expenditure at current prices was taken from various issues of "Combined Finance and Revenue Accounts of the Union and State Governments in India" and then deflated using the WPI (2004-05 prices).

In order to test the hypothesis if agriculture R&E and extension and training expenditure has a significant effect on agriculture growth in our study states, we use a three-step procedure to estimate the relationship between agricultural growth and the selected explanatory variables. In the first step, we test if the natural logarithm of the selected variables is integrated of the same order using the Augmented Dickey Fuller (ADF) test. Depending upon the outcome of the tests, the second stage involves determining if the series are co-integrated (i.e., testing for long-term relationship between the variables) using Engle and Granger's (1986) two-step residual based procedure. We use this method because we are interested in the elasticity of the explanatory variables. Accordingly, we first run a simple ordinary least square model to analyse if agriculture R&E intensity/agriculture extension intensity/Aggregate R&E and X&T has a significant effect on agricultural growth in the selected states and then perform a unit root test on the residuals of the model to determine if it is stationary. The null hypothesis in the Engle-Granger procedure is no co-integration and the alternative is co-integration.

A limitation to this approach is that we are unable to control for state specific heterogeneity. In case of the possibility of endogeneity among the regressor, creating a

district level panel data and using instrumental variable approach would have been a better approach than Ordinary Least Square (OLS) approach. However, due to paucity of district level data on agriculture extension & training and R&E we have undertaken a time series analysis. Also, we have tried to use combinations of regressor that are not expected to suffer from endogeneity, so that OLS yields consistent estimates. The second limitation is the number of observations is small as we have taken the period of analysis from 2000. This is mainly because three of our selected states namely Madhya Pradesh, Bihar and Uttar Pradesh were divided in 2000. In order to maintain symmetry in our analysis we had to take the year 2000 as our starting point.

Table 5: Regression Results Summary

Period: 2000-01 to 2014-15	R&E (Rs/Ha)	Extension & Training Intensity (Rs/Ha)	Aggregate R&E and Ext & Training intensity (Rs/Ha)	Irrigation Ratio (Gross irrigated area as a % of GCA)	Total Road Density (per 000 sq Km)	Surface Road Density (per 000 sq Km)	Livestock Sector (share of Livestock in GVOA)	Terms of Trade (Agriculture Deflator/ Industry Deflator)	Diversification (Fruits & Veg share in total value of Agri and Allied Activities)	Constant	Adjusted RSquare
Uttar Pradesh	0.05*** (0.01)			1.56*** (0.17)			0.56*** (0.05)			7.18*** (0.70)	0.97
Uttar Pradesh			0.07*** (0.01)	1.27*** (0.21)			0.61*** (0.07)			8.14*** (0.80)	0.97
Odisha	0.11* (0.05)			0.49*** (0.06)	0.49** (0.18)				0.15** (0.05)	8.29*** (1.13)	0.97
Odisha			0.20*** (0.04)	0.69*** (0.01)						11.3*** (0.31)	0.91
Bihar	0.29*** (0.05)							0.68** (0.23)		13.43*** (0.24)	0.77
Bihar			0.22** (0.08)			0.11** (0.04)		0.92** (0.15)		12.85*** (0.31)	0.83
Madhya Pradesh		0.36*** (0.11)						1.17** (0.53)		14.11*** (0.28)	0.68

Selection of explanatory variables were done in such a way that at least one variable is included from the category technology, one from incentives and one from infrastructure in order to proxy for all major determinants of agriculture growth and also reduces the possibility of endogeneity. Ideally we would like to model all variables in one framework, however as mentioned earlier in order to reduce the issue of multicollinearity we use a parsimonious model. Here, we are mainly interested to see if agriculture R&E or agriculture extension or Aggregate expenditure on Research & Education and Extension & Training has a significant effect on agriculture growth therefore we use these from the category technology. We define agriculture R&E intensity as agriculture R&E expenditure at constant prices as a proportion of gross cropped area and agriculture extension intensity as agriculture extension expenditure as a proportion of gross cropped area or Aggregate expenditure on Research & Education and Extension & Training as a proportion of gross cropped area.

Selection of explanatory variables was done in such a way that at least one variable is included from the category technology, one from incentives and one from infrastructure in order to proxy for all major determinants of agriculture growth.

(ii) Estimating Equation

In the Annexure, we have presented the correlation matrix of relevant variables for all the six states. Here, we are mainly concerned with the correlation between agricultural GDP and agriculture extension/R&E intensity and Aggregate expenditure on Research & Education and Extension & Training (AgRE&XT). It is observed that Odisha, Bihar, Uttar Pradesh and Madhya Pradesh GDPA show a significant and positive correlation with agriculture R&E intensity, agriculture extension intensity and Aggregate expenditure on Research & Education and Extension & Training. In case of Gujarat and Punjab, agriculture R&E intensity is statistically insignificant with agriculture GDP. We discuss this in greater details later in this section.

It is observed that Odisha, Bihar, Uttar Pradesh and Madhya Pradesh GDPA show a significant and positive correlation with agriculture R&E intensity, agriculture extension intensity and Aggregate Research & Education and Extension & training intensity. In case of Gujarat and Punjab, agriculture R&E intensity is statistically insignificant with agriculture GDP.

For the estimating equations for Odisha, Bihar, Uttar Pradesh and Madhya Pradesh, we have selected our variables is such a way that it reduces the possibility of multicolleanirity and also such that the selected series are integrated of order 1 and are co-integrated. We have run different specification of the estimating equation and have finally presented only those variables that have significant effect on agricultural GDP. We discuss the issue of stationarity and co-integration of the time-series data after discussing the estimating equation of each state (Section 5.3).

1. Odisha

The four explanatory variables in Equation 1 together explain around 98 per cent of the variation in agricultural GDP for the studied period.

In equation 1, we have estimated a static model to determine the relationship between agricultural GDP and the selected explanatory variables in Odisha for the period 2000-01 and 2014-15. We have also presented the results in Table 4 (in Annexure). It is observed that for Odisha, agriculture R&E intensity/AgRE&XT intensity, irrigation, diversification and road density have a significant and positive effect on agricultural GDP. The four explanatory variables in Equation 1 together explain around 98 per cent of the variation in agricultural GDP for the studied period. These results are similar to the results estimated by Hoda, Rajkhowa and Gulati (2017 a), wherein they determine the potential drivers of agriculture growth in Odisha. In this paper, we add the variable agriculture R&E intensity/AgRE&XT intensity to the same estimating equation to determine if agriculture R&E/AgRE&XT has a significant effect on agricultural GDP.

$$Y_t = \mathbf{8.29}^{***} + \mathbf{0.11}^{*}X_{1t} + \mathbf{0.49}^{***}X_{2t} + \mathbf{0.49}^{**}X_{3t} + \mathbf{0.15}^{**}X_{4t} + u_t [1]$$

$$Y_t = \mathbf{11.30}^{***} + \mathbf{0.20}^{***}X_{11t} + \mathbf{0.69}^{***}X_{2t} + u_t [2]$$

Here, X_{1t} is agriculture R&E intensity, X_{2t} is irrigation ratio, X_{3t} is road density and X_{4t} is a variable for diversification, which is defined as the share of fruits, vegetables and floriculture in the total value of output from agriculture and allied activities and X_{11t} is the aggregate expenditure on research & education and extension & training.

One per cent increase in agriculture R&E intensity increases agricultural growth by 0.11 per cent. Therefore, there is considerable scope to increase agriculture R&E intensity in Odisha, which has the potential to significantly affect agricultural growth.

Since we have estimated a double log model, the results can be interpreted as follows: ceteris *paribus*, a one per cent increase in agriculture R&E intensity increases agricultural growth by 0.11 per cent. Therefore, there is considerable scope to increase agriculture R&E intensity in Odisha, which has the potential to significantly affect agricultural growth. We have also tested this model using the AgRE&XT intensity. In Equation 2, we find that one percent increase in the share of this expenditure will increase agricultural growth by 0.2 percent.

Additionally, all else equal, a one per cent growth in the irrigation ratio increases agricultural growth by 0.49 per cent. Currently, Odisha has low irrigation coverage as compared to the national average. There is huge potential for Odisha to increase ground water irrigation. Hoda, Rajkhowa and Gulati (2017 a) discuss in their paper that about 39 per cent of Odisha's gross cropped area is irrigated (compared to the all India average of 48 per cent and an average of above 95 per cent in the Punjab-Haryana belt). Odisha

has large (70 per cent) untapped groundwater potential and about 50 per cent untapped potential from major and medium irrigation schemes. Assured access to water has the potential to stimulate agriculture growth in Odisha.

Similarly, we find that, all else being equal, a one per cent increase in road density increases agricultural GDP by 0.49 per cent. Hoda, Rajkhowa and Gulati (2017 a) in their paper discuss that it is not sufficient to increase road density but focus should be on increasing surfaced road density in order to augment agricultural growth. As on 2011-12, only 23.9 per cent of total road length was surfaced in Odisha, while Gujarat and Punjab had around 89 per cent of their roads surfaced. Uttar Pradesh, Madhya Pradesh and Bihar had 77 per cent, 61.5 per cent and 47.2 per cent of the total road length surfaced. Further, 46 per cent of villages in Odisha do not have all-weather connectivity.

Finally, Table 21 shows that, all else being equal, a one per cent increase in the share of fruits, vegetables and floriculture in the total value of output from agriculture and allied activities will increase agricultural growth by 0.15 per cent. Odisha's agricultural portfolio is gradually moving towards horticulture; however, in terms of acreage, around 74 per cent of gross cropped area falls under food-grains and only 13.7 per cent of GCA is under fruits and vegetables. Food grains are low value crops while fruits and vegetables are high value crops; increasing the area under fruits and vegetables has the potential to increase agriculture growth and incomes of small farmers in Odisha.

Odisha's agricultural portfolio is gradually moving towards horticulture; increasing the area under fruits and vegetables has the potential to increase agriculture growth and incomes of small farmers in Odisha.

2. Uttar Pradesh

Verma, Gulati and Hussain (2017), in a recent paper show through a simple OLS model that irrigation, road density and relative prices for agriculture have a positive and statistically significant effect on agricultural GDP. They show that, all else equal, on an average aone per cent increase in irrigation ration increases UP's agricultural GDP by more than one per cent; a one per cent increase in total road density in UP increases agricultural GDP in the state by 0.5 per cent and a one per cent increase in relative prices of agriculture increases the state's agricultural GDP by about more than 0.5 per cent. In this paper, we add the variable agriculture R&E intensity/AgRE&XT intensity and estimate a different specification to determine if agriculture R&E and AgRE&XT has a significant effect on agricultural GDP. Equation 3 and Equation 4, estimates the relationship between agriculture R&E intensity/AgRE&XT

intensity and agricultural GDP for Uttar Pradesh for the period 2000-01 and 2014-15.

In UP, Agriculture R&E intensity, irrigation ratio and diversification towards livestock together explain around 98 per cent of the variation in agricultural GDP for the studied period.

In Equation 3, we find that agriculture R&E intensity, irrigation ratio and diversification towards livestock (measured as value of output from livestock as a percentage of gross value of output from agriculture and allied activities (GVOA)) have a significant and positive effect on agricultural GDP. The three explanatory variables together explain around 98 per cent of the variation in agricultural GDP for the studied period.

$$Y_t = \mathbf{7.18}^{***} + \mathbf{0.05}^{***}X_{1t} + \mathbf{1.56}^{***}X_{2t} + \mathbf{0.56}^{***}X_{3t} + u_t \quad [3]$$
$$Y_t = \mathbf{8.14}^{***} + \mathbf{0.07}^{***}X_{11t} + \mathbf{1.27}^{***}X_{2t} + \mathbf{0.61}^{***}X_{3t} + u_t \quad [4]$$

Here, X_{1t} is agriculture R&E intensity, X_{2t} is irrigation ratio, X_{3t} is a proxy for diversification towards livestock, which is defined as share of value of output from livestock as a percentage of gross value of output from agriculture and allied activities and X_{11t} is the aggregate expenditure on research & education and extension & training.

Equation [3] can be interpreted as, ceteris paribus, a one per cent increase in agriculture R&E intensity increases agricultural GDP by 0.05 per cent. This effect is small compared to the effect of other explanatory variables in equation [3] and those estimated by Verma, Gulati and Hussain (2017). Similarly in Equation [4], we find that one percent increase in AgRE&XT intensity increases agricultural GDP by 0.07 per cent.

From equation [3], we can also interpret that all else equal, a one per cent increase in irrigation ratio increases agricultural GDP by 1.56 per cent. Verma, Gulati and Hussain (2017) in their paper explain thatin UP, the Western and Central Zones are relatively well-irrigated and so also the Eastern Zone, which naturally receives large amounts of rainfall for crop production as well as ground-water recharge. UP has a reasonably high irrigation ratio (77.9 percent in TE 2013-14) compared to the all-India average (47.4 percent) and is also better than a few agriculturally better-performing states of India. Tube-wells and wells are the most widely used sources of irrigation in the state accounting for 79.8 percent of the net irrigated area (TE 2013-14). The only region that lags behind is the Bundelkhand region with average irrigation ratio for the region being only 41 percent in 2013-14. However, due to erratic and short power supply in the fields, a majority of marginal and small farmers in the state depend on diesel pump sets for irrigation and this is a major cause of inadequate utilization of

irrigation facilities. In fact only 16.3 per cent of total power consumption (2012-13) goes to the agriculture sector in UP. Moreover, power intensity as measured by total power sales as a percentage of gross cropped area was around 378 Kwh/ha in TE 2012-13, as compared to 1,742 KWh/ha in Tamil Nadu, 1,612 KWh/ha in Andhra Pradesh, 1,490 KWh/ha in Karnataka and 1,456 KWh/ha in Punjab. Therefore there is scope for improving utilization of irrigation facilities and also expansion of irrigation in the Bundelkhand region.

