The current issue and full text archive of this journal is available on Emerald Insight at:
www.emeraldinsight.com/2042-5945.htm

Agricultural practices in a drought-prone region of India: opportunities for S&T innovations

Venkatesh Dutta, Manoj Vimal, Sonvir Singh and Rana Pratap Singh
DST Centre for Policy Research,
Babasaheb Bhimrao Ambedkar University, Lucknow, India

Received 3 April 2018
Revised 30 May 2019
Accepted 24 June 2019

Abstract

Purpose – The purpose of this paper is to assess the agricultural practices in a drought-prone region of India in an effort to find out how science, technology and innovation (STI) measures can address the existing problems and help achieve sustainable solutions. This study has been planned with two specific objectives: to study the agricultural practices of small and marginal-holding farmers in a drought-prone region and to examine the opportunities for suitable interventions to mitigate the impacts of droughts. The study is based on primary survey conducted in Banda district of Bundelkhand region, Uttar Pradesh, India.

Design/methodology/approach – Empirical survey was done in eight different blocks of a drought-prone region of India using structured questionnaire. The questionnaire was pre-tested with a group of 12 farmers during a workshop through a pilot survey conducted during April 2017. Stratified sampling based on land holdings (small farmers having 1–2 ha of land, medium farmers having 2.1–5 ha of land and large farmers having more than 5 ha of land) and irrigation types (canals and tube wells) were utilised in different blocks of the district for selecting farmers in the surveyed villages.

Findings – Findings suggest that due to various reasons like change in climatic conditions, frequent crop failure, crop diseases and high cost of production, farmers have adopted certain crops which are not suited to their agro-climatic conditions. The paper recommends that farmer's school or "on-farm training school" have to be initiated to integrate farmers' traditional knowledge with modern knowledge systems with amalgamation of STI tools.

Research limitations/implications – Uttar Pradesh is divided into nine agro-climatic zones; however, this study is focused on Bundelkhand and may be region specific, though the findings are important for other drought-prone areas.

Practical implications – The paper links the existing agricultural practices and further linking them with farmers' socio-economic, cultural and environmental settings. Only 17.5 per cent of respondents owned any agricultural equipment due to high cost of farm tools, difficulty in taking equipements on rental basis and lack of sharing tools among the farmers.

Social implications – This paper targets small and marginal farmers in the drought-prone region of India who face the dual shock of climate impacts and poverty. Adoption of modern agricultural practices and use of technology is inadequate which is further hampered by ignorance of such practices, high costs and impracticality in the case of small land holdings.

Originality/value – This paper has advocated for well-organised, efficient and result-oriented STI system to mitigate the adverse impacts of drought-prone agriculture. Farming community in drough-prone areas needs adequate investment, local-specific technology, better quality inputs, real-time information on weather and most importantly latest know-how for sustaining commercial and cost effective sustainable agriculture.

Keywords Policy, Technology, STI, Agricultural management, Precision irrigation

Paper type Research paper

1. Introduction

The socio-economic and cultural lives of the people of India for centuries have tremendously been shaped by agriculture that continues to be central to all strategies for planned socio-economic development of the country (Gupta, 2019; NAP, 2017). With production of

Support received from Policy Research Cell of Department of Science and Technology (DST), Govt. of India is greatly acknowledged. The paper is based on a project titled "STI for Inclusive Growth" carried out at DST Centre for Policy Research, Babasaheb Bhimrao Ambedkar University, Lucknow. All the authors contributed equally to this work.

World Journal of Science, Technology and Sustainable Development
Vol. 16 No. 4, 2019
pp. 208-226

