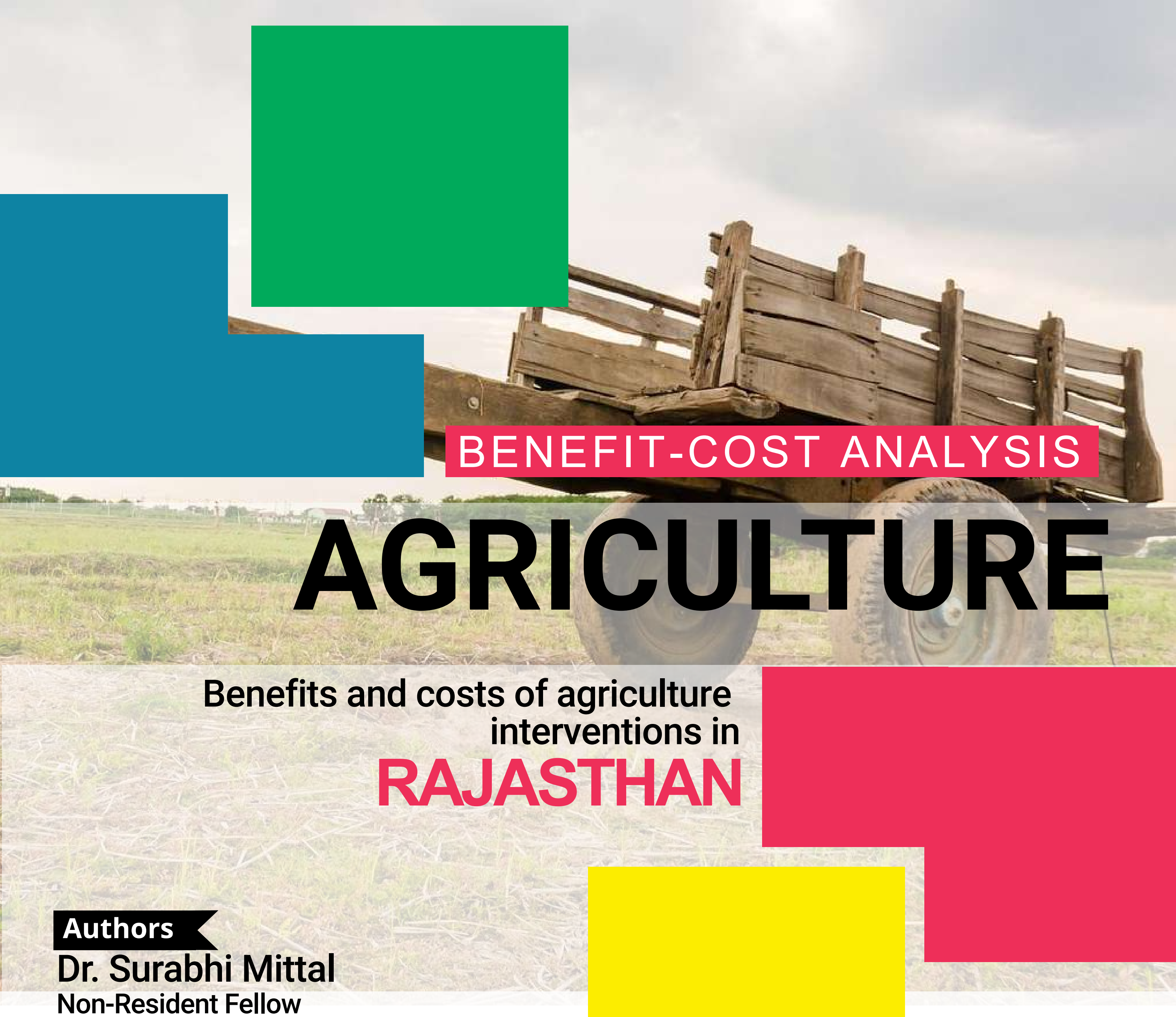

BENEFIT-COST ANALYSIS

AGRICULTURE

Benefits and costs of agriculture interventions in RAJASTHAN

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Cost-benefit analysis of agricultural interventions in Rajasthan

Rajasthan Priorities

An India Consensus Prioritization Project

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Academic Abstract

In the current policy environment, where the government is aiming to double farmer incomes by 2022, it is necessary to review existing agricultural policies, and in particular to evaluate strategies related to productivity enhancement which may provide pathways to improving incomes. To sustain a high growth rate in agriculture it is important to address major risks and challenges that the agriculture sector faces. One of the most important of these is climate change, which acts as a major threat to food production. This is excacerbated by a range of practices, including moncropping, low seed replacement rates, poor use of fertilizer resulting in inadequate soil quality, and limited acces to information and advice. Small and marginal farmers, who make up 80 percent of the total farming sector in India, are particularly vulnerable to these issues. Applying cost benefit analysis, this paper evaluates four agricultural policy inteventions in Rajasthan aimed at addressing the current challenges.

First, there is a need encourage farmers to adopt the oucomes of research on seed technology through certified seed production so that these can contribute to gains for the farmers as seed replacement rates improve. Second, the agriculture sector is still largely based on a system of monocropping and is driven mainly by staples such as rice and wheat. This lack of diversification leads to greater risks of poor yields and crop failure. Given the current threat from climate change, crop diversification would act as a risk mitigating strategy for the farmers. Third, the proper maintenance of soil health is necessary to protect the capacity of the soil to ensure higher crop productivity. The Soil Health Card, incroduced by the Ministry of Agriculture in late 2015, is one way to ensure optimal doses of fertilizers and cropping patterns, in line with scientific recommendations. Fourth, extension services play a crucial role in supporting overall agricultural activities by taking the research, the technology and the know-how to the farmers. Existing agricultural extension services are being improved with the introduction of modern information and communication technologies (ICTs). This supports the better delivery of relevant information to the farmers. The benefit cost ratios (BCRs) of these four interventions are presented in this report with certified seed production and promotion having the highest BCR.

Policy Abstract

The Problem

Improving agricultural productivity across the sectors is important in order to improve farmer incomes. The present Union Government's key agrarian agenda is doubling the income of farmers, and the state government is similarly prioritizing this. Increasing farmer incomes requires farmers to improve yields, have better productivity through the efficient utilization of resources, reduce crop losses and realize fair prices for the outputs.

This paper examines four interventions. First, improving the adoption of certified seed through better seed replacement rates. Second, increasing crop diversification to mitigate the risks from climate change. Third, promoting Soil Health Cards in order to better mange soil health. Fourth, enhancing the reachability of extension system with ICT.

The four interventions are evaluated in context of various issues which the agriculture sector faces. The sector is still largely based on a system of monocropping and is driven mainly by staples such as rice and wheat. This lack of diversification leads to increased risks of poor yields and crop failure. Given the current threat from climate change, crop diversification would act as a risk mitigating strategy for the farmers. Farmers mainly use farm saved seed and, unless these are replaced as regular intervals, the yield potential is not achieved. Better soil health helps reduce the cost of production and improve yields. Extension systems need to work efficiently to ensure that famers benefit from the improvements in agricultural technologies and practices. At present the agricultural extension system is failing to reach many farmers effectively. Hence need exists to widely disseminate and adopt the oucomes of research on seed technology so that they can contribute to gains for the farmers.