Further equation [3] shows that, ceteris paribus, a one per cent increase in share of livestock in total GVOA increases agricultural GDP by 0.56 per cent. Verma, Gulati and Hussain (2017) in their paper show that between 2000-01 and 2013-14, livestock was the largest contributor to agricultural growth in UP accounting for 39.4 per cent of the growth in GVOA. Consequently the share of livestock in GVOA has increased from 24 per cent in TE 2000-01 to 30 per cent in TE 2013-14. Within livestock, milk accounts for the largest share followed by meat. Despite, the expansion of the milk segment, UP's productivity in milk production was around 4 kg/day/animal in 2014-15, compared to 8.2 kg/day/animal in Kerela and 9.2 kg/day/animal in Punjab. Also processing levels in UP through organised dairies remain much below (less than 12 per cent) the all-India average (17 per cent) and those in states like Gujarat (49 per cent) . Therefore there is still scope to increase productivity of milk in UP with appropriate measures and also increase participation of successful cooperatives like AMUL and other private player in the processing of milk, in order to revolutionize agriculture-growth in the state (Verma, Gulati and Hussain; 2017).

One per cent increase in share of livestock in total GVOA increases agricultural GDP by 0.56 per cent. Verma, Gulati and Hussain (2017) in their paper show that between 2000-01 and 2013-14, livestock was the largest contributor to agricultural growth in UP accounting for 39.4 per cent of the growth in GVOA.

3. Madhya Pradesh

In case of Madhya Pradesh there has been a significant increase in expenditure on agriculture extension services. As mentioned in the previous section, while MP has witnessed a decline in agriculture R&E intensity from Rs 32.6 per hectare in TE 2002-03 to Rs 27.6 per hectare in TE 2013-14, agriculture extension intensity on the other hand has increased from Rs 7 per hectare in TE 2002-03 to Rs 20.2 per hectare in TE 2013-14. In fact expenditure on extension services as a percentage of agriculture R&E expenditure has increased from 21.4 per cent in TE 2002-03 to 72.3 per cent in TE 2013-14. Because of this growing importance of extension component in agriculture R&E, for Madhya Pradesh we test if agriculture extension intensity has a significant effect on agricultural GDP in Madhya Pradesh. Equation 5 estimates a static model of the relationship between

In case of Madhya Pradesh there has been a significant increase in expenditure on agriculture extension services. Agriculture extension intensity on the other hand has increased from Rs 7 per hectare in TE 2002-03 to Rs 20.2 per hectare in TE 2013-14.

agricultural GDP and the regressor in Madhya Pradesh. We have also presented the results in Table 17 (in the Annexure)

$$Y_t = \mathbf{14.11}^{***} + \mathbf{0.36}^{***}X_{1t} + \mathbf{1.17}^{**}X_{2t} + u_t [5]$$

Here, X_{1t} is agriculture extension intensity and X_{2t} is terms of trade in favour of agriculture defined as agriculture deflator divided by industry deflator.

One per cent increase in agriculture extension intensity increases agricultural GDP by 0.36 per cent. Although agriculture extension intensity has increased significantly in MP, there is still scope for further expansion.

The results of equation 5 can be interpreted as follows: ceteris paribus, a one per cent increase in agriculture extension intensity increases agricultural GDP by 0.36 per cent. Although agriculture extension intensity has increased significantly in MP, there is still scope for further expansion. Currently, MP's agriculture extension intensity (Rs. 20.2 per hectare) is much lower than the national average of Rs. 93.9 per hectare and far below Jammu and Kashmir (Rs 243.8 per hectare), Haryana (Rs 225.5 per hectare), Tamil Nadu (Rs 223.4 per hectare), Assam (Rs 206.3 per hectare) and Himachal Pradesh (Rs 189.2 per hectare).

Further, equation 5 also shows that, all else equal, a one per cent increase in terms of trade in favour of agriculture increases agricultural GDP by 1.17 per cent. In a similar analysis, Gulati, Rajkhowa and Sharma (2017), in their paper show that expansion of irrigationboth from surface sources, i.e. canal irrigation, and groundwater; improved availability and access to power for agricultural pump sets; strengthening the procurement machinery and expansion of storage facilities for food grains; a phenomenal expansion of the rural roads network to ensure connectivity; focus on farm mechanisation and the expansion of credit for purchase of agricultural inputs were the principle drivers of Madhya Pradesh's rise as one of the most agriculturally important states in the country. In this analysis, we have shown that in case of MP, agriculture extension intensity also has a positive and significant effect on agricultural GDP.

4. Bihar

Equation 6 and 7 estimates a static model of the relationship between agricultural GDP and the selected explanatory variables in Bihar. The correlation matrix of all the relevant variables are presented in Table 8 and the regression results are presented in Table 9 (in Annexure). It is observed that for Bihar, agriculture R&E intensity/Ag R&E and X&T, surfaced road density and terms of trade in favour of agriculture have a significant and positive effect

on agricultural GDP. The two explanatory variables together explain around 76 per cent of the variation in agricultural GDP in equation 7 and 83 per cent in equation 8 for the studied period. Hoda, Rajkhowa and Gulati (2017 b) show in their paper that irrigation, terms of trade, road development and the milk sector have a significant and positive effect on agriculture GDP. In this paper, we test if agriculture R&E has a significant effect on agricultural GDP.

$$Y_t = \mathbf{13.43}^{***} + \mathbf{0.29}^{*}X_{1t} + \mathbf{0.68}^{***}X_{2t} + u_t [6]$$
$$Y_t = \mathbf{12.85}^{***} + \mathbf{0.23}^{**}X_{11t} + \mathbf{0.92}^{**}X_{2t} + \mathbf{0.11}^{**}X_{3t} + u_t [7]$$

Here, X_{1t} is agriculture R&E intensity,X_{2t} is terms of trade in favour of agriculture defined as agriculture deflator divided by industry deflator, X_{3t} is surfaced road density and X_{11t} is the aggregate expenditure on research & education and extension & training.

The results of equation 6 can be interpreted as follows: ceteris paribus, a one per cent increase in agriculture R&E intensity increases agricultural GDP by 0.29 per cent. In the previous section we discussed that Bihar spends around 0.50 per cent of its GDPA on agriculture R&E (TE 2013-14). Although, this is higher than some of the comparator states such as Madhya Pradesh (0.12 per cent of GDPA), Uttar Pradesh (0.17 per cent), Odisha (0.25 per cent of GDPA) and Punjab (0.41 per cent of GDPA), it is still lower than the national average of 0.77 per cent. Further, agriculture R&E intensity in Bihar was Rs. 227 per hectare (TE 2013-14) as compared to the national average of Rs 302 per hectare. Agriculture R&E intensity has been increasing over the years in Bihar (Figure 17), however there is still scope for further expansion. In equation 7, both AgRE&XT and surfaced road density have a significant and positive impact on agricultural GDP.

In the case of Bihar, aggregate agriculture R&E intensity, surface road density and terms of trade in favor of agriculture have a significant and positive impact on agricultural GDP

In equation 6 shows that, all else equal, a one per cent increase in terms of trade in favour of agriculture increases agricultural GDP by 0.68 per cent. Hoda, Rajkhowa and Gulati (2017 b) argue in their paper that remunerative prices help farmers take informed decisions and also incentivises farmers to make higher investments. However, in case of Bihar low procurement of food-grains due to poor marketing infrastructure has affected the market price of food-grains, which is lower than the minimum support prices. The average price difference between farm harvest price and minimum support prices for the period 2008-09 to 2013-14 for paddy was 22.6 per cent and for wheat 10.2 per cent. Therefore, it is essential that Bihar strengthens its marketing infrastructure and procurement system to ensure that farmers in Bihar can avail the benefits of the centre's pricing policy (MSP).

Historically, the agriculture R&E and extension system, along with price policy and procurement support, have often been credited for ushering in the Green Revolution in Punjab in the 1960s.

Apart from agricultural universities and public research complimenting the arrival of new technology to the frontier, the state itself undertook massive steps to strengthen infrastructure development in power, roads, irrigation and regulated agricultural markets for procurement.

5. Punjab

In Table 21 we have presented the correlation matrix of selected variables for Punjab. It can be seen that, in case of Punjab, the correlation between the agriculture GDP series and agriculture extension series is statistically insignificant while the correlation between agricultural GDP and agriculture R&E intensity is statistically insignificant at 1 per cent and 5 per cent level of significance and significant only at 10 per cent level for the period 2000-01 and 2013-14. Therefore we are unable to establish any significant relationship between agriculture R&E or extension and GDPA in Punjab for the given period using a simple OLS model. However, historically, the agriculture R&E and extension system, along with price policy and procurement support, have often been credited for ushering in the Green Revolution in Punjab in the 1960s.According to Kohli and Singh (1997) between the TE 1961-62 and TE1985-86, Punjab experienced the highest annual growth rate of food grain output among all the states of India. The annual growth rate of food grain output for Punjab was 6.4 per cent, which was two and a half times that of the all India-level. These high growth rates were accompanied by high levels of adoption of technological innovations. One of the key factors of this transfer of technology were research institutes and their close proximity to farms making rapid feedback between research and practice feasible. Apart from agricultural universities and public research complimenting the arrival of new technology to the frontier, the state itself undertook massive steps to strengthen infrastructure development in power, roads, irrigation and regulated agricultural markets for procurement. Consequently, Punjab's consumption of power per hectare of cropped area stood at 1,456 KWh/ha as compared to the all-India average of 776 KWh/ha in TE 2012-13.Surfaced road as a percentage of total road length stood at 89 per cent in 2011-12 compared to the national average of 63 per cent and irrigation coverage reached 98 per cent of gross cropped area, while the all India average stood at 48 per cent in 2013-14.Additionally, public agencies procure around 39 per cent of total wheat procurement and 24 per cent of rice procurement from Punjab (TE 2013-14).

In late 1970s, with the entry of the World Bank's T&V programme and its expansion in different parts of the country, the situation of agriculture extension improved in Punjab. However extension alone was not a catalyst in raising agricultural productivity, Punjab had other factors in place to allow the diffusion of technology to take

place apart from the public extension system. For instance land reforms, consolidation of land holdings, availability of fertilizers, and technical training programme for farmers, construction of all-weather roads and efficient education and health facilities were in place. This enabled Punjab in adopting and adapting new technologies of the green revolution.

In Punjab, the public extension system did not directly influence productivity but had close links with other factors like price incentives in the form of price subsidies that facilitated adoption of technology. Zarkovic (1987) found that the responsiveness of Punjab to this price subsidy had a greater positive influence and partially determined the adoption of HYVs in wheat and rice regions of the state. During the green revolution, price incentives were also offered indirectly through schemes like special tax concessions, credit subsidies on adoption of a particular innovation or greater availability of subsidies on complementary goods and services like power supply and irrigation facilities. Another factor that has been instrumental in producing higher levels of growth in Punjab is the appropriate adaptation of new technology to suit local conditions. The nature of mechanical inputs supplied to the markets were altered, pump-sets, automatic threshers and tractors became smaller in scale and better fitted for local conditions especially middle sized farms (Kohli and Singh, 1997).

In Punjab, the public extension system did not directly influence productivity but had close links with other factors like price incentives in the form of price subsidies that facilitated adoption of technology.

A major player in the extension scenario for Punjab was the Punjab Agricultural University in Ludhiana which spearheaded technical changes in the agricultural sector by undertaking multiple tasks of dissemination and adoption of new technologies supplemented by its extension wing. It worked through an interactive system with the local farmers and coordinated their efforts through an effective feedback system. The research focused on developing HYVs in wheat, rice and cotton crop production and practices.

Punjab Agricultural University in Ludhiana spearheaded technical changes in the agricultural sector by undertaking multiple tasks of dissemination and adoption of new technologies supplemented by its extension wing. It worked through an interactive system with the local farmers and coordinated their efforts through an effective feedback system.

In a study by Sindhu and Bhullar (2005) it was found that farmers' contact with input dealers, fellow and progressive farmers was stronger than any other information source in Punjab. Their contact with information sources like agriculture extension staff fell under the second line of contact; this implies that progressive farmers and input dealers were a major catalyst for transferring information and technology in the farming communities of the state and forming a strong integrated rural network during the green revolution. This is further substantiated by Sims (1988) who, in her field surveys suggested that agricultural extension, while active in Punjab, had a

During the 1980s, the momentum of the green revolution slowed down bringing in a lot of irreversible changes especially in Punjab. Ecological imbalances like adverse impact on the water table and over-use of land brought the need to change cropping patterns, diversify and use new technology.

limited direct impact on new technology adoption. However, the study argues that the availability of HYV seeds did matter, and farmers were heavily influenced by their neighbors' actions.