2042-5945
DOI 10.1108/WJSTSD-04-2018-0019

agriculture activity of about $375.61bn, India is among the major producers of agriculture product accounting for 7.39 per cent of the total global agricultural output. However, the contribution of agriculture has reduced significantly in total gross domestic product (GDP) over the years. Agriculture and allied sectors shared 17.9 per cent of India's GDP in 2014 that further declined to 14.39 per cent during 2018. Service sector contributes most with 57.9 per cent followed by industry (24.2 per cent) (GoI, 2018; Planning Commission, 2014). Though with decline in its contribution in India's GDP over the years, agriculture with its allied sectors unquestionably is still the largest livelihood partner in India (FAO, 2018; NPI, 2017). As per the 2017 data, about 54.6 per cent of India's population is engaged in agriculture and allied activities (DACFW, 2017), and out of this, 82 per cent of farmers are small and marginal (FAO, 2018). According to India Economic Survey of 2018, the percentage of agricultural workers of total work force would drop to 25.7 per cent by 2050 from 58.2 per cent in 2001 (GoI, 2018). Though India has experienced continuous decline over the years in this sector, agriculture still acts as a foundation on which India's economy rests. Most of the rural households derive their livelihood from this sector. Indian agriculture and allied activities have witnessed a green revolution that increased agricultural production during 1960s, a white revolution that transformed India into world's largest milk producer, a yellow revolution that increased the production of edible oils and a blue revolution made remarkable emergence of aquaculture (NPI, 2017).

There is a diverse pattern of farming in India that is governed by agro-climatic conditions, farm size, input prices, profit margin and government policies. Due to large dependency on rainfed irrigation, the agriculture sector in India registered significantly higher growth in 2016–2017 than the previous two years due to normal monsoon (GoI, 2018). Climate change, abrupt land-use modifications and degradation of natural resource have aggravated drought occurrences and vulnerability, thus disrupting the normal socio-economic settings in semi-arid and arid regions of the country (Kundu *et al.*, 2015; Gupta *et al.*, 2011). The drought and resultant agrarian crisis during 1965–1967 led to "green revolution" in India. However, the success was limited to few states only where irrigation facility was developed over the years. Many of the drought affected regions still struggling to cope with the recurrent dry weather. About 13 states have been repeatedly declared as drought-prone where consecutive deficient rainfall has resulted in drought-related deprivation and conflicts such as crop failure, drying up ecosystems and shortage of fodder and drinking water. Adoption of modern agricultural practices and use of technology is inadequate that is further hampered by ignorance of such practices, high costs and impracticality in the case of small land holdings.

Understanding the agricultural practices in a drought-prone region of India and opportunities for science, technology and innovation (STI) is an important issue and relevant for the policy makers for formulating appropriate policies for the country. There have been studies on farming community in drought-prone regions, and some agreed that small-holding farmers have local knowledge and their agricultural practices seem to be less harmful to the environment and more adaptive to local climatic issues. Dry regions in India include about 94 mha with one-third of India's population (about 300m people). It is also observed that more than 50 per cent of the region is affected by drought once every four years (Gupta *et al.*, 2011; UN, 1990). Planners have repeatedly failed to undertake an ecosystem approach for drought management. Most of the measures were short-term strategies that did not address improper agriculture practices and poor water management. India's STI Policy released in 2013 emphasises on the need of science-based solutions to such problems by intervention of STI measures. The agriculture sector has got special priority in the STI Policy 2013. It also aims to integrate agriculture research and development (R&D) that is articulated by Indian Council for Agriculture Research with that of national R&D (STIP, 2013).

New Agriculture Policy stresses on the need of regionalisation of agricultural research based on identified agro-climatic zones (Gupta 2019; Paroda, 2018; NAP, 2017). Application of frontier sciences like bio-technology, remote sensing technologies, pre-and post-harvesting technologies, energy saving technologies, technology for environmental protection through national R&D as well as propriety research will be of strategic importance in enhancing overall yield. This policy aims to build a well-organised, efficient and result-oriented agriculture research system and education system to introduce technological change in Indian agriculture (NAP, 2017). Sustainable agriculture, in terms of environmentally sustainable technologies such as soil conservation, food security, rural employment, sustainable natural resource management and biodiversity protection, is essential for holistic rural development (NPI, 2017).

This study has been planned with two specific objectives: to study the agricultural practices of small and marginal-holding farmers in a drought-prone region and to examine the opportunities for suitable interventions to mitigate the impacts of droughts. The study is based on primary survey conducted in Banda district of Bundelkhand region, Uttar Pradesh, India.