Intervention 1: Certified Seed Production and Promotion

Overview

The National Seeds Policy 20021, clearly emphasizes that "It has become evident that to achieve the food production targets of the future, a major effort will be required to enhance the seed replacement rates of various crops. This would require a major increase in the production of quality seeds…" The policy document also shows that there are huge yield gaps and one of the reasons for this is the low seed replacement rate (SRR which is basically a percentage of certified seeds in comparison to farm saved seeds that are sown in total crop area2) in the country. Increasing the adoption of quality seeds can increase the yield potential of crops significantly and thus, is one of the most economic and efficient inputs to agricultural development (Abebe and Amanuel, 2017, Pavithra et.al, 2017).

The need for achieving optimal seed replacement rates should be one of the focus areas, along with creating mechanisms for the distribution and storage of appropriate seed varieties (Planning Commission, 2011). A strong back up seed multiplication and distribution system is needed in order to increase the adoption and diffusion of improved varieties as a way to enhance agricultural production and productivity. The provision of greater quantities of improved seeds to farmers through efficient seed systems is a constant challenge, involving substantial resources and a range of actors. There is the continuous need to strengthen the public extension system, increasing the emphasis on information dissemination and field demonstration, as well as farmers' participatory research and training programs, to achieve higher rates of adoption (Ghimire 2015).

Implementation Considerations

Improved crop productivity is an important strategy to increase farmer incomes GoR (2017). Seed is one of the crucial inputs that help to improve productivity. The seed replacement rates and varietal replacement are low for most of the crops in the state of Rajasthan3. Government targets include improving the seed replacement rate in the state by increasing

[1] http://seednet.gov.in/PDFFILES/National%20Seed%20Policy,%202002.pdf
[2] http://agritech.tnau.ac.in/seed/seedconcepts.html#seed_replacement_rate
[3] http://niti.gov.in/writereaddata/files/Rajasthan_Presentation_0.pdf

seed production and by ensuring that the seed is available to the farmers. To enable this, the Rajasthan State Seeds Corporation has geared up to enhance the processing, storage and marketing capacity for the next five years.

In this intervention we compute the benefit cost ratio of achieving a desirable seed replacement rate, which is higher than the present rate. This costs of producing and marketing more seed are taken as the main costs in this intervention. The major benefits that come from the adoption of better seed varieties are improved crop productivity and thus improved farmer incomes. The intervention is built up over a three-year period time frame.

Costs and Benefits

Costs

The costs include two components. First is the cost of production of the additional seed required to achieve the higher SRR. This computation is done for all the major crops in Rajasthan - Wheat, Mustard, paddy, Maize, Jowar, bajra, ragi, guar, barley, arhar/tur, black gram, green gram, red gram, moth, groundnut, soyabean, sesamum, castor and cotton.

The seed rate and existing SRR for each of these crops is used to compute the amount of additional seed required to achieve the improved SRR. Given the seed production cost, which is proxied by seed prices4, we calculate the cost of the intervention to achieve the higher level of SRR.

We assume that a higher SRR is achieved over a three year period through this intervention, by expanding extension, demonstration and field days, so that more farmers can adopt the modern seed varieties. Thus, the second cost component of this intervention is the cost of promotion to incease the adoption of the improved seed. This is primarily the additional extension cost that is required for the increase in land under cultivation under modern varieties. This cost is Rs 186 per hectare (Birthal et.al, 2015) for knowledge transfer resulting in enhanced adoption.

[4] http://www.fao.org/docrep/V4450E/V4450E07.htm#Pricing%20policy

Benefits

The benefit from this intervention is mainly the increased yields because of the use of certified seed. The higher yields lead to increased production and thus higher incomes. The income gain to farmers is the total benefit. Yield gains of 10% are assumed in the study. This assumption is based on a review of yield gains from several studies (GoAP, 2015; Singh and Singh, 2016; Abebe, 2017; Clayton 2009). These studies estimate a yield gain in the range of 15-20 percent because of varietal improvement and seed replacement. In this study we have only accounted for the seed replacement rate, so the estimate of a 10% yield increase resulting from the intervention is conservative.

Intervention 2: Crop Diversification

Overview

Diversification in general is defined as moving from monocropping to multiple cropping or moving away from traditional cropping systems to high value crops. Changing cropping pattern of farmers is largely a function of market prices. Farmers also aim to diversify crops to reduce risks and have higher value outputs. In this way, they are also trying to diversify their income base (Mittal and Hariharan, 2016).

Since the 1990s, the Indian economy has witnessed a shift in consumption patterns from traditional cereals to a more holistic and nutritious diet of fruit and vegetables, milk, fish, meat and poultry products. This is due to the rapid growth of the economy, with rising incomes creating increased demand for diversified diets. Hence, agricultural diversification towards high-value crops has been instituted within Indian agriculture. (Kumar, 1998; Mittal 2006; Kumar and Gupta 2015; Kumar and Mittal, 2003, Mittal and Hariharan, 2016).

Crop diversification provides a common solution for income and resource sustainability, especially relevant in the present time when climate variability adds to the risk of crop failure. This is because there is a growing consensus among agricultural scientists that crop diversification leads to sustainable productivity growth by increasing cropping intensity (Bobojonov et al., 2012), by reducing risks of pests and diseases that may attack in the mono-cropping systems (Lin, 2011) and minimizing the risk of crop failure (Pandey et al., 2007).

Crop diversification is one strategy that small farmers can apply to reduce their vulnerability to the increasing challenge of climate change (McCord, 2015).

Implementation Considerations

Crop diversification is an important strategy to improve farmer incomes. The Rajasthan government also proposes crop diversification as a part of their strategy to double farmer incomes by 2022 (GoR, 2017, Swain, 2012; GoR, 2013). The government has been promoting crop diversification through continuous awareness programs and by ensuring the availability of inputs and technical know-how to support diversification. In this intervention we analyze the benefits of crop diversification as the increase in income as well as some modest water savings. The costs are the higher cost of production due to the increase in farmed land area under a crop, requiring greater input costs, and continued promotion costs via extension.

Costs and Benefits

Crop diversification interventions account for changing cropping patterns, both in terms of a shift in area between crops and increased crop intensification. The intervention takes into account the complete agricultural cropping pattern of Rajasthan- cereals, coarse cereals, pulses, fruits, vegetables, pulses, oilseeds and cotton.

Given the long history of crop diversification efforts in the past, it is assumed that further extension activities will accelerate the trend of crop diversification efforts by 10% which are changing towards higher value crops like fruits, vegetables and oilseeds, while no extension will leave current cropping patterns and intensity at current levels. In the context of Rajasthan, water constraints mean that the area under cotton is declining.

The calculations for the costs are based on the change in area, and the percentage annual change in area between 2011-17. Yields are assumed to remain the same. The primary driver of cost is the expansion in effective cropping area, brought about increased cropping intensity. The benefit-cost ratio therefore estimates the efficiency of increasing production at the extensive margin.

It is estimated that in one year, the area under production for the state would increase by 5.8% from 17.6m ha to 18.6m ha. The total cost of production in this time would increase by 3,827 crore, or an increase of 6.1%. Note this is the weighted average of thirty major crops grown in Rajasthan.

The second component of the cost is the cost of extension services. Continuous extension activities have to be undertaken to improve awareness among farmers for crop diversification towards crops that help to increase their incomes and reduce risk. To compute this cost, we considered the per hectare cost of extension as Rs. 186, as per the Birthal et.al 2015 study. This amounts to Rs 451 crore per year for the entire state of Rajasthan.

Benefits

With the change in areas under different crops, there is also a change in production. The total change in value of agricultural produce at the wholesale prices of individual crops is used to compute the net benefit to the state resulting from crop diversification. The benefit is 4,308 crore or a 7.0% increase in income.