In India, the prime emphasis during the late 1980s was on producing more to feed the growing population. Next, the need was to accelerate the process of agricultural growth and widespread diffusion of modern technology coupled with institutional and infrastructural development. The national impetus given to raising yields also impacted Punjab and put pressure on the state to perform better. According to Kohli and Singh (1997) during the years between 1967-68 and 2001-02, the value of production in Punjab increased to three times and the value of productivity per unit of area doubled (in constant prices). The compound growth rate (CGR) was estimated by them to be 3.5 per cent per annum for the total value of output and 2.2 per cent for value of productivity during 1967-68 to 2001-02. Literature shows however that during the 1980s, the momentum of the green revolution slowed down bringing in a lot of irreversible changes especially in Punjab. There was a stagnation of yields and rising cost of cultivation. Ecological imbalances like adverse impact on the water table and over-use of land brought the need to change cropping patterns, diversify and use new technology. A committee was formed under the Chairmanship of S.S Jhol in 1985 to recommend policy changes for the state's agricultural sector. The committee report that came out in 1986 recommended diversification away from wheat-paddy rotation to the extent of 20 percent in favor of fruit and vegetable, fodder and oilseed crops. Currently, only 6.2 per cent of gross value of output from agriculture and allied activities is contributed by fruits and vegetable and oilseeds in Punjab, while food-grains constitute around 43 per cent of GVOA (TE 2013-14). The post-green revolution era saw the decline of extension efforts which was due to more focus on R&E to compensate for the lull in productivity and find innovative ways to foster growth. From figure it can be seen that Punjab spends a mere 0.01 per cent of its GDPA on agriculture extension, while it spends around 0.5 per cent of its GDPA on agriculture R&E.

6. Gujarat

As mentioned earlier, the correlation matrix for Gujarat (Annexure Table 20) shows that agriculture R&E intensity is statistically significantly correlated with agriculture GDP, however, the correlation between the variable agriculture extension intensity

and GDPA is insignificant. Additionally, from Table 20 (in Annexure) it is observed that the agriculture R&E intensity is highly correlated with all our other explanatory variables and due to this statistical issue we are unable to establish any relationship between public agriculture R&E and agricultural GDP in case of Gujarat.

Despite this statistical issue, one cannot undermine the importance of agriculture R&E or extension service in Gujarat, specifically the role of private players. In 2001-02 to 2013-14, Gujarat witnessed an astounding agriculture growth of 9.7 per cent per annum, spearheaded by cotton. In 2002-03, Gujarat with three million bales, produced 22 per cent of India's cotton, which rose to 11.6 million bales and a 31 per cent all-India share in 2013-14. Cotton yields grew by 131 per cent in Gujarat, way above all-India gains, over the same period. One of the most critical reasons for this expansion was the diffusion of genetically modified (GM) seeds of cotton amongst farmers through private input dealers. Of course, complementary infrastructure in terms of irrigation, roads and power also played its role, but the catalyst was the BT cotton seed promoted by private extension services. Consequently, the revolution in the cotton sector in Gujarat resulted in India's cotton production to shoot up from 14 million bales in 2000-01 to 39 million bales in 2014-15, a 178 per cent increase (Cotton Advisory Board estimates). Cotton yields at the all-India level rose by 84 per cent, from 278 kg/ha to 511 kg/ha during the same period. Consequently, India emerged as one of the largest global players in cotton. From a net importer in 2000-01, India became a net exporter (the second-largest after the US) in 2014-15 as well as the largest producer (surpassing China's 38.4 million bales)[12].

In 2001-02 to 2013-14, Gujarat witnessed an astounding agriculture growth of 9.7 per cent per annum, spearheaded by cotton. In 2002-03, One of the most critical reasons for this expansion was the diffusion of genetically modified (GM) seeds of cotton amongst farmers through private input dealers.

(iii) Stationarity and Co-integration

It is important to note that time series data have a common tendency of growing over time. If we ignore this tendency of two or more sequences trending in the same or opposite direction, we can erroneously conclude that changes in one variable are actually caused by changes in another variable. In many cases, two time series processes appear to be correlated only because they are both trending over time for reasons related to other unobserved factors (Wooldridge, 2009). In other words, we need to account for unobserved, trending factors that affect the dependent variable being correlated with the explanatory variables. If we ignore this

[12] *http://indianexpress.com/article/opinion/columns/gm-crops-cotton-heading-backwards/*

possibility, we may find a spurious relationship between our dependent and explanatory variables. According to Granger and Newbold, R2 >d where d is the Durbin-Watson statistics, is a good rule of thumb for suspecting that the estimated regression is spurious. From the regression results presented in the Annexure for all states, we find that R2 <d; therefore, based on this rule of thumb and economic theory, we can conclude that the estimated regression is not spurious. We also check for the stationarity of our time series variables by using the Augmented Dickey Fuller test or Kwiatkowski-Phillips-Schmidt-Shin test (KPSS).

In Table 5 (in Annexure) we have presented the results of the Augmented Dickey Fuller test (ADF) for Odisha. We find that the gross domestic product from agriculture (GDPA), agriculture R&E intensity, irrigation ratio and road density are integrated of order 1, i.e., they are stationary in the first difference form, I (1). However, we reject the null hypothesis of unit root for the variable 'diversification'. The KPSS test (Table 6) with its natural null of stationarity contradicts the results of ADF. Based on the results of the unit root tests, the five series are taken to be integrated of order 1 but their differenced values are I(0). It is possible that these series contain a common stochastic trend and need not be spurious. In this case, despite the trend, they will move together over time such that they will be co-integrated. Economically speaking, the five series will be co-integrated if they have a long-term, or equilibrium relationship between them.

In Table 10 and Table 14 and Table 18 (in Annexure), we have presented the results of the Augmented Dickey Fuller test (ADF) for Bihar, Uttar Pradesh and Madhya Pradesh respectively. We find that for Bihar, gross domestic product from agriculture (GDPA), agriculture R&E intensity and terms of trade are integrated of order 1, i.e., they are stationary in the first difference form, I (1) at 5 per cent level of significance (Table 10). Table 14 presents the stationarity test for the variables used in equation [3]. In UP, GDPA, agriculture R&E intensity, irrigation ratio and share of livestock in GVOA are integrated of order 1 at 5 per cent level of significance. In MP, GDPA, agriculture extension intensity and terms of trade in favour of agriculture are integrated of order 1 at 5 per cent level of significance (Table 18). Based on the results of the unit root tests, the series used for the equation [2], equation [3] and equation [4] are taken to be integrated of order 1 but their differenced values are I(0) for Bihar, Uttar Pradesh and Madhya Pradesh respectively. Therefore we can say that, despite there being a trend, these series will move together over time such that they will be co-integrated.

(iv) Engle-Granger Test for Co-integration

To test for co-integration between the non-stationary time series in each of the models, we simply run the OLS regression, and then run the ADF test on the residual to determine if it is stationary. This method is similar to the Engel and Granger (1986) two-step residual test. The time series are said to be co-integrated if the residual is itself stationary. In effect, the non-stationary I(1) series have cancelled each other out to produce a stationary I(0) residual.

Table 7, presents the Augmented Dickey Fuller Test for the residuals from the estimating equations for Odisha, Bihar, Uttar Pradesh and Madhya Pradesh. We reject the null

hypothesis of non- stationarity at the 1 per cent level of significance for the equation for Odisha, Bihar and Madhya Pradesh and at 5 per cent level of significance for the equation for MP. Given that we have established that there is co-integration between GDPA and the respective regressor for each state, the OLS results presented in Table 4, Table 9, Table 13 and Table 17 are perfectly meaningful and not spurious, even though we are using levels of non-stationary data.

(v) Field visit and Focus Group Discussions

Purpose of the visit

(I) Identifying the reach and impact of the Public Extension System through discussions with the stakeholders of extension including farmers and extension officials.

(ii) Linking the current status of extension with the need of the hour, since there has been a paradigm shift in agriculture towards market-led extension, diversification, innovation and sustainable agriculture.

(iii) Describing socio-economic characteristics of the extension agents and determining the attitude of the extension agents toward their job.

(iv) Identifying the problems faced by the extension agents in the study area.

(v) Verifying traditional problems faced by farmers and to what extent has the public extension system helped them

(vi) Identifying private extension providers or farmer organizations that work independently or along with the government.

We analyse problems in the extension system and farmers' needs on the basis of a non empirical sociological focus group discussion that comprises attitudes of agricultural extension workers in two of the largest states in India- Madhya Pradesh and Uttar Pradesh in this section. We then combine it with intensive focus group discussion with small and marginal farmers ascertaining their needs. We have chosen two contrasting models in both the states in order to learn best practices from the better performing State ie Madhya Pradesh with the idea of replicating similar structures and policies in the poor performing state, Uttar Pradesh. At the same time, we also look at the food bowl of India, The Punjab-Haryana belt to see how it is doing in terms of technological advances in agriculture and sustainability.

Most Indian states are plagued with low level of farmers' education, lack of information and knowledge regarding new technologies and market situation, agricultural extension is a very important factor for future farm modernization. Which is why it becomes important to see the linkages extension has with local farmers (women included) and why it is successful or not successful and what could be the possible reasons for the inefficiencies in the system.

In that sense, we believe that considering the extension staff's opinion on many issues regarding the reforms of "their" extension organization would be very motivating for them and might be the one of several conditions for success of future reforms.

Focus Group discussion in Madhya Pradesh

Key takeaways:

- Majority of Farmers (90%) in Agar (town in Malwa district; Our Sample town) do not go to the Mandis to sell their produce, instead they have close ties with an FPO (Framer Producer Organisation) called 'Samarth' to meet their needs. The FPO provides them with the following set of services:
  - Sells them seeds at a lower price than the market and buys from them at a higher price
  - Provides Extension Knowledge regarding production and marketing.
  - The Company also provides them with tractors from time to time for a fee.
- There are public extension officers visiting once a month (on an average) along with agricultural scientists for field demonstrations but dependency on these extension workers is very low (3-4%)
- Major Source of Extension, training and monitoring of quality of produce is done by the FPO:
  - Crop production
  - Seeds and fertilizer knowledge
  - Water management
  - Modern machinery
- The services implemented in the field on the advice of the Private sector (in this case-FPO) have produced good results and have been moderate to beneficial.
- In terms of sustainable and organic farming, farmers have tried to grow organic crops but there is still a hitch in accepting organic farming even though they hope to get a higher price for organic produce - No market, lower storage value, no trust in the market)" The majority of farmers were satisfied with the FPO model.
- 80% of them have a bank account (Bank of India)
- Krishi Vigyan Kendra and Krishi Call centre services are used more frequently than other extension services. TV, WhatsApp (100% farmers have a cell phone, 5% have WhatsApp and use it actively to connect with other farmers and FPO staff) and the local news paper, are all other sources of gaining extension knowledge.
- In terms of irrigation, their major problem is the natural lack of water in the region which makes the uncertainty and risk associated with agriculture high. No use of Drip irrigation due to very less space between two soyabean plants making it difficult to use drip. However certain farmers growing Chillies use drip irrigation. In the case of Oranges, full drip irrigation is used.

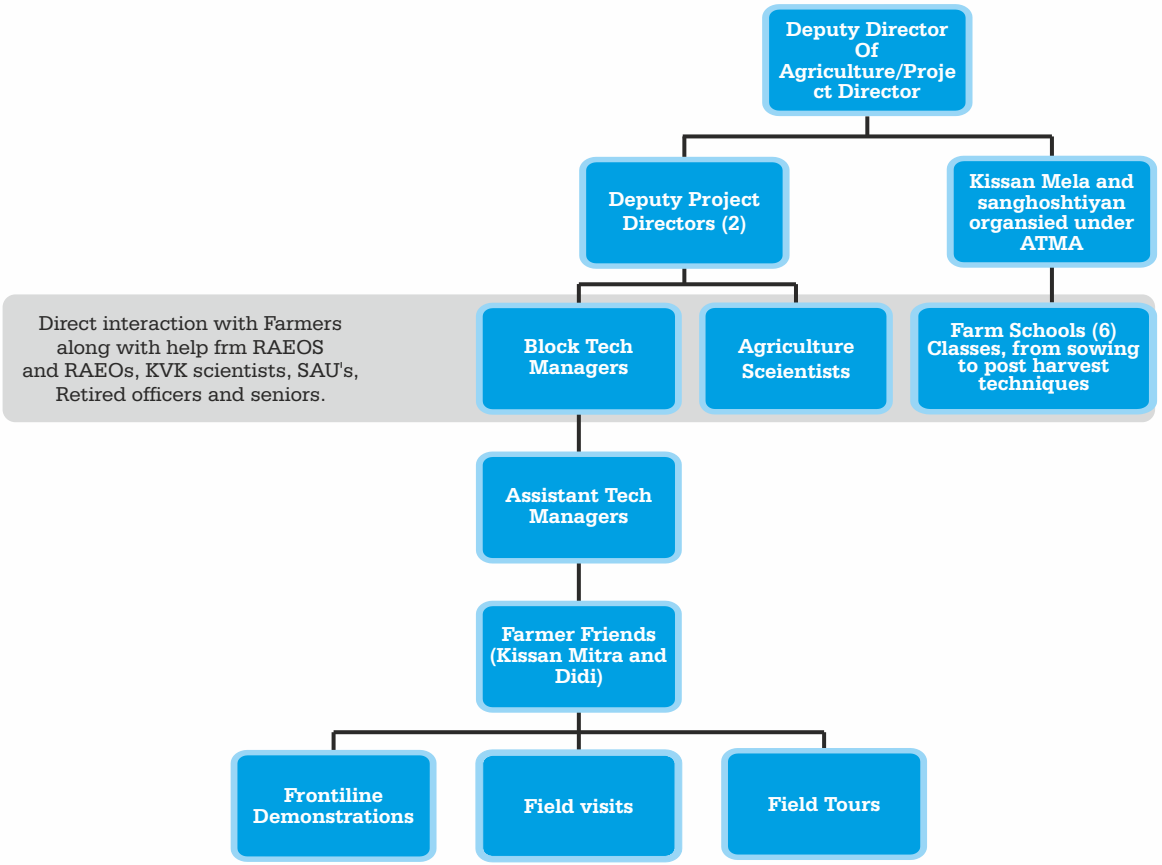
Suggestions offered by farmers:

- Storage Problems- increasing warehousing facilities
- Increasing Demand for Sustainable/Organic farming
- Same quality produce is sold at different prices in Mandis
- Farmers are not in full support of Loan waivers

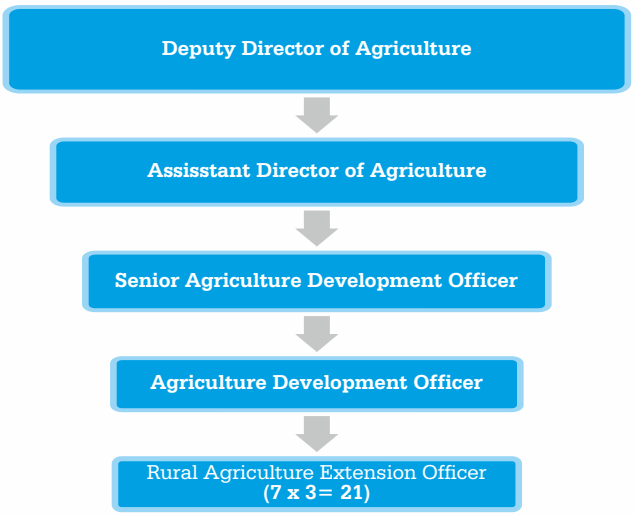
Focus Group discussion with Women in Agar

- About 70% of the women in agar were organized as Self-help groups or 'Mahilasamooh'
- Almost all women worked in the field right from sowing to Harvesting helping their husbands and doing laborious work (which is not separately accounted for in most studies) along with managing the household responsibilities
- On the finance side, The Self-help group works on the model that every member deposits a certain fee for entry after which a pool of savings is created and is given out to the ones in need of credit. The group has also registered itself with the local Bank (ICICI and Bank of India also lend formally to them)
- They are given knowledge about production techniques and animal husbandry by RAEO's and ATMA scientists, monthly. The meetings are held weekly and fortnightly in some cases, where they discuss their problems and convey them to the Sarpanch.
- The self help group meetings are useful for imparting knowledge on hygiene, sanitation, schooling their children and skill development apart from only agriculture related information. Other livelihood activities include-stitching, bangle making and art and craft.
- The major issues they are facing are to do with the lack of demand for their art and craft in the market, they take loans to improve skills and produce products that do not get sold. They want more livelihood opportunities
- However every woman we interacted with had a sense of independence and felt empowered after being associated with the self-help group and wanted to learn more and get out of the household and the traditional notion of being limited to household chores and raising children.

ATMA (Agriculture Technology and Management Agency) - Operates at block and Zila Level.



Public Extension Structure



Meeting with Progressive farmers of Mirzapur (Village 10 kms from Indore)

Key takeaways:

- Soyabean is largely grown, but they are diversifying into floriculture and horticulture (onion, Potatoes)
- Organic farming has picked up in a good way but there are still uncertainties about getting good prices for the produce (which the extension officer verified by saying that some farmers do not understand that shifting to organic farming is a slow procedure and more sustainable and the process needs to be taken up with patience)
- The farmers are well aware of extension services and are very well connected with the RAEOs with full knowledge of information pertaining to:
  - Crop production (seeds, fertilizers, machinery, soil health cards)
  - Animal husbandry
  - Vermicompost, Azola (helped in increasing the milk produced by cows by 2 ltrs on an average per day), Bee keeping
  - They sell at the Mandi
  - Self grading done by farmers with the help of the tools and machinery provided by extension staff.
  - Irrigation sprinklers used.
  - P.M. Awaas Yojna helped to Dig The Balaram Pod which has been beneficial for irrigation, breeding Fish and repairing the water table.
- Farmers who have diversified to high value agriculture eg floriculture are earning higher than soya bean producers, but with higher risks.
- Some Extension officials for eg from the horticulture division have never visited the field at all- Lack of trust. The farmers also insisted that they want better storage facilities for their crops so that they can benefit from speculation.



Focus Group discussion in Uttar Pradesh

- As far as Public Agriculture Extension is concerned, extension from the Horticulture Division to Small and Marginal Farmers was nearly absent. The officials visited the fields once or twice every year. This was compounded with duplication and stagnation of information provided on production techniques which the farmers were already aware of.
- There are no FPOs present in and around Agra for potatoes as of now. The private sector does no extension work, sometimes farmers procure seeds from private traders and companies which are mostly poor in quality.
- Dissemination of knowledge on innovations and sustainable practices is also absent. The only Diversification technique that was tried (rather unsuccessfully) was Organic Farming.
- Further, there is hardly any inspection by scientists, district officials or KVK-staff to make sure if farmers are following new techniques or given timely advice. The set of farmers we interacted with were very poor and backward, with high risk aversion. This is in contrast with what we saw in Madhya Pradesh, where FPOs were taking a major lead in spreading extensions services along with the State government being pro-active.
- There is an urgent need to address the lack of efficient Extension services given to farmers in an area which is being plagued by over-production and low prices. Traditional approach to Extension needs to be changed and focused towards Market-led extension through:

Suggestions:

1. Community Farm schools and demonstrations (giving knowledge on diversification towards other high value crops)
2. Community Skill Development
3. Community Enterprise (to capitalize on diverse markets)



Focus group discussion in Punjab- Haryana Belt

This region is primarily referred to the 'Food Bowl of India', which is why an assessment of farming practices and the extension services here is critical to how India's agricultural innovations are shaping the future of farming.

The region is mainly dependent on ground water for irrigation and due to excessive use of water in the region during the green revolution impetus, the water table has been severely impacted. Overexploitation of ground water sources have resulted in a steep fall in fresh water belts and rise in salinity. Around 70% of the cultivable area is covered by various Canal commands that are functional, however the intensity of canal irrigation is not uniform due to highly skewed distribution of canal water. Thus the need for water management and sustainable irrigation facilities are the prime concern

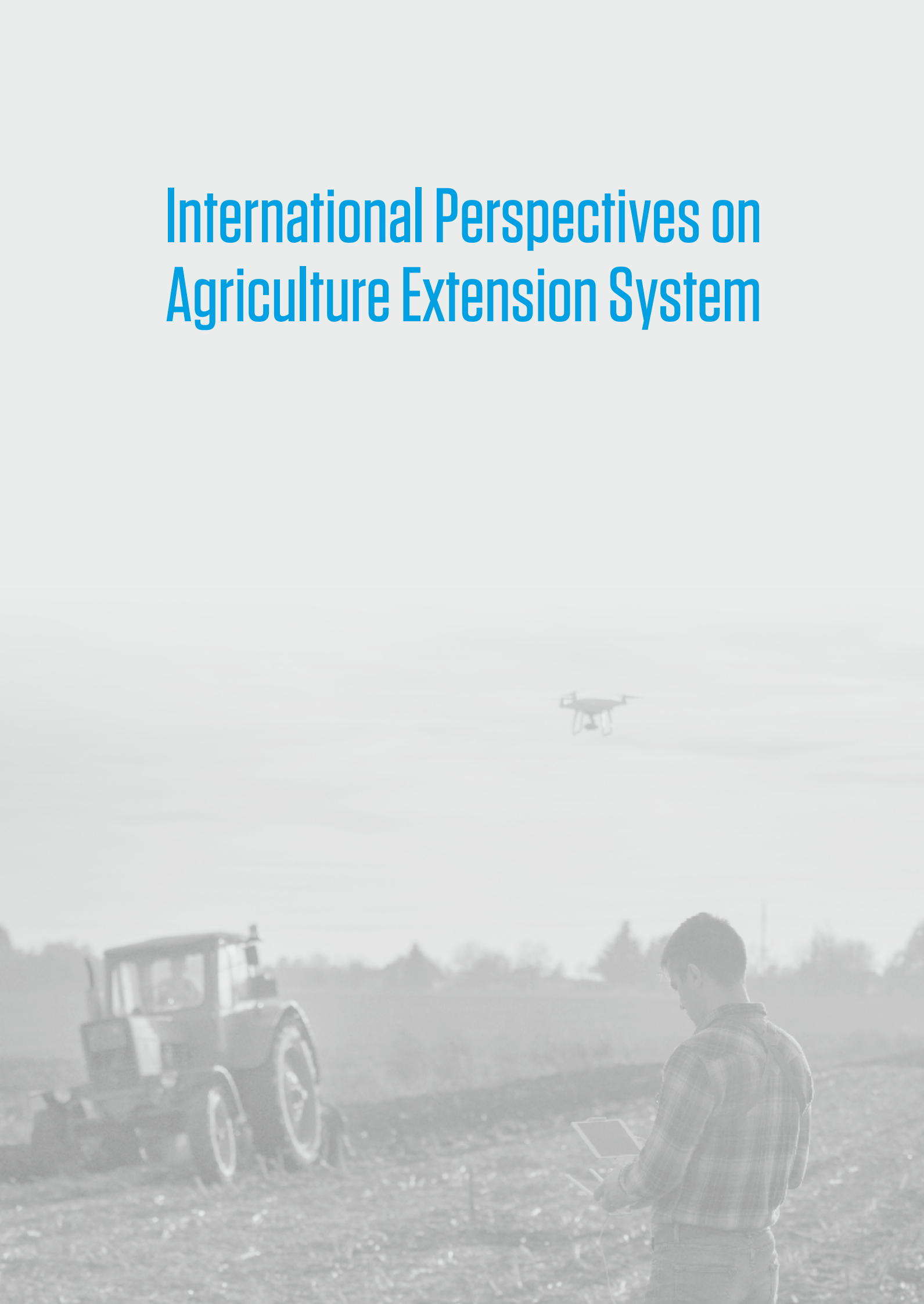
The growing water crisis along with the vision of 'per drop more crop' has brought micro-irrigation schemes to the forefront. By replacing the traditional flood irrigation technique for paddy with drip irrigation which is useful in reducing energy consumption, labour savings and fertilizer efficiency along with water management. Micro-irrigation schemes have come up slowly this belt with regard to rice cultivation. The increasing demand on limited water resources and the urgent need to increase food production have led a lot of farmers to adopt drip irrigation with benefits like precision placement of water, efficient chemical and fertilizer application, crop yield enhancement and improved disease control.

The case of a Pilot Project for Micro-irrigation in Pehowa which is in the Haryana belt and shares similar characteristics with adjoining Punjab districts is a demonstrative project implemented by the Command Area Development Authority on a pilot basis. It involves:

- Installation of community based solar plus grid powered mirco-irrigation infrastructure in existing canal commands in 13 districts of Haryana.
- The project is unique in the way that it uses a community based approach by getting about 30 farmers in each district to participate and benefit from the installations.
- The main idea behind their approach is to evaluate and compare whether-flood irrigation, sprinkler or drip is the best method for rice cultivation in the region:
    - Uniformity in water application because of the storage structure
    - Improving cropping intensity
    - Saving farm land and appreciating land use
    - Improving water use efficiency

- The set-up is a zero cost model which does not require the farmer to pay out of his pocket, rather, the benefits are shared by all of them with mutual understanding even in case of machinery use.
- Pressurized irrigation system of this form requires technical assistance which is provided by CADA itself timely along with demonstrations held for farmers.
- Extension services are held on a large scale by Punjab Agricultural University and is accessible to farmers in the area. Apart from dissemination of traditional services, the annual 'KrishiMela' which is attended by farmers is popular among them.
- Solar energy used in the project is another added advantage which tilts this initiative towards a more sustainable angle, although costs are slightly higher but the benefits would cover the additional costs in the future through energy security, low transmission losses and environmental benefits.

International Perspectives on Agriculture Extension System



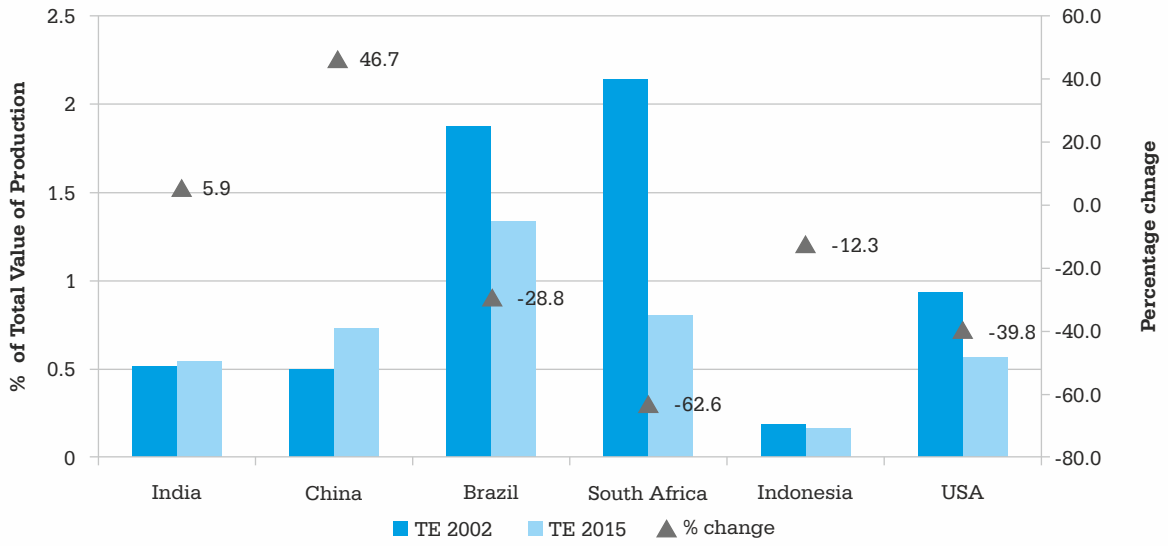
6 International Perspectives on Agriculture Extension System

This section describes the various extension models in five different countries to compare the best practices in agriculture extension. In the recent decades there has been a global shift in the focus of research from merely production based to more demand driven and market-led approaches with innovation at the centre of agriculture growth. The reason for selecting this pool of five countries was based on the agriculture performances of these countries starting with China being our neighbour and close competitor, moving on to Indonesia that also started off with the same structural changes as India. The Latin American experience is represented by Brazil and its fast growing livestock sector. USA is considered for the comparison by virtue of being an advanced nation and to see if some lessons could be a leap of faith for India. This chapter principally deals with the expenditure of each country on research and knowledge pertaining to agriculture including extension and what proportion of GDPA does this research hold from the years 2000-2015[13]

The recent trend in Agriculture Extension dynamics around the world in the early 1990s and 2000s has been the importance of technology transfer, human capital development and resource management in the wake of sustainability and climate change. This has also impacted the scope of extension and agricultural research. Most countries started off with a strong centralized public extension system and over the years have tried new approaches with the entry of an active private sector and a variety of civil society organizations in re-organizing extension services. In Countries like India and China public extension systems have been decentralized to the district/county levels. In USA, the role of the public sector has diminished and the private sector has taken a lead in disseminating knowledge and new technology.