2. Review of agricultural practices in drought-prone region

The strong dependence of Indian agriculture and the county's economy on monsoon is well established. Rainfall is the ultimate source of water, affecting crop production and other biomass by directly influencing soil-moisture status as well as supporting surface and ground water irrigation. However, possibilities of occurrence of drought in India vary in different states (NRAA, 2009). In Bundelkhand region, agriculture is rainfed, complex, diverse under-invested, vulnerable and risky (Anuja *et al.*, 2018; Suthar, 2018). Rajasthan's chronically drought-prone regions have been known for its coping and resilience systems, whereas Bundelkhand has recently become a new hotspot due to consecutive drought amidst susceptibility and poverty (Gupta *et al.*, 2014). All the available natural resources for sustainable development of agriculture in drought-prone rainfed areas too have to be harnessed to increase the food grain production that was bypassed during the Green Revolution era (Gautam and Bana, 2014). About 28 per cent of agricultural land in India is drought prone and as such suffers from critical water shortages (Samra, 2004). A major impact of drought in agriculture is crop failure and yield losses depending on their geographic spread, intensity and duration. The drought-prone areas are low in agricultural productivity and thus underperform towards overall economic growth. This results in unemployment and low productivity of labour. Droughts have been categorised in number of ways like meteorological, agricultural, hydrological, ecological and socio-economic droughts. Agricultural drought is a period of dryness affecting the soil-moisture status and preventing the growth of plants. Various adaptation mechanisms are developed by plants to survive and reproduce during the drought conditions. Farmers also try to adopt the agronomic practices for collecting, conserving and utilising soil-moisture to improve water use efficiency (Gautam and Bana, 2014).

Various studies have shown that droughts have multiplier effect on agricultural production and impacts of successive droughts are evident even during subsequent years. This is due to interplay of a variety of factors such as declining trends of ground water recharge, land degradation, non-availability of quality seeds, rising input prices and loss of income of farmers. Thus, a large number of farming communities fall back into poverty during drought years (Pandey and Bhandari, 2009). Policy makers are facing a serious challenge to help out poor farmers in Bundelkhand to come out of vulnerability to poverty and also in integrating the drought-prone areas into the mainstream of development. Bundelkhand region is one of the poorest regions of India even though it is in close proximity to heartland of green revolution states of Punjab, Haryana and Western Uttar Pradesh (Shakeel *et al.*, 2012).

Over the years, India has developed a fairly elaborate governance system for drought monitoring and mitigation at different levels. Pradhan Mantri Krishi Sinchayee Yojana

(Prime Minister Agriculture Irrigation Scheme) is being implemented in mission mode with the help of command area development to complete 99 major and medium irrigation projects covering 7.6m ha in a phased manner by December 2019 to increase the coverage of irrigated area and thereby agricultural productivity. The government is implementing Crops Diversification Programme in cereal centric regions that were the original green revolution states, namely Punjab, Haryana and Western UP mainly to diversify paddy growing area to less water-intensive crops, and also reduce the price shocks and post-harvest losses. Similarly, National Food Security Mission (NFSM) is targeted to increase production of pulses that is suitable for dry land farming.

3. Study area

Banda lies at the south of the Yamuna River (a tributary of Ganges) in the Bundelkhand region of Uttar Pradesh, India (Figure 1). Uttar Pradesh is divided into nine agro-climatic zones; however, this study is focused on Bundelkhand (Table I). The total area of district is 4,414.10 sq.km that is further divided into 8 blocks with 660 villages. The region has both irregular uplands and elevated plains that are interspersed with detached rocks of granite. Total population of Banda district in 2011 was 1,799,410 (Census, 2011). Rivers Yamuna, Ken, Bagein and Paisuni cross Banda district. It consists of Vindhyan plateau. The district receives about 850 mm rainfall annually. This district has low ground water table. Tapping of ground water in all places is not possible due to underneath hard rocks. This leads to low soil fertility and problems of water logging, sodicity and erosion. Soil also has imbalanced nutrient level and low organic carbon content (C-DAP). Around 1.23 lakh ha area is under cultivation. Net sown area is 3.51 lakh ha with a cropping intensity of 112.2 per cent (C-DAP). Economy of Banda is mainly based on agriculture. Kharif (July–October) and Rabi (November–March) are two main cropping seasons. Crops during Kharif season include Paddy, Jowar (Sorghum), Bajra (Millet), Til (Sesame), Moong (Green gram), Urd (Black gram) and Arhar (Pigeon pea). Wheat and Barley along with Chickpea, Linseed, Mustard, Masoor (Lentil) and Peas in grown in Rabi season. Seasonal fruits such as Kharbooja (muskmelon) and Tarbooj (watermelon) and some vegetables are grown during Zaid season that is the short duration between Rabi and Kharif seasons, mainly from March to June. The livestock sector comprises of goats, sheeps, cows, buffaloes and poultry birds.