The second benefit is environmental gains because of diversifying away from high water consuming crops. For this study analysis of cotton and soybean is taken as these are the most water consuming crops5 (high water footprint). Thus, net water saving because of crop diversification is calculated as an environmental benefit. The value of water savings is taken as Rs 8 per m3 i.e. Rs. 8 per 1000L (Water experts Copenhagen Consensus) and the total benefits are 76 crore.

Intervention 3: Soil Health Card

Overview

In India, the current consumption of NPK (nitrogen, phosphorus, potassium) as a ratio is 6.7:2.4:1, which is highly skewed towards nitrogen, as against the ideal ratio of 4:2:1 (Reddy, 2017). There is recognition that a better balanced use of fertilizers is needed, and to support

[5] http://claroenergy.in/5-most-water-intensive-crops/

this the Government of India introduced the Soil Health Card Scheme across India (GoI, 2017, Yadav et at., 1998). The proper maintenance of the soil health, which is necessary from an agricultural point of view, refers to the capacity of the soil to ensure higher crop productivity. On 5th December 2015 the Ministry of Agriculture introduced the Soil Health Card (SHC) scheme. Using optimal doses of fertilizers and cropping patterns, in line with scientific recommendations, is the first step towards sustainable farming.

Considerations

Soil testing is a useful tool to determine the adequacy of a plant nutrient and the quantity of fertilizer required to obtain profitable crop yields. The Soil Health Card (SHC) scheme[6] was launched in February 2015 and it is a complete evaluation of the quality of soil. It contains corrective measures that a farmer should adopt to obtain a better yield. Since its launch in India, three states have led in the distribution of the Soil Health Cards to farmers - Andhra Pradesh followed by Punjab and Tamil Nadu. The intervention[7] proposes to develop modalities for soil sample collection along with standard sampling norms, quality control in the soil analysis, training of sampling staff and lab personnel, intensive use of ICT for database management for faster delivery of Soil Health Cards in PPP mode and popularizing soil testing based integrated nutrient management practices through field demonstrations/field days.

Overall the Soil Health Card scheme has been found to be beneficial to the farmers in terms of increasing their income. However, there is a need to generate awareness about the benefits of this scheme among the farmers, along side strengthening the soil testing services / laboratories for a wider adoption of Recommended Doses of Fertilizers (RDF). The constraints reported by the farmers in the adoption of recommendations included high cost, difficulty in adoption, low credibility of soil testing report, and a long distance to the laboratory.

[6] http://soilhealth.dac.gov.in/
[7] http://www.nmsa.dac.gov.in/pdfDoc/SHM_Guidelines472016.pdf

Costs and Benefits

Costs

The cost estimates used for the interventions are based on the guidelines on SHC provided by the government 8. This includes, the cost of the Soil Health Card (Rs 190 per sample), training for soil analysts, financial assistance for the package of nutrient recommendations, capacity building of farmers and experts, regular monitoring and evaluation costs, and the cost of managing the mission. This is built up over the three years. For Rajasthan there are a total of 59 soil testing labs (government and private) as per the MANAGE study (Reddy, 2017). The total number of soil samples considered for the cost analysis are as per the targets of cycle 2 for Rajasthan, which is 11.54 lakhs. This target is repeated every year and it accounts for 46 percent of households in the state, per year. The largest cost is for micronutrients.

Benefits

The Rajasthan government's plan of action includes covering at least one third of the state every year 9. Reddy (2017) states that about 66% of the farmers can understand the content of the SHC, about 57% of the farmers find the recommendations suitable for their farms and about 53% are able to follow the recommendations. Thus, the study assumes that even if the households get the SHC the utilization is going to be low. The benefits of using soil health cards are usually experienced in the third year.

Further, the main benefit from the adoption of SHC is the reduced cost of fertilizer and manure because of improved efficiency, where improved soil health leads to yield gains. Makadia and Kuthe (2017) estimated a reduction in the cost of fertilizer use by 6.8% and an increase in income because of yield gains of 2.2 percent in Gujarat for selected crops. An impact study by Reddy 2017, indicated that there is a reduction in Nitrogen based fertilizers and increase in bio-fertilizer and micro-nutrients use.

[8] http://www.nmsa.dac.gov.in/pdfDoc/SHM_Guidelines472016.pdf
[9] State agricultural policy draft- http://www.cuts-international.org/cart/ProOrganic/pdf/Useful_Information-Draft_Agriculture_Policy_Rajasthan.pdf

In response to a parliamentary query10, it was said that, following a study conducted by the National Productivity Council (NPC), the application of fertilizer and micro-nutrients based on Soil Health Card recommendations resulted in savings of 8-10% of fertilizer. There is an overall increase in the yield of crops to the tune of 5-6% from adopting SHC recommendations. In this study, we based the calculations on an average of 8 percent as the fertilizer saving and 5 percent as the yield gains across all the crops.

Intervention 4: Improving/ expanding extension services via ICT

Overview

In all the above interventions we have used extension services as a critical component to improving yields, incomes, the adoption of technologies like certified seed or machinery, and improving soil health. The extension services in India had primarily been the responsibility of the public sector. The government has a huge R&D infrastructure in the form of institutions such as the Indian Council of Agricultural Research (ICAR), state agricultural universities (SAUs) and Krishi Vigyan Kendras (KVKs). Public sector extension services are usually criticized for their ineffective targeting, poor reach and the huge administrative cost of delivering information (Mittal, 2012). It is important to strengthen the agricultural extension system for increasing productivity, profitability, sustainability and incomes for the farmers. The Indian extension system has undergone reforms since the late 1990s and experienced major conceptual, structural, and institutional change (Raabe, 2008). These changes were undertaken to improve the efficiency, effectiveness and timeliness of services. These reforms included the forging of public private partnership to provide extension services and strengthening the linkages between researchers in laboratories and farmers in the field.

ICT-based extension services provide an opportunity to strengthen these linkages. In India, some of the very initial models using modern techniques were the kisan call centers and village knowledge centers that were based on landlines and internet-based computer centers in villages. These were initiated mainly by the government or NGOs. Projects like the Agricultural Technology Management Agency (ATMA), e-sagu and e-choupal gave the initial

[10] http://loksabha.nic.in/Members/QResult16.aspx?qref=58523

thrust. During the past few years, with the increase in mobile penetration even in rural areas, there has been an evolution of ICT-based extension services models to disseminate agriculture related information. The overall goal of using the mobile phone-enabled information delivery mechanism is to have inclusive growth by reducing the knowledge gap between large and small farmers and by creating awareness. At the national level the m-Kisan SMS Portal[11] was inaugurated by the President of India on July 16, 2013. Farmers who registered on this Portal could access advisory services. This intervention aims at reaching the farmers on mobile phone in the form of SMS and IVR services.

In the calculation of the BCR for this intervention, we have built up the model to assess what would be the cost of reaching all farmers who have access to mobile phones over a period of 5 years with advisory services and what is the potential benefit of utilizing these services.

Implementation Considerations

ICT has the potential to transform the traditional agricultural extension system, because of its wide reach and low cost of delivering information. Despite this, there are certain constraints on the use of mobile phones.

The key challenge that the service providers face is to develop content according to farmers. needs and to market that service to the farmer efficiently (Mittal, 2012; Glendenning and Ficarelli, 2012). Mittal et al., (2010) states that mobile and internet-based information delivery models have to be complementary to conventional extension services. Mobile phone-based initiatives alone cannot play the role of extension agents. To leverage the full potential of information dissemination enabled by mobile telephony, along with supporting infrastructure and capacity building amongst farmers, it is essential to ensure the quality of information, its timeliness and its trustworthiness (Mittal, 2012; Glendenning and Ficarelli, 2012; Mittal and Mehar, 2013; Aker et al, 2016).