[13] *Taken from PSE Database; Agriculture Policy Monitoring and Evaluation 2017, OECD*

Figure 18: Agriculture Knowledge & Innovation as a percentage of Value of Production (TE 2002 & TE 2015)[14]



Source: PSE Database; Agriculture Policy Monitoring and Evaluation 2017, OECD, Combined finance and Revenue accounts of the centre and states, National Accounts Statistics (CSO)

1. China

The Chinese agriculture system is one of the biggest in the world employing 31.4 percent of population and contributing to 9.2 percent of GDP in 2015[15]. This enormous agricultural system encompasses a well-defined public agriculture extension system employing about 787,000 extension workers catering to about 637,000 villages. In late 1970s, China established the public agricultural extension system (PAES) which contributed significantly to the growth of agriculture. Between the late 1980s and early 1990s, the system employed an extension staff of more than one million, about 70 percent of whom had graduated from technical high schools or colleges (Hu, 2009). An important feature of this extension model was the extensive coverage of area, which included every major town and villages even in remote areas providing high quality agricultural extension services.

There was a transformation from a supply centered approach to a Demand driven extension system between 1966-77. Post which, till 1989 the agricultural economy underwent a recovery and development phase which strengthened the extension system. 1990's were a period of in-dept reforms which was spearheaded by long-term investment in Public Agriculture R&E, Improving institutional structure and finally research allocation priorities were revised to move from traditional approach to a market led extension system. The China Agriculture Extension Special Task Force was set up in the 90's which was bound to support extension workers and farmers to set up profit sharing schemes to improve productivity and rural development.

In terms of science and innovation, the Chinese economy has focussed on food security. Major crops are cultivated with improved quality and yield potential. Livestock and poultry breeds have also seen improvement. The improvement in quality has contributed to a 43% increase in agriculture production. The environmental benefits of using new and improved

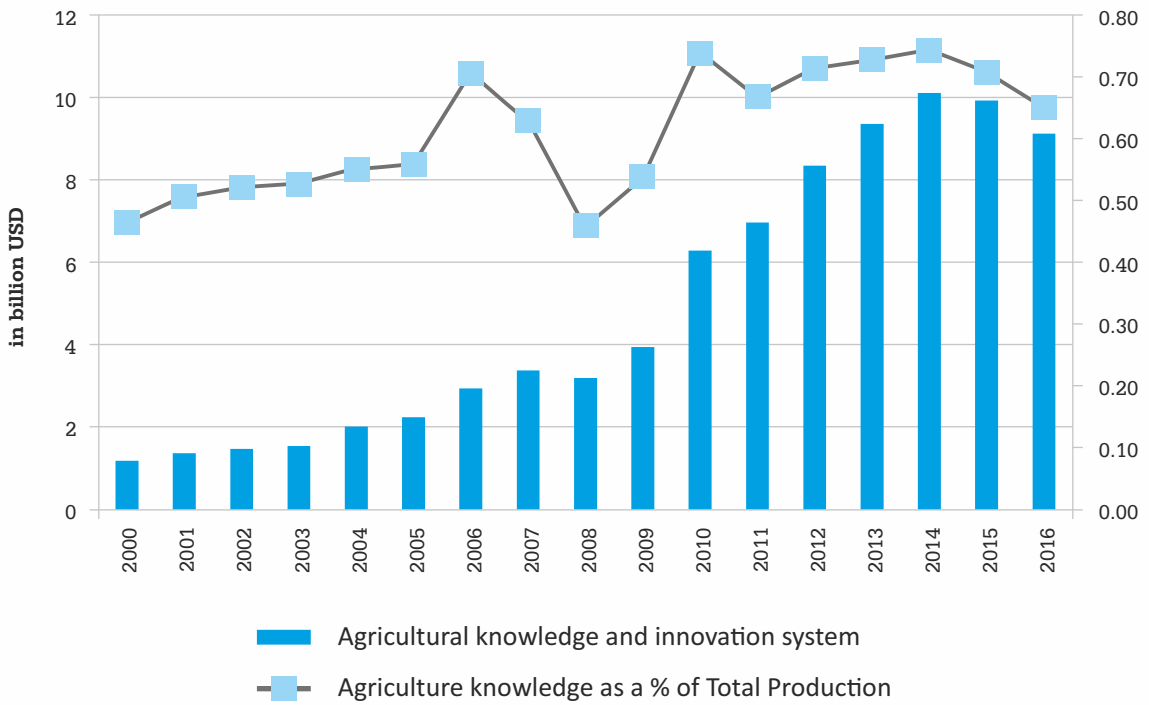
[14] *In India we have taken the aggregate expenditure on research & education and Extension & Training for union as well as states.*

[15] *Agriculture Monitoring and Evaluation, 2017, OECD*

technology have pushed nitrogen and phosphorus emission down by 60%. Two major impacts of Research and innovation which have been successfully coordinated with extension are as follows, first is the enhancement of agricultural innovation capacity and the absorption rate. A number of research platforms have been established for functional genomics, proteomics and metabonomics to help crops cope with biotic and abiotic stress tolerance thus contributing to crop improvement. Research is not one sided but has taken a multi-dimensional approach to incorporate new targets and market centric approaches to disseminate hi-end technology to farmers. The second impact thrust is in the methods established of water saving in arid and semi-arid areas. Straw briquets, biomass pyrolysis oil and biogas have been used as fuels on a large scale. Rice straw mulching technology adopted in southern hill regions has reduced water and soil loss on sloping land by 70% and increased soil productivity by 20% (Deng et al, 2017)

In recent years there has been a high level of investment by private sector companies in extension services. The expenditure on Agriculture Knowledge and Innovation as a share of value of production has been fluctuating between 0.4 percent to 0.6 percent and has settled at 0.65 percent for 2016. The highlights of China's agriculture extension system are briefly summarized below:

Figure 19: China: Agricultural Knowledge and Innovation system



Source: PSE Database, OECD Monitoring and Evaluation Report

1) Public Sector Agencies

Agriculture Technology and Extension Service Centres (ATESC): These service centres function under the ministry of agriculture, with the mandate to implement the priorities of the national government. Two features stand out for attention: the close partnership developed with private sector extension services and financial incentives availed by public sector extension agents working on behalf of private companies. This unique hybrid model, which can be termed a form of public-private partnership, has enabled China to

substantially increase its outreach through trained extension agents, deliver higher quality services and inputs even in remote regions and reap the rewards through massive gains in production and productivity of major crops in line with national priorities.

2) Role of Private Players, Farmer cooperatives, Supermarket Value Chains and NGOs

Private actors are also contributing significantly to agriculture extension services in China even independently. Most of them are involved in the promotion and sale of agriculture products and also package technical assistance with the product. Da BeiNong group and Nestle are prominent names in the private sector extension network.

Farmer cooperatives have also played a significant role in enhancing extension services since the beginning of 1990s. Supermarkets sourcing produce from farmers are also supporting agriculture extension services, with the major actors being Walmart, Carrefour, RT Mart and China Resources Enterprises. Some NGOs have also been active in agriculture extension services, notably The China Foundation for Poverty Alleviation (CFPA), The Amity Foundation and The Rural Women Knowing All Association

2. Brazil

The agricultural extension service began in Brazil in 1948 and one of the most integral part of its operating activities was the use of rural credit. It aimed at providing farmers access to rural credit as well as agriculture extension and technical services. A unique feature of the technical assistance provided to farmers was that it combined public and private extension services and made use of compulsory extension services where subsidized credit was used.

An important step taken by the government in 1973 was the expansion of the Brazilian Agricultural Research Corporation (EMBRAPA) to strengthen agriculture in Brazil solely funded by the government. This helped in the development of much needed seed varieties suitable to tropical climates and low altitude areas, breeding cattle; developing biodegradable fabrics and edible wrapping papers; and introducing new mechanization techniques suitable for the terrain and the environment (Wickramasinghe, Syed and Siregar,2012).

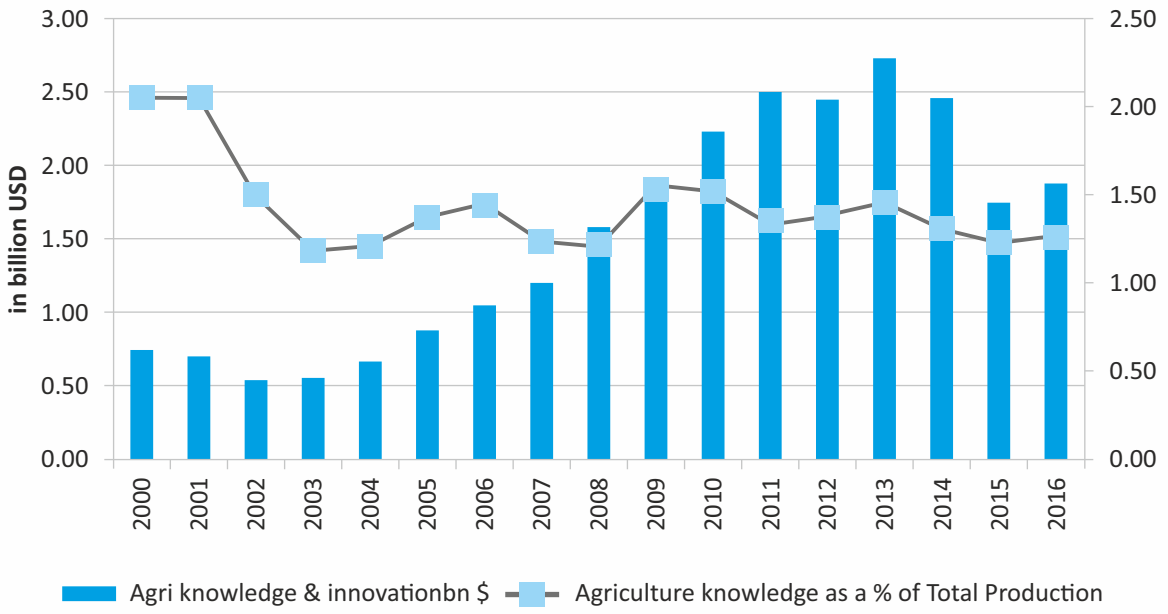
In 2003, the government of Brazil formed Ministry of Agrarian Development (MDA) to support family farming and agrarian reforms. Under MDA, a new National Rural Extension Department (DATER) was created within the Family Farming Secretariat. Thus, extension services were considered equally important and placed side by side by with other policies such as subsidised credit, crop insurance and price guarantees programs.

In 2003, the government of Brazil formed Ministry of Agrarian Development (MDA) to support family farming and agrarian reforms. Extension services were considered equally important and placed side by side with other policies such as subsidised credit, crop insurance and price guarantees programs.

The Ministry of Agriculture, Livestock and Food Supply has the overall responsibility for providing public extension and advisory services to farmers. Although agricultural extension is decentralized in Brazil and states are responsible for the provision of extension services, the Ministry retains supervisory, coordination, national policy matters, funding and backstopping like functions (Grafts). Private sector, NGOs, farmer producer organization and cooperatives also play an important role in proving extension services to farmers.

According to OECD methodology, expenditure on agricultural knowledge and innovation and transfer accounted for 80 percent of the total General Services Support Estimate (GSSE) in 2014-16. Although expenditure on agriculture knowledge and innovation as a percentage of value of production is one of the highest in Brazil, this trend has been declining. It has decreased from 2.05 percent in 2000 to 1.27 percent in 2016.

Figure 20: Brazil: Agriculture Knowledge & Innovation



Source: PSE Database, OECD Monitoring and Evaluation Report

3. South Africa

South Africa was characterized by a dichotomous extension system which was differentiated on the basis of racial parameters with different levels of support and operation. The white commercial farmers were on one side and on the other side were largely poor and under-developed black and Indian farmers getting little to no extension support for a long time. This inefficient system was then broken down to create the South African Society for Agricultural Extension (SASAE) and tertiary training institutes in agriculture in 1966. However, post the Apartheid era saw an influx of cooperatives, community organizations and private players.