4. Survey design

A field survey was done in Banda district that is part of Bundelkhand region of Uttar Pradesh. A structured questionnaire was prepared for face-to-face interview of farmers. Focus group discussion (FGD) was conducted at a farmer's orchard in Banda during a training programme, and the questionnaire was further modified based on the respondents' feedback. The farmers during the FDG complained of shortage of rainfall along with its erratic distribution during rainy season. Parameters like caste, education level, farm income, ration card, type of household items owned and size of land holdings were chosen to assess the socio-economic profile of the respondents. Fertilizers usages, use of farm tools and agriculture wastes (gobar gas), irrigation practices, awareness for use of government schemes were other parameters chosen on which questionnaire was prepared. The questionnaire was pre-tested with a group of twelve farmers during a workshop through a pilot survey conducted during April 2017. Stratified sampling based on land holdings (small farmers having 1–2 ha of land, medium farmers having 2.1–5 ha of land and large farmers having more than 5 ha of land) and irrigation types (canals and tube wells) were utilised in different blocks of the district for selecting farmers in the surveyed villages. In total, 40 farmers from 12 villages were selected covering all the 8 blocks of the district. The main survey was conducted during the month of October 2017. While six villages had both canals and tube wells as irrigation facilities, the remaining six villages had only tube wells for irrigation. The surveyed farmers represented small and marginal land holdings of the region.