For implementation of this intervention it is important for farmers to have access to mobile phones and to have registered with the program with specific information about their

[11] https://mkisan.gov.in/Default.aspx

cropping patterns, location and farm size. The information utilization is another important aspect of the intervention. Farmers might get the information, but they also need to put it into action to realize the benefits.

Costs and Benefits

Costs

The costs are calculated for the number of agricultural households that are going to receive the services. The total number of agricultural households is obtained from the Situation Assessment Survey of Agricultural Households NSSO, (2005). This is then adjusted downwards by the number of households who have access to mobile phone. Yamano et. al 2017 estimated that 85% of rural households have access to mobile phones12.

In the costs we have three components. 1) cost of delivering agricultural advisories through SMS 2) Cost of IVRS (Integrated Voice Recording Service) 3) Other costs of operations. Since agriculture is an activity throughout the year, the assumption of 200 SMS per year at the rate of Rs. 1 per SMS is added as a cost.

Based on estimates of running the mobile phone based advisory service, the operational cost is taken as $0.83 per household per month. The cost of running an IVR service is included in the operational costs. This is based on the Cole and Fernando 2014 study of a randomized trial in Gujarat. These costs are repeated every year over a period of 5 years.

Benefits

The main benefit of improved extension services is increased farmer incomes. Maini and Rathore (2011) estimated an income increase of 10-15 percent and a reduced cost of production of 2-5 percent from the use of ICT based information. Birthal et. al 2015 estimated the income increase due to information as 12%, though this was for all types of information, not just those delivered by ICT.

[12] https://updateox.com/india/state-wise-mobile-phone-users-in-india-census-2011/ Gives the census 2011 mobile users. But with the increasing growth of mobile users per year as reported in http://www.indiatechonline.com/it-happened-in-india.php?id=545 we have assumed that 85% of households have access to mobile phone.

Manjappa and Yeledalli (2013) showed that the weather based agro advisories have an impact on economic gains in the range of 4.8 to 16.7 percent for various crops. In another study, Cole and Fernando (2014) estimated that households that had access to ICT based advisories have 16 percent higher profits than the control group.

We have used the benefit estimates from the Cole and Fernando (2014) study to assess the difference between the baseline and the post-intervention income. The average of small and marginal farmers is taken as the base income figure and income of large farmers have been kept out to remove any bias.

The evaluation of ICT programs, (Palmer 2014, GSMA 2015) show that only 10 percent of the households are registered users of the services in the present government program scenario. These numbers are not available at the state level. Of these, only 25 percent of households are repeat users of services. Given such poor utilization of mobile based advisory services, we have built up the intervention over the 5 year period with users at 20 percent in year 1, 40 percent in year 2, and up to 60 percent by year 5.

BCR Table

Summary Table

Intervention	Benefit (in crore Rs)	Cost (in crore Rs)	BCR	Quality of Evidence
Certified seed production and promotion	11,586	584	20	Strong
Crop diversification	4,176	4,074	1.0	Medium
Soil health card	2,601	2,406	1.1	Limited
Improving / expanding extension services via ICT	6,862	1,899	4	Strong

Notes: All figures assume a 5% discount rate

1. Introduction

The state of Rajasthan is endowed with diverse soil and weather conditions comprising of several agro-climatic environments. About 65 per cent population of the state is dependent on agriculture and allied activities for their livelihood (Swain 2012). It is noted by researchers that there exists a large variation in food grain production across states, and very high risks are involved in food grain production in the state of Rajasthan (Chand and Raju, 2009). Reducing instability in agricultural production has been a major policy concern for several years. With the objective of doubling of farmer incomes, the Government of Rajasthan is focusing on increasing the seed replacement rate, enhancing crop productivity through improved soil health, crop diversification towards high value commodities, and strengthening the extension system, along with improved livestock-based systems. Four key agricultural interventions are studied in this report using cost benefit analysis.

2. Data

The data on area, yield and production of major crops in Rajasthan is collected from the directorate of economics and statistics (DES) publication, Government of India. The data on prices of crops is from the publication "agricultural prices in India, DES, GoI. The cost of production data is taken from the Cost of Cultivation Statistics published by CACP, DES, GoI. Seed replacement rate data is obtained from the national seed policy document. Information on Soil Health Cards is obtained from the soil health card portal

3. Certified Seed Production and Promotion

3.1 Description of intervention

Increasing crop productivity is an important strategy to raise farmer incomes GoR (2017). Seed is one of the crucial inputs that lead to increase in productivity. The seed replacement rates and varietal replacement are low for most of the crops in the state of Rajasthan13. Government targets to improve the seed replacement rate in the state by increasing seed

[13] http://niti.gov.in/writereaddata/files/Rajasthan_Presentation_0.pdf

production and by ensuring that the seed is available to the farmers. To enable this, the Rajasthan State Seeds Corporation has geared up to enhance the processing, storage and marketing capacity for next five years.

For this intervention, we compute the benefit cost ratio of achieving a desirable seed replacement rate which is higher than the present rate. The costs of producing and marketing more seed are taken as the main costs in the intervention. The major benefits that come from the adoption of better seed varieties is in terms of improved crop productivity and thus improved farmer incomes. The intervention takes place over a three-year time frame.

3.2 Literature Review

The National Seeds Policy 200214, clearly emphasizes that "It has become evident that to achieve the food production targets of the future, a major effort will be required to enhance the seed replacement rates of various crops. This would require a major increase in the production of quality seeds…" The policy document also shows that there are huge yield gaps between the states of India and also between India and rest of the world. One of the reasons for this high yield gap is the low seed replacement rate (SRR which is basically a percentage of certified seeds in comparison to farm saved seeds that are sown in total crop area15) in the country.

Quality seed is the most basic input for sustainable modern food crop production and its potential benefits are widely acknowledged. (Katungi et.al, 2011). Farmers need more crop seed varieties to improve their crop yields. In the present context, this also builds resilience to climate change (Singh and Singh, 2016; Kumara 2014). Increasing the adoption of quality seeds can increase the yield potential of the crop significantly. It is therefore one of the most economic and efficient inputs to agricultural development (Abebe and Amanuel, 2017, Pavithra et.al, 2017).

[14] http://seednet.gov.in/PDFFILES/National%20Seed%20Policy,%202002.pdf
[15] http://agritech.tnau.ac.in/seed/seedconcepts.html#seed_replacement_rate

It is empirically shown (Singh, 2013; Natrajan, Jacob, & Mandal, 2009) that with a small increase in seed expenses from adopting modern varieties, the yield enhancement could be increased significantly. Studies have shown substantial net economic surplus from investment in seed multiplication as an economic activity (Tripp 2000, Furtas 201, Rao et.al 2003,)

It is estimated that the direct contribution of quality seed alone to the total production is about 15-20 percent, depending upon the crop. This can be further raised up to 40-50 percent with effective management and using other inputs. However, the yield potential cannot be realized if due care is not taken regarding varietal and physical purity, seed health and vigor.

An extremely low seed replacement rate (SRR) remains one of the hindrances to introducing high yielding varieties. In India, in general farm saved seed (FSS) is the most prominent source of seed for staple crops. More than 70 percent seed usage, particularly for food crops, is through FSS resulting in very low SRRs. SRR has a strong positive correlation with the productivity and production of crops. This needs a change in order to improve productivity. This trend continues despite the introduction of a good variety of seeds in the country (Pattanaik, 2013, Clayton, 2009).