The Previously compartmentalized extension services of the state were re-organized into nine provincial services putting pressure on the size of the Public extension system to grow from a mere 2210 extension staff to 5500 (Dept of Agriculture, 2005). The present state of extension is far better than the historically disadvantaged start, but the delivery of advisory

support is highly dependent on human resource capacity and finance. The focus needs to be on improving skills, expertise and qualifications of the extension staff to improve the overall quality of the system. Women are playing a major role within the emerging farming sector with their home-garden and handicrafts- they are often referred to as 'pillars of hope'.

The national department of Agriculture has planned to revitalize the existing system by cooperating along five new pillars established in 2011:

1. Ensure Visibility and accountability of extension. 2. Promote professionalism and improve the image of extension. 3. Recruit more motivated extension personnel 4. Re-skill and re-orient extension workers 5. Provide ICT services and improve its adoption to expand them. The Department of Agriculture, Forestry and Fisheries (DAFF) has committed to increase the number of extension personnel to the recommended for extension-to-farmer ratios of 1:400 in crop farming, 1:500 in livestock and 1:500 in mixed farming. The Provinces are making maximum effort to reach the target of 9000 extension workers through recruitment and capacity building. South Africa has nine Agricultural Universities in place, out of which only three are focused only on extension training.

One of the latest extension successes in South Africa among others comes from the livestock sector. The farmers get information on animal care and rearing along with genetically improved breeds at the local extension offices itself.

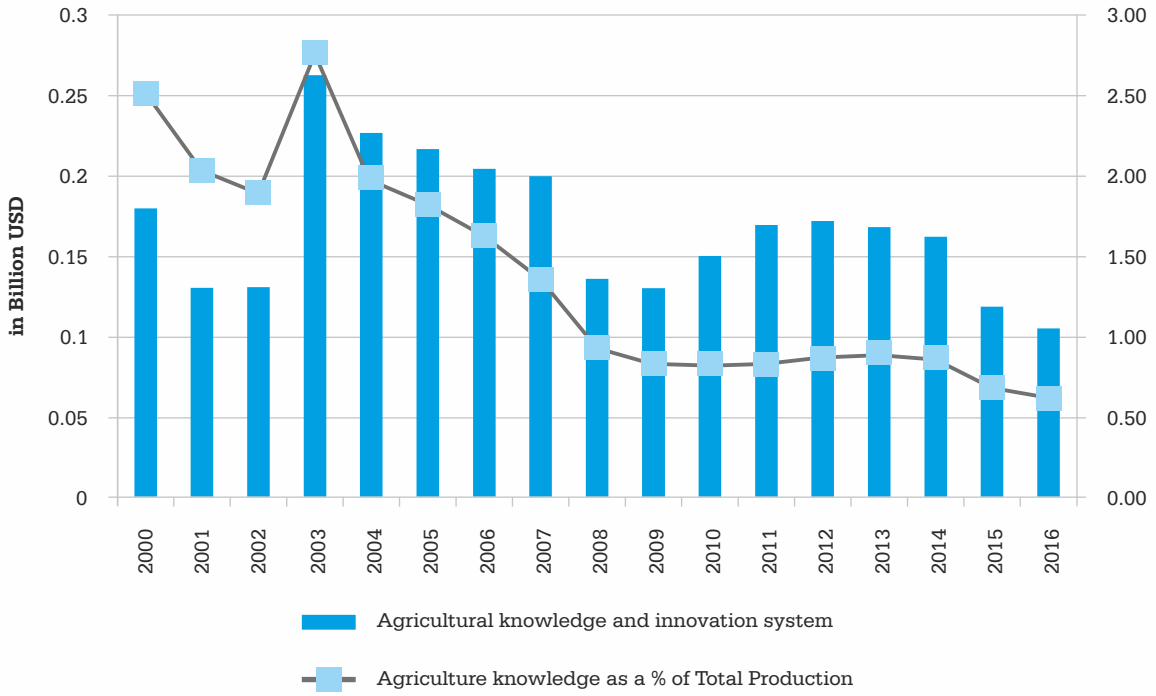
The comprehensive Agricultural Support Grant which has been recently introduced aims at disseminating effective agricultural and allied activities support services to disadvantaged producers.

One of the latest extension successes in South Africa among others comes from the livestock sector. Genetically improved animals introduced to framers have enhanced the quality of livestock increasing farmers' income from the sector. This development has also led to balancing food security and increased access to a new set of markets. The farmers get information on animal care and rearing along with genetically improved breeds at the local extension offices itself. The comprehensive Agricultural Support Grant which has been recently introduced aims at disseminating effective agricultural and allied activities support services to disadvantaged producers. This value-addition is a similar phenomenon in the Indian livestock sector which is contributing a major chunk to Agri GDP and bringing in foreign exchange through increased exports.

However, the decline in the expenditure on research and development has had serious consequences on funding on research and development activities. As a share of value of agriculture production, expenditure on knowledge and innovation has declined from 2.5 percent in 2000 to 0.61 percent in 2016. This has led to a sharp fall in the number of doctoral level research staff by about 80

percent (OECD, 2006). Moreover, the Agricultural Research Council is undertaking contracts for research entities and their objective may not be aligned to the requirements of the farmers or policymakers.

Figure 21: South Africa: Agriculture knowledge & Innovation



Source: PSE Database, OECD Monitoring and Evaluation Report

4. Indonesia

The experience of Indonesia with respect to agriculture extension has seen a transformation from a top-down and heavily centralized approach in the 1970s to a more participatory and inclusive approach in the recent years. There was a sharp reduction in funding along with decentralized ICT driven services aiding upstream flow of information and technology. In 2006, the government of Indonesia placed a new law to revitalise their extension system. A pluralistic approach has been adopted with the involvement of both public and private sector. Fisheries and forestry sector has been put together under one institution called Agency for Extension Coordination (BAKORLUH), (GFRAS, Indonesia).

Historically, modernization in Indonesian agriculture was much like India's with introduction of a similar 'Green Revolution' giving an impetus to agricultural inputs (High Yielding Varieties, Chemical fertilizers and pesticides), mechanization and irrigation. All these technological advances changed from a uni-dimensional paradigm to a more integrated approach that focused on not only inputs but also on marketing, credit and sustainability via expansion of extension services. The earlier focus in extension was driven by a rice-intensification approach by the government involving various scientists and faculty from the Agricultural University of Indonesia (Now Bogor agricultural University). Five technologies of rice: seeds, chemical fertilizers, pest control, planting space and

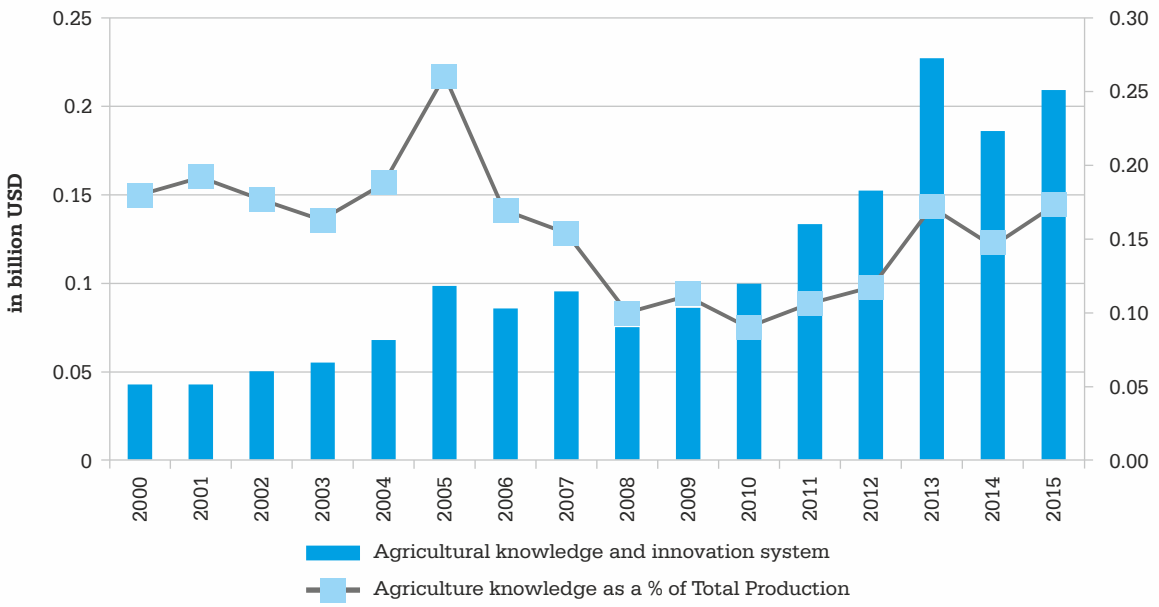
irrigation were strengthened and helped to improve land productivity. This was clubbed under the umbrella approach called the BIMAS program (BimbinganMassal=Mass Guidance) which implemented various steps to achieve rice self-sufficiency through a LAKU (LatihandanKunjugan) or training and visiting programme introduced by the World Bank as part of the Green Revolution technology campaign in the 1970s.

One of the first modern experimental approaches in extension was the world Bank-assisted DAFEP (Decentralized Agriculture and Forestry Extension Project 2000-2005) which provided impetus for demand driven extension along with institutional reforms. The main objective of the DAFEP programme was to assist the Govt of Indonesia in enhancing farmer' capacity to participate in and also spearheaded extension activities, which was to be done by reviving farmer groups and organizations (World Bank, 2007).

In 2005, the Government launched another program called Revitalization of Agriculture, Fisheries and Forestry with three key focal points: Pro-growth, Pro-job and Pro-poor. This was later complimented by Revitalization of Agriculture Extension launched in 2006. Presently Indonesia has picked up and adapted to new technological changes in the global world especially in the case of ICT based extension. The current agricultural and fisheries extension system relies on capacity building programs for extension workers and farmers, targets motivations of farmers to adopt new technologies and performance evaluation.

In the autonomy era, the focus is more bottom-up with coordinated efforts across agriculture, forestry and fisheries. However, there is still an array of challenges Indonesia faces in maximizing its extension efficiency. Even as extension funding has seen a rise, the proportion of research and knowledge out of the total agriculture GDP share is still lower compared to the desired levels. The Indonesian government is currently giving considerable attention to the fisheries sector, especially shrimp farming, with its potential for foreign exchange earnings.

Figure 22: Indonesia: Agricultural Knowledge & Innovation System



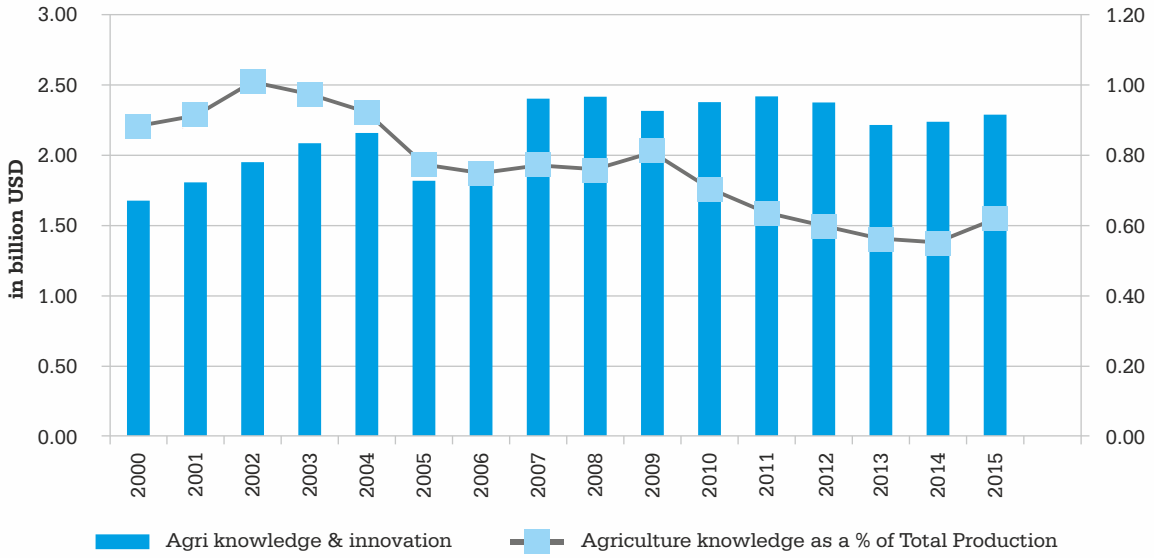
Source: PSE Database, OECD Monitoring and Evaluation Report

5. USA

Agriculture extension began in USA in 1914 through the creation of United States Cooperative Extension System that included land-grant universities as state partners with funding from the United States Department of Agriculture (USDA), state, and local sources. This three way partnership between the federal government, the states and the local communities was established to deliver new technologies to the farms as well as to convey farmers' needs to university researchers. Over decades, public extension system matured and there was a gradual decline in funding by federal government (Krell, Fisher and Steffey,2016). State and local bodies gained more importance and the role of private players in providing extension services increased significantly.

With a majority of US farms entering commercial markets and using high end technology, the role of extension in today's modern context has changed significantly. Farmers receive information from input dealers, suppliers and agronomic consultants on a fee-for-service basis. However, in a few states both public and private extension providers co-exist. For example, private consultants and input suppliers provide direct information to commercial farmers but they receive information from university extension specialists. Thus, both private and public extension service providers could play a complementary role to enhancing extension services.

Figure 23: USA: Agriculture Knowledge & Innovation



Source: PSE Database, OECD Monitoring and Evaluation Report

Lessons for India

The lessons for India from the extension models reviewed in the above countries start with a positive picture and point to the fact that extension systems are dynamic and transformative. A shift from a top down approach to a more demand driven and market-oriented approach is the need of the hour for economies like China, India and Indonesia.