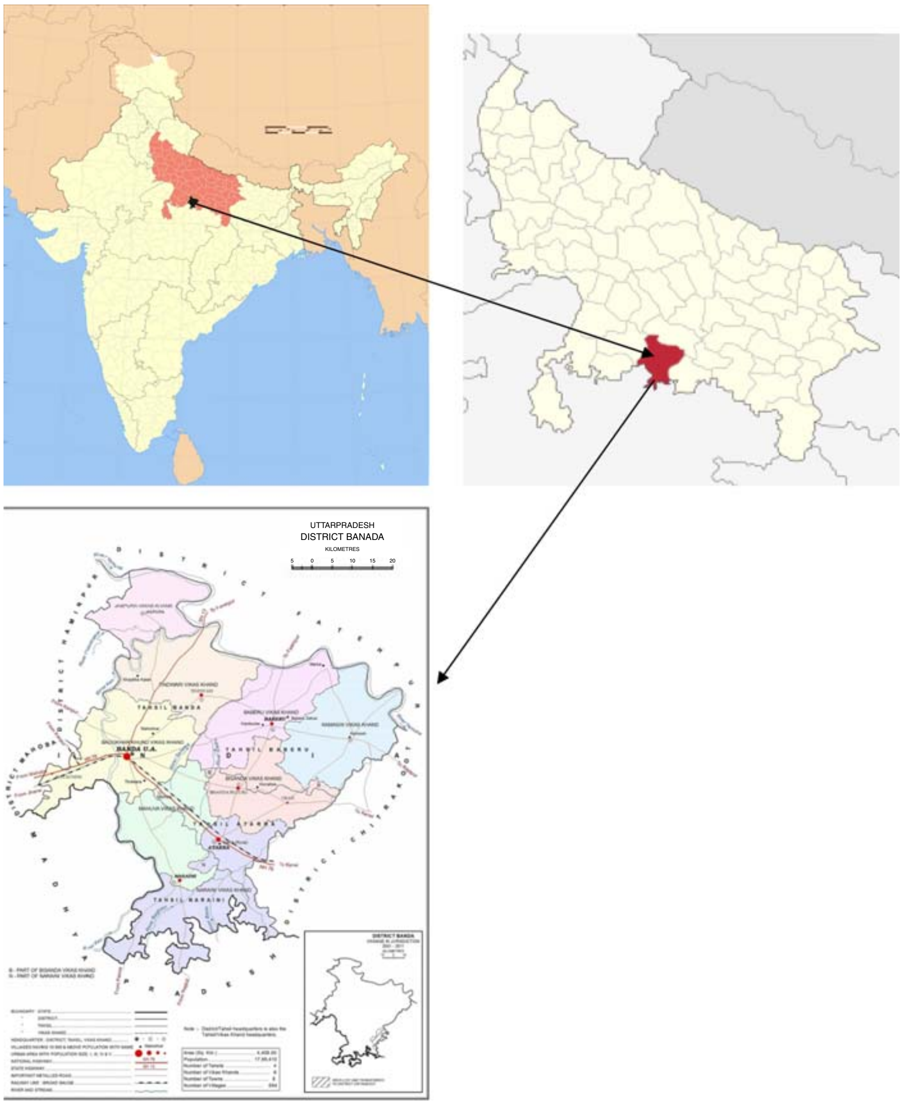


Figure 1.
Map of the study area with eight survey blocks

5. Results

Results contain the profile of the sampled villages followed by background information of the respondents and the magnitude of the problems faced by the famers during droughts.

5.1 Socio-economic profile of the farmers

As the questions were asked to the head of the households, most of the respondents were found to be male out of which 25 per cent belonged to SC/ST category (scheduled caste and scheduled tribes, as defined by the census of India), 40 per cent OBC (other backward classes) and 35 per cent general category (Figure 2). These demographic data are important determinants while accessing the natural resources such as forests, land and water, and

Zones	No. of districts	Average rainfall (mm)	Soil type	Cropping intensity (%)	Limitations that can be tackled through STI interventions
Tarai	13	1,400	Alluvial with coarse	146	Drought prone
Western Plain	9	950	Alluvial deposits by Ganga	157	Water logging and salinity
Mid-West Plain	8	800	Alluvial	150	Salinity and alkalinity
South-West Plain	8	770	Alluvial and aravallis	146	Brakish water and alkalinity
Central Plain	16	1,020	Alluvial, some Vindhyan	155	Usar soil
Bundelkhand	7	1,000	Rakar, Parwa, Mar	111	Lack of resources, inferior soil, irrigation practices
North-East Plain	11	1,470	Alluvial some calcareous	152	Flood prone
Eastern Plain	14	800	Alluvial with silt and clay, sandy loam	138	Alkaline/Saline
Vindhyan	4	1,100	Light to heavy	133	Undulated and rocky area

Source: DST-CPR (2018)

Table I. Agro-climatic zones-Uttar Pradesh with soil type, cropping intensity and limitations

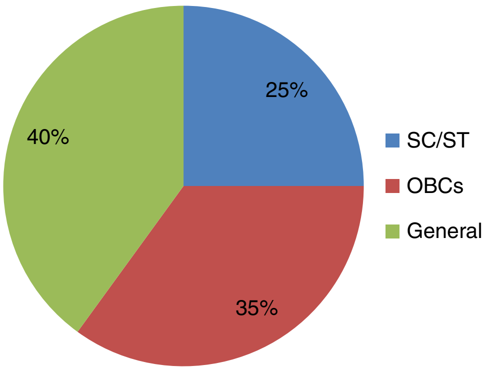


Figure 2. Socio-demographic profile of Rural Bundelkhand (Banda) based on respondent participated in the survey

socio-political structure of Bundelkhand or any other part of India. It is a known fact that cultivable land and other natural resources are inequitably distributed across classes and castes in the region (PERSPECTIVES, 2010). Among the respondents, 7.5 per cent were illiterate, whereas 92.5 per cent had at least primary level education. Among the literates, about 15 per cent received education up to middle school, 30 per cent cleared their high school, 15 per cent higher secondary and only 15 per cent were graduates or post-graduates (Figure 3).

Among the literates, the employment facilities and job opportunities were short and unemployment was common. It was observed that seasonal migration for employment (mainly as farm labour in other states) was common during droughts as the region provided little incentive for income generation. This survey shows male literacy rate of 87.50 per cent, whereas census 2011 data show the male literacy rate of 77.78 per cent (Census, 2011). Most of the respondents (60 per cent) were in the age group of 18–40 and 40 per cent were in the age group of 41–70. Annual income of respondents was also analysed. Majority (77.50 per cent) of them had their annual income ranging between 26,000 and 50,000 Indian rupees, whereas 12.5 per cent had between 51,000 and 80,000 and 10 per cent had their annual income more than 80,000 rupees (Figure 4). This indicated low purchasing power of the people.