The need for achieving optimal seed replacement rates should be one of the focus areas along with creating mechanisms for the distribution and storage of appropriate seed varieties (Planning Commission, 2011).

The availability of certified seed is a big bottleneck to the adoption of improved seeds. The Planning Commission, Government of India in its mid-term appraisal of the 10th Five Year Plan (2002-07) has concluded that, with respect to seed, despite the public and private sector institutional framework for seed production, availability of good quality seeds continues to be a problem for farmers (National Seed Plan, 2002). To increase the adoption and diffusion of improved varieties to enhance production and productivity, a strong back-up of a seed multiplication and distribution system is needed. Abebe and Amanuel (2017) mention that when there are different seed sources available and farmers can access them, there is high probability of adoption of improved varieties. Enhanced seed availability though formal or informal or both sources will improve smallholder farmer's access to seeds and improve variety adoption. Seed information is transmitted through informal channels in addition to the government extension system (Joshi et. al., 2007 and Yadav et. al., 2010).

The provision of increasing quantities of improved seeds to farmers through efficient seed systems is a constant challenge, involving substantial resources and a range of actors. Pal and Tripp (1998) examined the flow of information about seed markets to farmers and found that inspite of the constraints there is a significant transfer of information through different means. In particular, direct farmer-to-farmer interactions gradually raise awareness about the availability and benefits of modern seed varieties. They do emphasize that lack of appropriate mechanisms for diffusing such information may mean that much of the investment in public agricultural research is not able to achieve its desired impact. Emerick et al (2016) show that farmer field days lead to 40% adoption of a new seed variety after one year. Thus, there is continuous need to strengthen the public extension system, increased emphasis on information dissemination, field demonstration, and farmers' participatory research and training programs to achieve higher adoption (Ghimire 2015).

3.3 Calculation of Costs and Benefits

3.3.1 Costs

Costs include two components. First is the cost of production of the additional seeds required to achieve the higher SRR. This computation is done for all the major crops in Rajasthan - Wheat, Mustard, paddy, Maize, Jowar, bajra, ragi, guar, barley, arhar/ tur, black gram, green gram, red gram, moth, groundnut, soyabean, sesamum, castor and cotton.

Seed rate and existing SRR for each of these crops is used to compute the amount of additional seed requirement to achieve the improved SRR. Given the seed production cost, which is proxied by seed prices16, we get the cost of the intervention to achieve the higher level of SRR.

Following the current trend of the seed rolling plan of Rajasthan, 2017-21, the desirable SRR is: 33% for self-pollinated crops with replacement every 3 years; 50% for cross pollinated crops with replacement in every 2 years; and 100% for hybrids with annual replacement17. As for the intervention, we assume that a higher SRR can be achieved in the next three years by improving the reach of extension programmes, demonstration and field days, resulting in a large number of farmers adopting the modern varieties. The higher SRR is based on evidence from literature that the availability of extension services significantly increases the adoption of modern varieties among farming households (Kaliba et.al, 2000, Ghimire 2015, Mignouna et al, 2011). Kaliba et.al, 2000 study shows that increases in the intensity of extension service increased the average proportion of land allocated to improved varieties by 66 percent. Similarly, Mignouna et al (2011) also emphasized that strengthening extension services can increase adoption of modern varieties by 44 percent.

Thus, the second cost component of this intervention is the cost of promotion to improve the adoption of the more modern seed varieties. This is primarily the additional extension cost that is required for the increase in land under cultivation with modern varieties. This cost is taken as Rs 186 per hectare (Birthal et.al, 2015), as the cost of knowledge transfer for enhancing adoption. Cost breakdown by seed and promotion costs for important crops in Rajasthan are presented in Table 1 below.

[16] http://www.fao.org/docrep/V4450E/V4450E07.htm#Pricing%20policy
[17] http://documents.gov.in/RJ/9717.pdf

Table 1 – Cost breakdown of seed production and promotion by crop type

Type of Crop	Current seed replacement rate (%)	Seed replacement rate from intensified extension (%)	Cost per kg of seed (Rs / kg)	Total costs new seed per year (Rs crore)	Total costs of promotion per year (crore)
Paddy Variety	33	50	33	3	1
Maize Variety	50	80	117	62	5
Jowar Variety	75	80	46	1	1
Jowar Hybrid	50	100	46	1	1
Bajra Variety	50	80	61	11	8
Black gram / Urad	50	80	61	11	2
Green gram / Moong	33	50	90	42	4
Moth	33	50	50	14	3
Groundnut	33	50	69	90	2
Soyabean	33	50	64	104	4
Sesame	50	80	158	5	2
Wheat	33	50	23	119	10
Barley	33	50	20	9	1
Red gram	33	50	32	39	3
R&M	50	80	140	43	14

3.3.2 Benefits

The benefits in this intervention are increased yields from the use of certified seed. The higher yields lead to increased production and thus better incomes. The income gain to farmers is the total benefit. A yield gain of 10% is assumed in the study. This assumption is based on a review of yield gains from several studies (GoAP, 2015; Singh and Singh, 2016; Abebe, 2017; Clayton 2009). These studies estimate a yield gain in the range of 15-20 percent because of varietal improvement and seed replacement. In this study we have only accounted for the seed replacement rate, so the estimate of a 10% yield increase resulting from the intervention is conservative. Benefits by crop type are presented in Table 2.

Table 2 – Annual benefits from increased use of certified seed

Type of Crop	State wide Increase in production from increased use of certified seeds (tonnes)	Price (Rs / tonne)	Increase in income per year (Rs. Crore)
Paddy Variety	69149	20346	141
Maize variety	384218	13839	532
Jowar Variety	18935	17167	33
Jowar Hybrid	18000	17167	31
Bajra Variety	431690	12719	549
Black gram/ urad	37815	40352	153
Green gram/ moong	111611	88270	985
Moth	55705	55484	309
Groundnut	196110	38597	757
Soyabean	186768	31476	588
Sesame	38052	97307	370
Wheat	1845875	16047	2962
Barley	143313	13021	187
Red gram	157144	44261	696
R&M	1075136	36037	3875

3.4 Assessment of Quality of Evidence

There is wide consensus that use of certified seeds is a key input into improving crop production. There is also literature that examines how use of extension services improves SRR at scale which are generally consistent with each other. Thus, the estimation is valued as strong.

4. Crop Diversification

4.1 Description of intervention

Crop diversification is important strategy to improve farmer incomes. The Rajasthan government also proposes crop diversification as a part of the strategy to double farmer incomes by 2022 (GoR, 2017, Swain, 2012; GoR, 2013). The government has been promoting crop diversification through continuous awareness programs and by ensuring availability of inputs and technical know-how to diversify. For this intervention we analyze the benefit of crop diversification as the increase in farmer incomes, and the costs as the increase in the costs of production, arising from larger area of farmland under a crop which raises the input costs.

4.2 Literature Review

Diversification in general is defined as moving from monocropping to multiple cropping or moving away from traditional cropping systems to high value crops. Changing cropping pattern of farmers is largely a function of market prices. Farmers also aim to diversify crops to reduce risks and have higher value outputs. In this way, they are also trying to diversify their income base (Mittal and Hariharan, 2016).

Since the 1990s, Indian agriculture has experienced a notable change from staple crops to commercial crops, like plantation and horticultural crops (Saha 2013). The economy has also witnessed a shift in consumption pattern from traditional cereals to a more holistic and nutritious diet of fruit and vegetables, milk, fish, meat and poultry products, due to rapid growth of the economy. Hence, agricultural diversification towards high-value crops has been instituted within Indian agriculture. (Kumar, 1998; Mittal 2006; Kumar and Gupta 2015; Kumar and Mittal, 2003, Mittal and Hariharan, 2016).