Taking the case of China which adopted a unique hybrid model in the form of a public-private partnership in extension is a very interesting and effective model that could be

The research and extension services provided to Chinese farmers have moved forward from solely food security goals towards sustainable and innovative farming practices. Having said this, it is also crucial to take into account the changing role of the agriculture sector itself which has transformed from a food provider to a more profitable sector for its stakeholders.

followed by India given the expansion of private companies and corporate into the field of Agriculture. The research and extension services provided to Chinese farmers have moved forward from solely food security goals towards sustainable and innovative farming practices. Having said this, it is also crucial to take into account the changing role of the agriculture sector itself which has transformed from a food provider to a more profitable sector for its stakeholders.

Different countries adapt according to their growth trajectories and structural changes for instance, Brazil has realized the importance the credit as the most critical farm input and has linked extension to credit by providing compulsive extension services to loanee farmers.

In more developed countries, like USA, production technologies are increasingly becoming 'private goods' and with a large number of farmers producing commercially, extension and advisory services are increasingly becoming privatized. However, this level of privatization might not be the model India is seeking at present, although a coalition would prove to be more efficient given the dominance of small and marginal farmers.

South Africa has performed exceptionally well in the high-value agriculture and allied sectors, especially in the case of the livestock sector, India also has tremendous potential in livestock as a driver of agricultural growth. The contribution of just the livestock sector to GVOA as seen earlier is 26.5%. Diversification is gaining more recognition proving that markets and not just technology has become the prime driver of agriculture growth in many countries.

In the emerging global agricultural scenario, the traditional top-down production oriented extension system has collapsed to give rise to more inclusive models that focus on improving output and livelihoods through consistent agriculture innovations framework adapted to local conditions keeping in mind the global trend.

Conclusion and Policy Implications

7 Conclusion and Policy Implications

Based on the analysis and review of extension practices within India the following conclusions may be drawn:

1. In 2014-15, India on average spent around 0.7 percent of GDPA on aggregate agri-R&E as well as on agri-extension, of which 0.54 per cent was on agriculture R&E, and 0.16 per cent on agri-extension. Public investment on agriculture R&E in India is low as compared to the suggested spending of 2 per cent of GDPA (World Bank, 1981). Moreover there are wide variations across states.

2. Amongst our focus states, Gujarat spends the most on agriculture R&E (0.59 per cent), followed by Bihar (0.50 per cent), Punjab (0.41 per cent), Odisha (0.25 per cent), Uttar Pradesh (0.17 per cent) and Madhya Pradesh (0.24 per cent)

3. The econometric analysis shows that there is a positive and significant effect of agriculture R&E/aggregate expenditure on R&E and X&T on agricultural GDPA in Bihar, Uttar Pradesh, Odisha and Madhya Pradesh. However, there are other factors such as irrigation, road development and price incentives which are critical variables that determine agriculture growth.

4. Agriculture extension services in India are predominantly centred on crop husbandry with a pronounced tilt towards Transfer of Technology (ToT). Around 70 per cent of the agriculture R&E budget was allocated for crop husbandry, while 92 per cent of the budget on agriculture extension was allocated to crop husbandry. The approach of public sector extension is to offer a one-size-fits-all product to all farmers. In a country with over 86 per cent of farmers categorized as small and marginal, this is a self-limiting strategy as the huge variations in resource endowment, agro-climatic conditions and legal exigencies are not factored into the model of agriculture extension being followed either by the government.

5. In recent years, the growth in the High Value Agriculture (HVA) sector has been twice or sometimes even thrice that of the crop husbandry sector. In fact, of the 5.7 percent growth in GVOA between 2001-02 and 2013-14, 26.3 per cent was contributed by livestock, 15.4 per cent by food-grains and 14 per cent by fruits and vegetables. Yet, agriculture extension services for HVA sectors remain weak and disorganized.

6. While NGO-led extension models offer far more variety and display sensitivity to local priorities and conditions, they do not have the capacity or scale to make a significant impact across large regions. They are also seriously hampered in scaling up due to paucity of resources, as public sector extension agencies rarely explore synergies or cooperation and donor support continues to be project-driven and episodic.

7. The above analysis also suggests that the government, private sector, NGOs and others providing agriculture extension services are working in isolated silos with little or no functional coordination at the field level. This leads to restriction of good practices generated in each of these sectors and an opportunity for wider application is lost.

8. Lastly, it may be concluded that the large number of players in the agriculture extension arena function without any standards or certification of quality. This leaves questions of accountability up in the air as the majority of farmers are not in a position to pursue legal remedies in case of erroneous or even harmful advice.

Keeping these conclusions in mind, the following issues require further attention in the context of agriculture extension system in India:

1. The links between research and extension have weakened over the years after the initial euphoria of the Green Revolution. Cross sharing of experiences between the public, private and civil society sectors is minimal, if not non-existent, in most cases. Given the increasing importance of HVA subsectors, formal mechanisms for greater sharing of knowledge, not just between research centres and service providers but also between farmers and the service providers will have to be activated with special focus on animal husbandry and dairying.

2. The role of the private sector, civil society and farmers' groups in extension needs to be urgently and specifically delineated. Quite clearly, public led extension efforts will not suffice in an environment where the market is the primary driver of cropping patterns and choice of technology. The state can shift from being a major provider to an enabler of equitable access to agricultural technologies, especially for resource poor farmers. It can assume as agnostic attitude towards particular technologies and efforts to mainstream them, satisfying itself on issues of public health and safety and preventing market dominance.

3. The issue of the capacity of service providers, their quality certification by an independent authority and adherence to technical norms as well as accountability in different circumstances will also require clearer articulation and definition. This presumes the existence of a body / authority backed by sufficient legal powers to study enforce standards and accountability norms in agriculture extension.

4. The viability and long terms fiscal sustainability of agriculture extension services is an issue confronting even the developed countries. Given the important role of agriculture in India and the scale of services required, this issue will have to be addressed in a

holistic manner both by the public and private sectors. Is agriculture extension to be treated as a public good for certain categories of farmers? If so, how are they to receive delivery of this public good? Is the public sector the only channel for delivering this category of public goods? These and similar questions need to be addressed in the context of this challenge.

5. Given the huge diversity of farming conditions in agriculture in India, farmers and farming communities have built up a large bank of coping mechanisms and innovative practices over generations. These remain confined to informal channels within a small geographical area and rarely travelled widely even within a district, let alone the State. Innovation networks permitting free two-way flow by ideas and technologies must be designed and implemented to capture the rich data banks of local knowledge available in different parts of the country. Digital technologies have a huge role to play in achieving this goal in a cost effective manner

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Annexure

Table 1: List of Activities undertaken by ATMA in Madhya Pradesh

Year	Unit	(In Units)								
		2012-13		2013-14		2014-15		2015-16		2016-17
		Target	Achievement	Target	Achievement	Target	Achievement	Target	Achievement	Target
Farm School	Numbers	1565	1565	1565	1454	942	942	1565	1300	1565
Agriculture demonstration	Numbers	8150	8150	12000	10249	15000	14800	11000	10840	33957
Agriculture (Others)	Numbers	1885	1800	4500	4311	6000	4310	6045	4176	15000
Krishi Vigyan Mela	Numbers	50	50	50	48	51	46	51	51	51
Krishi Sangoshti	Numbers	626	626	626	626	626	603	626	616	626
Agriculture demonstration outside state	Number of People	6260	5760	15650	13717	8000	7152	8000	7201	15650
Agriculture demonstration inside state	Number of People	15650	15600	31300	30669	12000	8857	12000	8923	31300
Agriculture demonstration inside district	Number of People	18780	18000	39260	38947	50000	36510	50000	38854	78250
Travel (outside state)	Number of People	15650	15000	11750	18382	42860	42860	15650	14802	15650
Travel (inside state)	Number of People	78250	78250	16500	12350	62600	34215	37420	25385	78250
Travel (inside district)	Number of People	31300	31300	31300	24393	31300	17961	18000	16498	31300
Capacity development	Numbers	3130	3130	2500	2146	6260	5112	6260	5159	6260
Best group award	Numbers	50	27	50	32	313	116	255	134	1565
Development Fund Level Agriculture Award	Numbers	313	290	313	278	313	258	1565	1052	1565
State level Best Agriculture Award	Numbers	10	10	10	10	10	10	10	10	10
District Level Best Agriculture Award	Numbers	50	22	50	36	102	37	102	60	255
Staff Training	Number of People	8100	4744	8100	1800	7600	2661	11250	9630	10600
Staff Travel	Number of People	2500	2150	2500	2005	2500	1623	2500	1097	2550
Krishak Mitra	Numbers	26000	2215	26000	25698	25900	23512	26000	23771	25933

Source: Government of Madhya Pradesh

Table 2: Details of extension activities/programs organised in Orissa during 2013-14

Extension activities/Program	Total number of activities	Total number of beneficiaries	Objectives
Capacity building program (through KVKs under OUAT)	1667 vocational training	42,386 farmers and farm women	The objective of this program was to train beneficiaries in regard with commercial mushroom production, conservation agriculture, organic farming, contingent crop planning, fish-cum-duck farming in small backyard tanks, income generating activities for WSHGs, integrated fish farming, micro & secondary nutrient application, use of drudgery reduction implements by farm women and integrated management of crop/weed/water/pest.
	371 trainings	6397 youths	
	191 trainings	2779 extension functionaries	
On Farm Testing (OFT)	472	5594 farmers	Introduction of new varieties of field and horticultural crops, aromatic rice, N management through Leaf Colour Chart (LCC), integrated nutrient management, integrated pest and disease management including use of organic pesticides and bio control agents, use of improved farm implements, formulation of diet supplements for domestic animals, OFT on new plant protection chemicals, mushroom cultivation, composite fish culture, fresh water prawn culture etc.
Front Line Demonstration (FLD) (under direct supervision of KVK scientist)	508	4962 farmers	Demonstration on hybrid paddy, maize, horticultural crops, farm machineries were given.
	91	1533 farmers	Groundnut, field pea, toria, mustard, sesame, niger, sunflower and red gram, black gram, green gram, Bengal gram etc.
Other extension activities			
Farmer fair	37	22026	To facilitate farmers.
Field days	330	12575	
Special day celebration	102	7637	
Exhibitions	82	229234	
Film shows	944	24719	
TV talks	218		
Radio talks	135		
Scientist visit to farmers	6625	33288	
Farmer's visit to KVK		17517	
Diagnostic visits	2024	13351	
Animal health camp	56	5067	
Group meeting	799	13615	
SHG conventions	88	1345	
Kissangosthi	99	2590	
Farmers club formed	60	1214	
Farmers club meeting	108	2727	
University Extension Block Program (UEBP)	12 field days 4 training camps 2 exhibitions 8 farmer-scientist interaction 62 farm advisory service	_____ _____ 258 farmers	This program is operating in 4 villages of Khurda district. Through these activities farmers were educated on how to use HYV seeds, biological control methods, integrated nutrient management, use of rhizobium culture etc.

Extension activities/Program	Total number of activities	Total number of beneficiaries	Objectives
Information and communication	A quarterly magazine "ChasiraSansar" Monthly handouts		OUAT has a full-fledged Press. So, sometimes farmers are communicated through this print media.
Distance education	1562 farmers enrolled	18826 persons	The beneficiaries had been educated through postal correspondence on latest technologies on rice, vegetables, groundnut, mushroom, bee keeping, fruit crops, dairy, poultry, pisciculture, commercial crops and betelvine.
Video project	22	_____	To disseminate latest farm technology to the rural community.
Agricultural Technology Information centre (ATIC)	_____	1334 farmers 230 extension personnel and NGO officials	To provide single door delivery of technologies, services, information and inputs.
Orissa Gender Resource Centre (OGRC)	3 training-cum-workshop	153 Farm women	Gender sensitization, capacity building and empowerment of farm women
Mobile soil and plant health clinic	5 soil health camps	379 soil samples	Training on collection of representative soil samples, plant nutrient deficiency symptoms and their amelioration and use of soil health card.