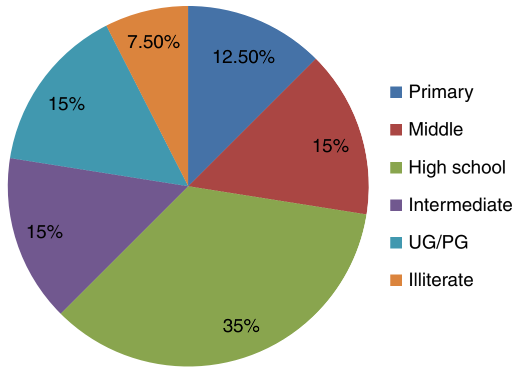
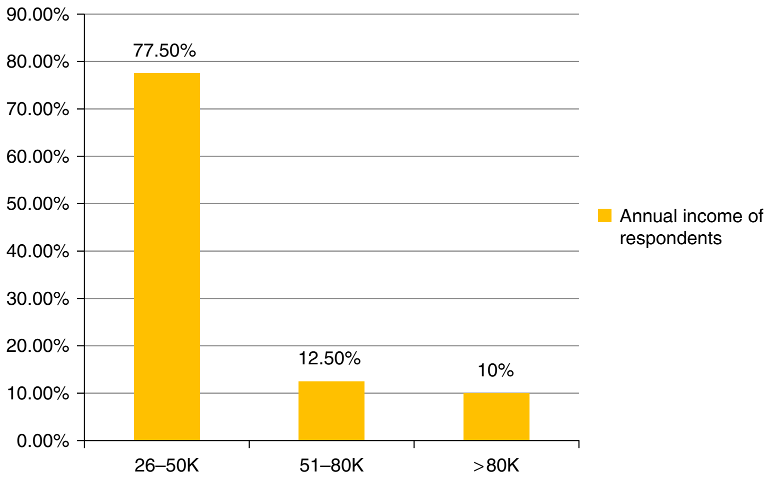


Figure 3.
Level of education among respondents of surveyed area



Source: Based on respondent's statements

Figure 4.
Annual income of farmers in surveyed area

About 88.5 per cent of the respondents had their *pucca* house (cemented house). Regarding the type of household items owned by respondents, 45 per cent had Liquefied Petroleum Gas cylinder connections in their homes as the cooking gas. In total, 75 per cent had mobile phones, whereas 65 per cent had television sets, 40 per cent had refrigerators, 57.5 per cent had two wheelers and only 17.5 per cent had their own pumping sets for use in agriculture purpose (Figure 5).

In total, 80 per cent of respondents watch television daily, 95 per cent respondents never listen to radio, 62.5 per cent respondents sometimes read newspaper and 80 per cent never used internet. The usage of smart phones was almost negligible. Television can be a great medium to communicate with farmers as they indulge maximum (80 per cent) to this medium in their leisure time.

5.2 Integration of public distribution system (PDS) with unique identification (UID) system
To distribute subsidised food grains among the masses, there is a network system known as PDS in India, which are like fair price shops for essential food items. Food grains and fuel like kerosene oil are distributed through ration shops with the objective to provide food security to