Crop diversification provides a common solution for income and resource sustainability, especially relevant in the present time when climate variability adds to the risk of crop failure. There is a growing consensus among agricultural scientists that crop diversification leads to sustainable productivity growth by increasing cropping intensity (Bobojonov et al., 2012), by reducing risk of pests and diseases that may attack in monocropping systems (Lin, 2011) and by minimizing the risk of crop failure (Pandey et al., 2007). Crop diversification is one strategy that small farmers can apply to reduce their vulnerability to the increasing challenge of climate change (McCord, 2015). Satyasai and Premi (2015) have shown that better off districts in India have higher level of diversification than states, which are resource poor.

Conventionally, diversification is seen as move away from cereal crops to high value crops like fruits and vegetables. But, along with the higher prices they fetch, these crops are prone to higher risks (Kumar et al., 2012, Jain 2005). Thus, cereal based crop diversification is also crucial for sustainable productivity growth as well as helping with adaptation to climate risks (Singh and Kumar 2016). In India, and in particular in the North-Western parts of the country, the traditional rice-wheat cropping system which is very water intensive, is becoming unstable due to climate change and the resulting degradation of natural resources.

Diversification towards water efficient or water saving crops can reduce pressure on the aquifer.
Thus, there is a need to modify the on-going farm practices to better adapt agriculture to climate change (Smit and Skinner, 2002). Government of India's trend towards allocation of funds for crop diversification in the North-Western India, where natural resources like water are used in excess for rice wheat cropping system, is a policy move in this direction of sustainability.

4.3 Calculation of Costs and Benefits

4.3.1 Costs

Crop diversification interventions account for changing cropping patterns, both in terms of a shift in area between crops and increased crop intensification. The intervention takes into account the complete agricultural cropping pattern of Rajasthan- cereals, coarse cereals, pulses, fruits, vegetables, pulses, oilseeds and cotton.

Given the long history of crop diversification efforts in the past, it is assumed that further extension activities will accelerate the trend of crop diversification efforts by 10% which are changing towards higher value crops like fruits, vegetables and oilseeds, while no extension will leave current cropping patterns and intensity at current levels. In the context of Rajasthan, water constraints mean that the area under cotton is declining.

The calculations for the costs are based on the change in area, and the percentage annual change in area between 2011-17. Yields are assumed to remain the same. The primary driver of cost is the expansion in effective cropping area, brought about increased cropping intensity. The benefit-cost ratio therefore estimates the efficiency of increasing production at the extensive margin.

It is estimated that in one year, the area under production for the state would increase by 5.8% from 17.6m ha to 18.6m ha. The total cost of production in this time would increase by 3,827 crore, or an increase of 6.1%. Note this is the weighted average of thirty major crops grown in Rajasthan.

The second component of the cost is the cost of extension services. Continuous extension activities have to be undertaken to improve awareness among farmers for crop diversification towards crops that help to increase their incomes and reduce risk. To compute this cost, we considered the per hectare cost of extension as Rs. 186, as per the Birthal et.al 2015 study. This amounts to Rs 451 crore per year for the entire state of Rajasthan.

4.3.2 Benefits

With the change in areas under different crops, there is also a change in production. The total change in value of agricultural produce at the wholesale prices of individual crops is used to compute the net benefit to the state resulting from crop diversification. The benefit is 4,176 crore (5% discount) or a 7% increase in income.

The second benefit is environmental gains because of diversifying away from high water consuming crops. For this study analysis of cotton and soybean is taken as these are the most water consuming crops18 (high water footprint). Thus, net water saving because of crop diversification is calculated as an environmental benefit. The value of water savings is taken as Rs 8 per m3 i.e. Rs. 8 per 1000L (Water experts Copenhagen Consensus) and the total benefits are 76 crore.

4.4 Assessment of Quality of Evidence

The study uses historical data on area changes which are predominantly driven by crop diversification and intensification efforts and market forces. However, using historical

[18] http://claroenergy.in/5-most-water-intensive-crops/

changes as the basis for future promotion efforts is reasonable, we cannot be certain that the past accurately predicts the future. Therefore, the evidence is assessed as medium.

5. Soil Health Card

5.1 Description of intervention

Soil testing is a useful tool to determine the adequacy of a plant nutrient and the quantity of fertilizer required to obtain profitable crop yields. The Soil Health Card (SHC) scheme19 was launched in February 2015 by Government of India which provides a complete evaluation of the quality of soil and contains corrective measures that a farmer should adopt to obtain a better yield. Since its launch in India, three states have led in the distribution of the Soil Health Cards to farmers - Andhra Pradesh followed by Punjab and Tamil Nadu. The interventions20 proposes to develop modalities for soil sample collection along with standard sampling norms, quality control in the soil analysis, training of sampling staff and lab personnel, intensive use of ICT for database management for faster delivery of soil health cards in PPP mode and popularizing soil testing based integrated nutrient management practices through field demonstrations/field days.

5.2 Literature Review

In India, the current consumption of NPK (nitrogen, phosphorus, potassium) as a ratio is 6.7:2.4:1, which is highly skewed towards nitrogen, as against the ideal ratio of 4:2:1 (Reddy, 2017). There is a need for balanced use of fertilizers, both from the view of efficient use of input to reduce cost of production and for improved soil health (Hegde and Sudhakarbabu, 2004). The Soil Health Card Scheme is a step in this direction. On 5th December 2015 the Ministry of Agriculture introduced the soil health card (SHC) scheme. Using optimal doses of fertilizers and cropping pattern as per the scientific recommendation is the first step towards sustainable farming.

[19] http://soilhealth.dac.gov.in/
[20] http://www.nmsa.dac.gov.in/pdfDoc/SHM_Guidelines472016.pdf

Though there are a number of studies on the ill effects of poor soil quality across the different states of India, they mostly focus on micro situations. There are no all India studies on the impact of improved soil health. Of late, some studies have assessed the impact of soil health management programmes in Karnataka, Andhra Pradesh, Bihar, Gujarat, Madhya Pradesh (Reddy, 2017, Wani, 2013, 2016; Chander et al 2013).

In the India states of Madhya Pradesh and Rajasthan, the soil analyses of farmers' fields revealed widespread deficiencies of nutrients. The Chander et al., 2013 study shows that the soil test-based addition of deficient nutrient fertilizers led to increased crop yields by 6–40% and decreased the use of chemical fertilizers by up to 50%. Similarly, Wani et.al 2016, showed that, through participatory action research on soil test-based fertilizer applications in Madhya Pradesh, farmers realized benefits in crop productivity to the tune of 5 to 45% in the season of application. Yields improved by 5 to 27% due to the residual effects of micro nutrients in the succeeding three seasons.

Chouhan et.al 2017 found that yields of paddy, soybean and maize increased by 19.42 per cent, 13.79 per cent and 9.6 per cent, respectively after the adoption of recommended dosages of fertilizer. Overall farmers realized an increase in income.

Fishman, et al., 2016, carried out an impact assessment of SHC using randomized controlled trials in three districts of Bihar. They observed that there is a large gap between recommended and actual application of fertilizer, especially in the case of urea. Despite the recommendations provided in the SHC farmers failed to adopt them. The main reasons for this include that farmers did not understand the contents of the SHC; they did not trust the fertilizer recommendations from the soil analysis; and the high cost in adopting the recommendations (Chouhan et al., 2012, Sharma et. al., 2015; Goyal, n.d). This raises concerns about the SHC scheme and highlights the role of awareness and extension services to improve understanding among farmers of the benefits of the scheme. On the other hand, it is also important to strengthen the soil testing services / laboratories to encourage wider adoption of the recommended dosage of fertilizers (Chouhan et.al 2017).