Source: Govt. of Odisha

Table 3: Correlation Matrix for Odisha

Odisha	GDPA	Irrigation Ratio	Diversification (Fruits & Veg share in total value of Agri& Allied Activities)	Total Road Density	Per Hectare Extension Expenditure	Per hectare R&E Expenditure	Per hectare R&E and X&T Expenditure
GDPA (2004-05 prices)	1.00						
Irrigation Ratio	0.87***	1.00					
Diversification (Fruits & Veg share in total value of Agri& Allied Activities)	0.59**	0.66**	1.00				
Total Road Density	0.88***	0.60**	0.3064	1.00			
Per Hectare Extension Expenditure	0.34	0.25	-0.09	0.45	1.00		
Per hectare R&E Expenditure	0.81***	0.5032	0.2213	0.89***	0.5512	1.00	
Per hectare R&E and X&T Expenditure	0.76***	0.4782	0.1690	0.86***	0.89***	0,87***	1.00

**** Significant at 1% **significant at 5% * significant at 10 per cent*

Variables are in log form

##Diversification: Value of fruits Vegetables and floriculture as a per cent of total value of Agriculture & Allied Activities

Source: Calculated by Authors

Table 4: Regression results of agriculture growth in Odisha: 2000-01 to 2014-15

VARIABLES	Model 1	Model 2
	GDPA	
Agriculture R&E Intensity (Rs per hectare)	**0.11* (0.05)**	
Aggregate R&E X&T Intensity		**0.20*** (0.04)**
Irrigation (Gross irrigated area % of GCA)	0.49*** (0.06)	0.69*** (0.01)
Diversification (Fruits & Veg share in total value of Agri & Allied Activities)	0.15** (0.05)	
Total Road Density (per 000 sq km)	0.49** (0.18)	
Constant	8.29*** (1.13)	11.3*** (0.31)
Observations	14	14
R-squared	0.98	0.93
Adjusted R squared	0.97	0.91
Durbin-Watson d-statistics	1.65	

**** significant at 1 per cent, ** significant at 5 per cent and * significant at 10 per cent. Figure in parenthesis are robust standard error*

Source: Estimated by Authors

Table 5: Augmented Dickey Fuller test (ADF)-Odisha

	Augmented Dickey Fuller Test	
Variable	**Level (Coefficient)**	**First-Difference (Coefficient)**
Log (GDPA)	-0.21	-1.7***
Log(Agri R&E Intensity)	-0.06	-1.1***
Log (Irrigation Ratio)	-0.38	-1.4***
Log (Diversification)	-1.5***	-1.7***
Log(Road Density)	0.09	-1.5***

*** p< 0.01. ** p< 0.05. * p< 0.1. The null hypothesis is that the series is non-stationary.*

Source: Estimated by Authors

Table 6: Kwiatkowski–Phillips–Schmidt–Shin test (KPSS)-Odisha

	Lag	Test Statistics	Critical Value at 1% level of significance
Level	6	0.262***	0.216
First Difference	3	0.165	0.216

Source: Estimated by Authors

*** p< 0.01. ** p< 0.05. * p< 0.1. The null hypothesis is that the series is stationary*

Table 7: Co-integration Result - ADF on Residuals-Odisha

	Augmented Dickey Fuller Test
Variable	**Level (Coefficient)**
Residuals	-1.00***

Source: Estimated by Authors

Table 8: Correlation Matrix for Bihar

Bihar	GDPA	Irrigation Ratio	Fertiliser Consumption (Kg/Ha)	Agri R&E Intensity (Rs/ha)	Surfaced Road Density	SW Rain	Terms of Trade #	Per hectare R&E and X&T Expenditure
GDPA (2004-05 prices)	1.00							
Irrigation Ratio	0.84***	1.00						
Fertilizer Consumption (Kg/Ha)	0.75***	0.65**	1.00					
Agri R&E Intensity (Rs/ha)	0.85***	0.86***	0.83***	1.00				
Surfaced Road Density	0.68***	0.67**	0.80***	0.80***	1.00			
SW Rain	-0.23	-0.11	-0.16	-0.32	-0.22	1.00		
Terms of Trade#	0.58**	0.43	0.11	0.38	0.23	-0.38	1,00	
Per hectare R&E and X&T Expenditure	0.84***	0.86***	0.78***	0.97***	0.57	-0.32	0.39	1.00

Note: # Terms of Trade is defined as Agriculture Deflator/Industry Deflator

**** Significant at 1% **significant at 5% * significant at 10 percent ## Variables are in log form*

Source: Calculated by Authors

Table 9: Regression results of agriculture growth in Bihar: 2000-01 to 2013-14

Variable	Model 1	Model 2
	GDPA	**GDPA**
Agriculture R&E Intensity (Rs per hectare)	0.29*** (0.05)	
Aggregate R&E X&T Intensity		0.22** (0.08)
Surfaced Road Density		0.11** (0.04)
Terms of Trade (Agriculture Deflator/Industry Deflator)	0.68** (0.23)	0.92** (0.15)
Constant	13.43*** (0.24)	12.85*** (0.31)
Observations	14	14
R-squared	0.81	0.87
Adjusted R squared	0.77	0.83
Durbin-Watson d-statistics	2.62	

**** significant at 1 per cent, ** significant at 5 per cent and * significant at 10 per cent. Figure in parenthesis are robust standard error*

Source: Estimated by Authors

Table 10: Augmented Dickey Fuller test (ADF)-Bihar

	Augmented Dickey Fuller Test	
Variable	**Level (t-stat)**	**First-Difference (t-stat)**
Log(GDPA)	-1.6	-9.1***
Log(Agri R&E Intensity)	0.14	-4.6***
Log(Terms of Trade)	-2.7*	-6.6***

*** p< 0.01. ** p< 0.05. * p< 0.1. The null hypothesis is that the series is non-stationary.*

Source: Estimated by Authors

Table 11: Co-integration Result - ADF on Residuals-Bihar

	Augmented Dickey Fuller Test
Variable	**Level (Coefficient)**
Log(Agri R&E Intensity)	-0.06

*** p< 0.01. ** p< 0.05. * p< 0.1. The null hypothesis is that the series is non-stationary.*

Source: Estimated by Authors

Table 12: Correlation Matrix for Uttar Pradesh

Uttar Pradesh	GDPA	Irrigation Ratio	Total Road Density	Terms of Trade (Agriculture vs Non-agriculture)	Share of Livestock in GVOA	Per Hectare Extension Expenditure	Per hectare R&E Expenditure	Per hectare R&E and X&T Expenditure
GDPA (2004-05 prices)	1.00							
Irrigation Ratio	0.90***	1.00						
Total Road Density	0.95***	0.83***	1.00					
Terms of Trade (Agriculture vs Non-agriculture)	0.94***	0.76***	0.97***	1.00				
Share of Livestock in GVOA	0.85***	0.61**	0.78***	0.86***	1.00			
Per Hectare Extension Expenditure	0.79***	0.82***	0.78***	0.70***	0.44	1.00		
Per hectare R&E Expenditure	0.77***	0.63**	0.87***	0.83***	0.56**	0.77***	1.00	
Per hectare R&E and X&T Expenditure	0.82***	0.75***	0.86***	0.81***	0.52*	0.93***	0.95***	1.00

*Note: ##Agriculture deflator/non-agriculture deflator *** Significant at 1% **Significant at 5% * Significant at 10 per cent*
Variables are in log form All variables in log form

Source: Calculated by Authors

Table 13: Regression results of agriculture growth in Uttar Pradesh: 2000-01 to 2014-15

VARIABLES	Model 1	Model 2	Model 3 (Verma, Gulati and Hussain, 2017)
	GDPA (2004-05 prices)	GDPA (2004-05 prices)	GDPA (2015-16 prices)
Agriculture R&E Intensity (Rs. per hectare)	0.05*** (0.01)		
Agriculture R&E Intensity (Rs. per hectare)		**0.07*** (0.01)	
Irrigation (Gross irrigated area % of GCA)	**1.56*** (0.17)	**1.27*** (0.21)	**1.26*** (3.51)
Livestock Sector (Share of livestock in GVOA)	**0.56*** (0.05)		
Terms of Trade (Agriculture Deflator/Industry Deflator)		**0.61*** (0.07)	**0.81*** (4.20)
Total Road Density (per 000 sq km)			**0.43** (3.11)
Constant	**7.18*** (0.70)	**8.18*** (0.80)	**4.30*** (3.41)
Observations	14	14	14
R-squared	0.98	0.98	0.992
Adjusted R squared	0.97	0.97	0.990
Durbin-Watson d-statistics	1.65		1.64

**** significant at 1 per cent, ** significant at 5 per cent and * significant at 10 per cent. Figure in parenthesis are robust standard error*

Source: Estimated by Authors

Table 14: Augmented Dickey Fuller test (ADF)-Uttar Pradesh (Model 1)

	Augmented Dickey Fuller Test	
Variable	**Level (t-stat)**	**First-Difference (t-stat)**
Log(GDPA)	1.83	-2.95**
Log(Agriculture R&E Intensity)	-0.84	-3.73***
Log(Irrigation)	-2.07	-4.34***
Log(Livestock)	-0.54	-3.11**

*** p< 0.01. ** p< 0.05. * p< 0.1. The null hypothesis is that the series is non-stationary.*

Source: Estimated by Authors

Table 15: Co-integration Result - ADF on Residuals-Uttar Pradesh

	Augmented Dickey Fuller Test
Variable	**Level (Coefficient)**
Residuals	-1.20**

Source: Estimated by Authors

Table 16: Correlation Matrix for Madhya Pradesh

Madhya Pradesh	GDPA	Irrigation Ratio	Procurement	Deflator (Agri vs Industry)	Total Road Density	Per Hectare Extension Expenditure	Per hectare R&E and X&T Expenditure
GDPA	1.00						
Irrigation Ratio	0.96***	1.00					
Procurement	0.76**	0.71**	1.00				
Deflator (Agri vs Industry)	0.68**	0.55**	0.71**	1.00			
Total Road Density	0.91***	0.83***	0.83***	0.88***	1.00		
Per hectare Extension Expenditure	0.79***	0.88***	0.68**	0.52*	0.77**	1.00	
Per hectare R&E and X&T Expenditure	0.79***	0.75***	0.84***	0.76***	0.84***	-0.24	1.00

Note: ##Agriculture deflator/non-agriculture deflator

**** Significant at 1% **Significant at 5% * Significant at 10 per cent ## Variables are in log form*

All variables in log form

Source: Calculated by Authors

Table 17: Regression results of agriculture growth in Madhya Pradesh: 2000-01 to 2014-15

VARIABLES	Model
	GDPA
Agriculture Extension Intensity (Rs per hectare)	**0.36*** (0.11)**
Terms of Trade (Agriculture Deflator/Industry Deflator)	1.17** (0.53)
Constant	14.11*** (0.28)
Observations	14
R-squared	0.73
Adjusted R squared	0.68
Durbin-Watson d-statistics	2.42

**** significant at 1 per cent, ** significant at 5 per cent and * significant at 10 per cent. Figure in parenthesis are robust standard error*

Source: Estimated by Authors

Table 18: Augmented Dickey Fuller test (ADF)-Madhya Pradesh

	Augmented Dickey Fuller Test	
Variable	**Level (Coeff)**	**First-Difference (Coeff)**
Log(GDPA)	-0.19	-1.61***
Log (Agriculture Extension Intensity)	-0.16	-1.66**
Log(Terms of Trade)	0.09	-0.8**

*** p< 0.01. ** p< 0.05. * p< 0.1. The null hypothesis is that the series is non-stationary.*

Source: Estimated by Authors

Table 19: Co-integration Result - ADF on Residuals-Madhya Pradesh

	Augmented Dickey Fuller Test
Variable	**Level (Coefficient)**
Residuals	-1.35***

Source: Estimated by Authors

Table 20: Correlation Matrix for Gujarat

Gujarat	GDPA	Irrigation Ratio	Total Road Density	Terms of Trade (Agriculture Vs Industry)	Cotton Value in GVOA	Per Hectare Extension Expenditure	Per hectare R&E Expenditure	Per hectare R&E and X&T Expenditure
GDPA	1.000							
Irrigation Ratio	0.93***	1.000						
Total Road Density	0.85***	0.79***	1.000					
Terms of Trade (Agriculture Vs Industry)	0.83***	0.87***	0.89***	1.000				
Cotton Value in GVOA	0.88***	0.87***	0.67**	0.79***	1.000			
Per hectare Extension Expenditure	0.10	0.04	0.54	0.37**	-0.03	1.000		
Per hectare R&E Expenditure	0.67***	0.66***	0.92***	0.90***	0.55**	0.65**	1.000	
Per hectare R&E and X&T Expenditure	0.60**	0.58**	0.90***	0.90***	0.47*	0.65**	0.99**	1.00

Source: Estimated by Authors

Regression results of agriculture growth in Gujarat: 2000-01 to 2014-15

VARIABLES	Model
	GDPA
Aggregate R&E and X&T Intensity (Rs. per hectare)	**0.08 (0.10)**
Irrigation Ratio	1.26*** (0 .45)
Cotton Value in GVOA	0.19 (0.10)
Constant	9.48*** (1.26)
Observations	14
R-squared	0.90
Adjusted R squared	0.8

**** significant at 1 per cent, ** significant at 5 per cent and * significant at 10 per cent. Figure in parenthesis are robust standard error*

Source: Estimated by Authors

Table 21: Correlation Matrix for Punjab

Madhya Pradesh	GDPA	Irrigation Ratio	Deflator (Agri vs Industry)	Total Road Density	Real MSP	Per hectare R&E Expenditure	Per hectare Extension Expenditure	Per hectare R&E and X&T Expenditure
GDPA	1.000							
Irrigation Ratio	0.82***	1.00						
Deflator (Agri vs Industry)	0.91***	0.67***	1.00					
Total Road Density	0.95***	0.80***	0.88***	1.00				
Real MSP	0.70***	0.44	0.85***	0.68***	1.00			
Per hectare R&E Expenditure	0.52*	0.52*	0.47*	0.62**	0.44	1.00		
Per hectare Extension Expenditure	0.24	0.28	0.33	0.14	0.25	0.42	1.00	
Per hectare R&E and X&T Expenditure	0.53**	0.82**	0.48**	0.61**	0.46**	0.99***	0.51**	1.00

Source: Estimated by Authors

Regression results of agriculture growth in Punjab: 2000-01 to 2014-15

VARIABLES	Model
	GDPA
Aggregate R&E and X&T Intensity (Rs. per hectare)	**0.01(0.04)**
Irrigation Ratio	5.28**(1.81)
Deflator (Agri vs Industry)	0.31***(0.06)
Constant	-9.32 (8.22)
Observations	14
R-squared	0.91
Adjusted R squared	0.88

**** significant at 1 per cent, ** significant at 5 per cent and * significant at 10 per cent. Figure in parenthesis are robust standard error*

Source: Estimated by Authors

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