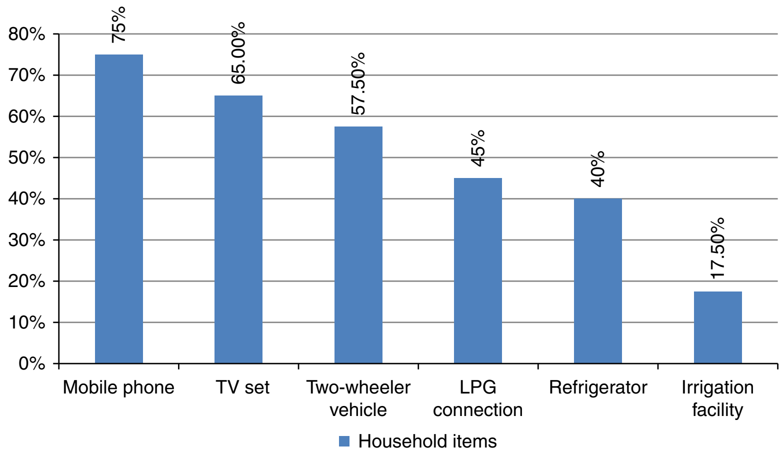


Figure 5.
Type of household items owned by respondents

the needy and poor. Based on socio-economic background and income profile, households have been categorised into four types – Above Poverty Line (APL), Below Poverty Line (BPL), Antyodaya and Annapurna. The number of fair prices shops is still low per unit of population in the surveyed villages. Only 15 per cent of the respondents possessed APL ration cards, whereas 17.5, 50 and 7.5 per cent of respondents had BPL, Antyodaya and Annapurna ration cards, respectively. About 10 per cent of the respondents did not have any type of ration card (Figure 6). Steps have been taken in some states in India to integrate PDS to UID, called "Aadhar" to check the irregularities in ration delivery to the citizens. Farmers participating in the survey had their bank accounts but only 57.5 per cent had their accounts linked with Aadhar scheme.

5.3 Land holdings and prevalence of Bataiyya (sharecropper) system

In total, 95 per cent of the respondents own their farms and only 26 per cent utilised *Bataiyya* (sharecropper) system along their own. Sharecroppers or *Bataiyya* are those farmers who share mostly the half of the crop yield with other farmers on whose farm the crops are grown. It is the *Bataiyya* who is responsible for pre- and post-harvesting of the crops, but the cost for seed, irrigation, fertilizers, etc., is shared equally among the *Bataiyya* and the farm owner. The prevailing physical, economic and institutional framework governs the land-use pattern of any region. Land use pattern keeps evolving in India as the result of

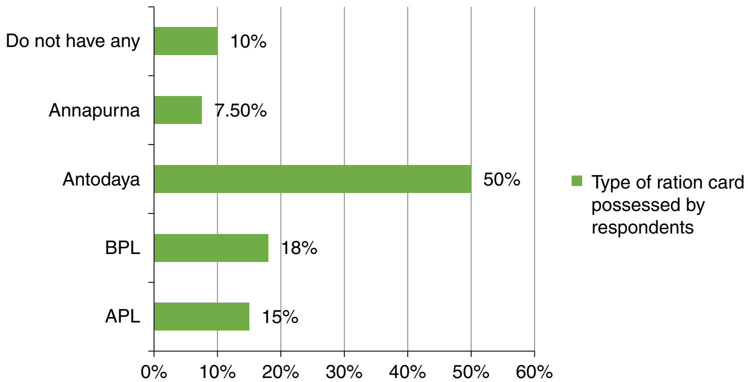


Figure 6.
Type of ration card possessed by respondents

dynamic relationship among various factors. Land use for non-agricultural purposes has been continuously increasing (Chaturvedi *et al.*, 2011). Based on size of agricultural land holdings, 72.5 per cent were found to be small and marginal farmers, 15 per cent medium and 8 per cent large farmers. In total, 7.5 per cent did not give any response (Figure 7). We tried to survey only the small and marginal farmers; however, it was revealed during the survey that average land holdings are high in this region compared to other parts of Uttar Pradesh even though abject poverty was observed due to crop failures and successive droughts.

5.4 Farming is not a preferred occupation among the youth

The agrarian crisis is evident from the fact that young farmers are not interested in farming as they find it labour-intensive and less-remunerative. The new generation of famers has lost their connection from traditional agricultural technologies. The agriculture productivity is linked to critical inputs such as timely irrigation, quality seeds, soil nutrients and fertilisers, credit facilities, tools and machines and extension services. As a large part of agriculture in drought-prone area is dependent on normal monsoon, any deficiency in the rainfall causes widespread decline in yield. In total, 65 per cent of the respondents in the surveyed villages liked farming as a profession and 35 per cent disliked farming. This result is similar to the findings from the National Sample Survey Organization (NSSO) done in 2003 by the Government of India. In that survey 40 per cent of farmers said they disliked farming (NSSO, 2005). Some scholars have argued that those who disliked farming comprised of resource-poor and most vulnerable farmers (Agarwal and Agrawal, 2017).