5.3 Calculation of Costs and Benefits

5.3.1 Costs

The cost estimates used for the interventions are based on the guidelines on SHC provided by the government 21. This includes, the cost of Soil Health Card (Rs 190 per sample), training for soil analysts, financial assistance for the package of nutrient recommendations, capacity building of farmers and experts, regular monitoring and evaluation costs, and the cost of managing the mission. This is built up over the three years. For Rajasthan there are a total of 59 soil testing labs (government and private) as per the MANAGE study (Reddy, 2017). The total number of soil samples considered for the cost analysis are as per the targets of cycle 2 for Rajasthan which is 11.54 lakhs. This target is repeated every year and it accounts for 46 percent of households in the state per year. Note that one soil sample can cover multiple households.

The schematic of costs and benefits is presented below in Table 3. The costs of soil testing is 22 crore per year, based on a soil sample cost of Rs 190. There are also modest training, capacity building and management costs. By far the largest cost is assistance provided to farmers for micronutrients to rejuvenate soil conditions. The SHM guidelines suggest that providing micronutrients to 90,000 farmers costs 22.5 crore, or approximately Rs 2500 per farmer. We apply this cost to the actual users of the SHC, not the recipients and our calculations assume 11.4m farming households in Rajasthan.

5.3.2 Benefits

The Rajasthan government plan of action includes covering one third of the state every year 22. Reddy (2017) states that about 66% of the farmers can understand the content of the SHC, about 57% of the farmers find the recommendations suitable for their farms and about 53% are able to follow the recommendations. Thus, the study assumes that even if the households get the SHC the utilization is going to be low. Furthermore, it is estimated that by the third year, 50 percent of the households who use Soil Heath Cards experience a benefit.

[21] http://www.nmsa.dac.gov.in/pdfDoc/SHM_Guidelines472016.pdf
[22] State agricultural policy draft- http://www.cuts-international.org/cart/ProOrganic/pdf/Useful_Information-Draft_Agriculture_Policy_Rajasthan.pdf

Further, the main benefit from the adoption of SHC is the reduced cost of fertilizer and manure because of improved efficiency, where improved soil health leads to yield gains. Makadia and Kuthe (2017) estimated a reduction in the cost of fertilizer use by 6.8% and an increase in income because of yield gains of 2.2 percent in Gujarat for selected crops. An impact study by Reddy 2017, indicated that there is a reduction in Nitrogen based fertilizers and an increase in bio-fertilizer and micro-nutrients use.

In response to a parliamentary query23, it was said that, following a study conducted by the National Productivity Council (NPC), the application of fertilizer and micro-nutrients based on Soil Health Card recommendations resulted in savings of 8-10% of fertilizer. There is an overall increase in the yield of crops to the tune of 5-6% from adopting SHC recommendations. In this study, we based the calculations on an average of 8 percent as the fertilizer saving and 5 percent as the yield gains across all the crops. The schematic of benefits is presented in Table 3 below.

[23] http://loksabha.nic.in/Members/QResult16.aspx?qref=58523

Table 3 – Soil Health Card Costs and Benefits

	Year 1	Year 2	Year 3
% of farmers with SHCs (needs to be replaced every 2 years)	46	92	92
% of farmers using SHCs	25	38	50
% of farmers who are beneficiaries	12	35	46
Area of Rajasthan with SHCs being used (ha)	2,787,066	8,361,197	11,148,263
Soil samples to be tested (lakhs)	11.54	11.54	11.54
Soil Testing Labs in Operation	59	59	59
COST ESTIMATION			
Cost of soil sampling based on Rs 190 per sample (crore)	22	22	22
Cost of micronutrients assistance based on Rs 2500 / farmer (crore)	329	987	1,315
Capacity building, training and mission management cost	0.66	0.69	0.69
Total Costs (crore)	351	1,009	1,338
BENEFITS ESTIMATION			
Benefits from improved yield	337	1011	1349
Benefits from reduced cost of fertilizer	28	83	111
Total Benefits (crore)	365	1095	1460

5.4 Assessment of Quality of Evidence

The evidence is inconclusive and conflicting. There are several papers that demonstrate yield and income improvement from application of recommendations from soil health cards (Reddy, 2017, Wani, 2013, 2016; Chander et al 2013). However the only randomized impact assessment, Fishman et al (2016) suggested that farmers did not apply the findings. There is also some indication that not all farmers use or understand SHCs, but the program is new and perhaps this could improve in the long run. Thus, the estimation is valued as limited.

6. Improving/ expanding extension services via ICT

6.1 Description of intervention

In all the above interventions we have used extension services as a critical component to realize the impact on yields, incomes, improving the adoption of technologies like certified seed or machinery, and improving soil health. The extension services in India had primarily been the responsibility of the public sector. The government has a huge R&D infrastructure in the form of institutions such as the Indian Council of Agricultural Research (ICAR), state agricultural universities (SAUs) and Krishi Vigyan Kendras (KVKs). Public sector extension services are usually criticized for their ineffective targeting, poor reach and the huge administrative cost of delivering information (Mittal, 2012). It is important to strengthen the agricultural extension system for increasing productivity, profitability, sustainability and incomes for the farmers. The Indian extension system has undergone reforms since the late 1990s and experienced major conceptual, structural, and institutional change (Raabe, 2008). These changes were undertaken to improve the efficiency, effectiveness and timeliness of services. These reforms included the forging of public private partnership to provide extension services and strengthening the linkages between researchers in laboratories and farmers in the field.

ICT-based extension services provide an opportunity to strengthen these linkages. In India, some of the very initial models using modern techniques were the kisan call centers and village knowledge centers that were based on landlines and internet-based computer centers in villages. These were initiated mainly by the government or NGOs. Projects like the Agricultural Technology Management Agency (ATMA), e-sagu and e-choupal gave the initial thrust. During the past few years, with the increase in mobile penetration even in rural areas, there has been an evolution of ICT-based extension services models to disseminate agriculture related information. The overall goal of using the mobile phone-enabled information delivery mechanism is to have inclusive growth by reducing the knowledge gap between large and small farmers and by creating awareness. At national level the m-Kisan SMS Portal24 was inaugurated by the President of India on July 16, 2013. Farmers who

[24] https://mkisan.gov.in/Default.aspx

registered on this Portal could access advisory service. This intervention aims at reaching to the farmers on mobile phone in the form of SMS and IVR services.

In the calculation of BCR for this intervention, we have built up the model to assess what would be the cost of reaching to all the farmers who have access to mobile phones over a period of 5 years to provide advisories and what is the potential benefit of utilizing these services?

6.2 Literature Review

Knowledge and communication is an important resource for agriculture and can contribute substantially to ensuring food security and sustainability by creating awareness and skill development through access to information. Research, extension services, literacy and infrastructure have been identified as the most important sources of growth in productivity by Mittal and Kumar, 2000. The World Development Report 2008 (Jock R. Anderson (2007) emphasized that agricultural extension plays a key role in agricultural development and in promoting sustainable, inclusive and pro-poor economic development.

The expected impact of different types of information are to improve productivity, through informed decision making about crop choice, seed varieties, agricultural inputs, agronomic practices and plant protection. Information also helps to reduce production costs through the adoption of improved and quality inputs and technologies, better management practices and helping in strengthening market information that helps in better price realization. However, the impact of mobiles as a mode of providing information for farming will depend on how mobile networks are able to link the farmers to all the required information in a timely and accurate manner. (Aker, 2011; Mittal and Mehar, 2013). The contribution in the use of mobile phones can be felt at all the stages of the agriculture cycle; the impact has been in terms of both quantifiable (increase in income, improved yield etc.) and non-quantifiable gains (social benefits of improved communications, information about education and health etc.) (Bhatnagar, 2008). Information is one of the key inputs to productivity growth (Anderson and Feder, 2007).

Few studies have shown the impact on income by efficient utilization of mobile phones or mobile based information services for agricultural purposes. An action research conducted in Tamil Nadu, Daniel et al., (2011) applied ANOVA method and found that the farmers who received agricultural information were able to get an additional Rs 475 (US$10.5) per acre during a 4-month season. The study found that in favorable years this can even double up to Rs 1,000 (US$22.2) per acre. A randomized evaluation of the introduction of a mobile phone-based agricultural consulting service, Avaaj Otalo (AO), to farmers in Gujarat, showed that the programme led to changes in management practices which in turn led to increases in yields for cumin by 26.3%, and for cotton by 3.5%. Overall the study found that each dollar invested by a farmer in the service generates a return of $10 (Cole and Fernando 2014).

A broader based examination of the effect of information (Birthal et al 2015) suggests the use of information leads to 12% higher net returns per hectare, which in value terms translates to rupees (Rs) 1140 per hectare of cropped area at 2002–2003 prices.

Constraint to adoption

ICT has the potential to transform the traditional agricultural extension system, because of its wide reach and low cost of delivering information. Despite this, there are certain constraints on the use of mobile phones.

The key challenges that the service providers face are to develop content according to farmers needs and to market that service to the farmers efficiently (Mittal, 2012; Glendenning and Ficarelli, 2012). Mittal et al., (2010) states that mobile and internet-based information delivery models have to be complementary to conventional extension services. Mobile phone based initiatives alone cannot play the role of extension agents. To leverage the full potential of information dissemination enabled by mobile telephony along with the supporting infrastructure and capacity building amongst farmers, it is essential to ensure the quality of information, its timeliness and trustworthiness (Mittal, 2012; Glendenning and Ficarelli, 2012; Mittal and Mehar, 2013; Aker et al, 2016). The economic sustainability of these extension models depends on the benefits generated and the efficient functioning of support from all the stakeholders in the system. The flow of information should be complementary to existing sources of information and has to be cost effective, Deichmanna et al (2016). Birthal et al 2015 suggest that investment in extension leads to higher returns than expenditures on extension services, which is net Rs 186 per hectare. Investments should be made on improving the efficiency of extension services to realize their full potential.

6.3 Calculation of Costs and Benefits

6.3.1 Costs

The costs are calculated for the number of agricultural households that are going to receive the services delivered. The total number of agricultural households is obtained from the Situation Assessment Survey of Agricultural Households NSSO, (2005) and is 11.4m in Rajasthan. This is proportioned by the number of households who have access to mobile phone. Yamano et. al 2017 estimated that 85% of the rural households have access to mobile phones25.

In the costs we have three components. 1) Cost of delivering agricultural advisories through SMS. 2) Cost of IVRS (Integrated Voice Recording Service) 3) Other cost of operations. Since agriculture is an activity throughout the year, the assumption of 200 SMS per year at the rate of Rs. 1 per SMS is added as a cost.

Based on estimates of running the mobile phone based advisory services the operational cost is taken as $0.83 per household per month. The cost of running an IVR service is already included in the operational costs. This is based on the Cole and Fernando 2014 study of a randomized trial in Gujarat.

The evaluation of ICT programs, (Palmer 2014, GSMA 2015) show that only 10 percent of the households are registered users of the services in the present government program scenario. These numbers are not available at the state level. Of these, only 25 percent of households are repeat users of services. Given such poor utilization of mobile based advisory services, we

[25] https://updateox.com/india/state-wise-mobile-phone-users-in-india-census-2011/ Gives the census 2011 mobile users. But with the increasing growth of mobile users per year as reported in http://www.indiatechonline.com/it-happened-in-india.php?id=545 we have assumed that 85% of households have access to mobile phone.

have built up the intervention over the 5 year period with users at 20 percent in year 1, 40 percent in year 2, and up to 60 percent by year 5.

The total costs of the intervention are 1889 crore over five years (at 5% discount rate) and are presented below in Table 4.

6.3.2 Benefits

The main benefit of improved extension services is increased farmer incomes. The Maini and Rathore 2011 paper estimated an income increase of 10-15 percent and a reduced cost of production of 2-5 percent. Birthal et.al 2015 estimated the income increase due to information as 12%.

The Manjappa and Yeledalli (2013) study showed that the weather based agro advisories have an impact on the economic gains of between 4.76 to 16.66 % based on the crops that households cultivated. The Cole and Fernando 2014 study estimated that households that had access to ICT based advisories have 16 percent higher profits than the control group. Thus, for this study we used the 16 percent increased profit figure. The average of small and marginal farmers is taken as the base income figure to remove the bias because of large farming households, Rs. 21,673 per household per year.

Table 4 – Costs and Benefits of Expanding Extension Services via ICT

	Year 1	Year 2	Year 3	Year 4	Year 5
Eligible HHs (Number of HHs with mobile phones)	9,722,882				
% coverage	20%	40%	60%	60%	60%
HHs covered	1,944,576	3,889,153	5,833,729	5,833,729	5,833,729
Costs (crore)	187	373	560	560	560
Benefits (crore)	674	1349	2023	2023	2023

6.4 Assessment of Quality of Evidence

The evidence on the intervention is consistent and points towards benefits similar in magnitude and of the same sign (positive). Costs come from a carefully surveyed randomized controlled trial and are consistent with costs from other interventions. Thus, the quality of evidence is strong.

7. Conclusion

The study reviews four interventions in the agricultural sector for Rajasthan. Seed is one of the most crucial inputs in increasing agricultural productivity. The intervention focused on improving the seed replacement rate by increasing the production and availability of certified seed. The BCR is 20 and the ratio shows the importance and overall gains from investing in improved seed adoption rates.

The second intervention is crop diversification, with a BCR of 1.0. Crop diversification is a continuous process and it is important as it helps to reduce risks and improve incomes.

The third intervention is the adoption of Soil Health Cards to improve soil health and yields for better agriculture. The BCR is 1.1. This is an important initiative, but due to the low adoption rates of the recommendations, the benefits accrued are low.

The improvement of extension services by introducing advisory services through mobile phones is a small component in improving the reach of extension services. But, it can play a catalyst role in strengthening the existing extension system. Among all the four interventions, the extension services play a significant role and it is repeatedly emphased that strengthening extension services will help to improve the benefits to farmers through other interventions. The BCR for this intervention is 3.6.

Summary Table

Intervention	Discount Rate	Benefit (in Crore Rs.)	Cost (in Crore Rs.)	BCR	Quality of Evidence
Certified seed Production	3%	11,811	596	20	Strong
	5%	11,586	584	20	
	8%	11,264	568	20	
Crop Diversification	3%	4,257	4,153	1.0	Medium
	5%	4,176	4,074	1.0	
	8%	4,060	3,961	1.0	
Soil Health Card	3%	2,722	2,517	1.1	Limited
	5%	2,601	2,406	1.1	
	8%	2,435	2,253	1.1	
Improving/ Expanding extension services	3%	7,320	2,026	3.6	Strong
	5%	6,862	1,899	3.6	
	8%	6,250	1,730	3.6	

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