5.5 Usage of improved seeds, fertilisers and pesticides

In total, 30 per cent of respondents used local variety of seeds only and 32.5 per cent used hybrid seeds only, whereas 37.5 per cent used both types of seeds. According to an earlier large input economic survey (2011–2012) carried out for the entire state, out of total operational holdings, only 9.4 per cent used certified seeds, 27 per cent used seeds of notified variety and 9.8 per cent used hybrid seeds (GoI, 2018). In total, 90 per cent of farmers used both chemical and organic fertilizers, whereas 10 per cent used only chemical fertilizers (Figure 8). When asked about the main reason for using chemical fertilizers, the respondents had different views as some (25 per cent) cited better yield, some (37.5 per cent) cited faster growth, whereas others (37.5 per cent) replied that there was the lack of availability of organic fertilizers. In total, 5 per cent of the respondents never used pesticides for their crops, whereas 52.5 per cent used rarely, 32.5 per cent used occasionally, 5 per cent used as per the needs and only 5 per cent always used pesticides for their crops. In total, 87.5 per cent of respondents informed that they have seen that various crops have destroyed due to different reasons in their area while 12.5 per cent did not see any crop destruction.

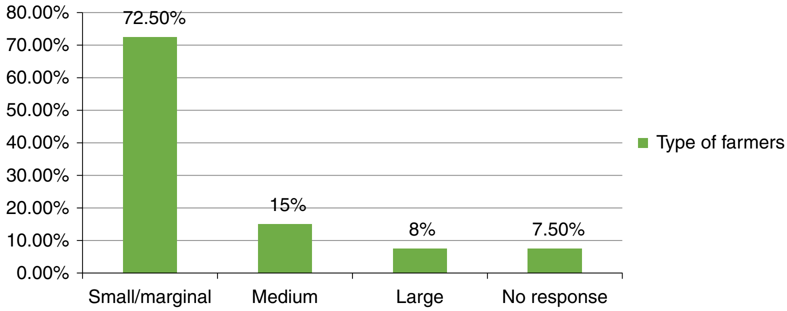


Figure 7.
Type of farmers based on land holdings

5.6 Minimum support price (MSP) and markets for crop produce

In total, 75 per cent of the respondents heard about MSP, whereas 25 per cent did not. Only 10 per cent sold their crops at government purchase centre, whereas 90 per cent did not. In total, 70 per cent sold their crops in open market, 20 per cent through small markets, whereas only 5 per cent sold through Bazaar Samiti. In total, 5 per cent did not give any response.

5.7 Access to cold storage facility and biogas

Only 20 per cent households had gobar gas plant (biogas plant using cow dung as the feed) while 80 per cent did not have in their households (Figure 9). The high cost of equipment, taking equipment on the rental basis or lack of sharing among the farmers without any rent can be reasons for it. Only 5 per cent of respondents informed that they had access to cold storage facility, whereas 95 per cent do not have access to such facility. The storage capacity at community and household level should be made available as this could minimise the post-harvest loss of the produce.

5.8 Shortage of fodder and "Anna Pratha"

Regarding biggest problem faced by farmers, 75 per cent of the respondents mentioned "*anna pratha*" or "*chutta janwar*" (i.e., stray animals) that means farmers abandon their unproductive cattle (mainly cows) to unburden themselves (Figure 10). This is done by farmers when they are not able to feed their cattle due to losses in agriculture. This practice is very prevalent in Bundelkhand region as it has been drought-hit that creates the problem for animal fodder. These cattles further affect the vegetation when they stray into the farmlands (Gupta *et al.*, 2014). Among the livestock, cows, buffaloes, bullocks, sheep and goats are kept as farm animals in this region. The number of farm animals particularly cows and buffaloes is high, it was revealed during the FGD that many farmers migrate to other

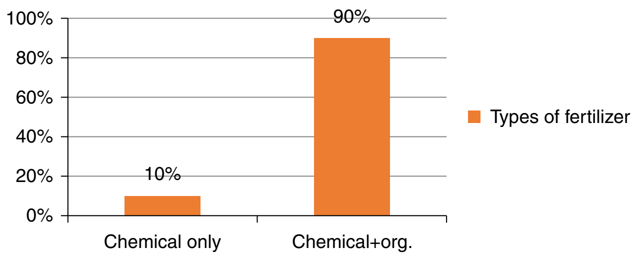


Figure 8.
Type of fertilizers used by the respondents

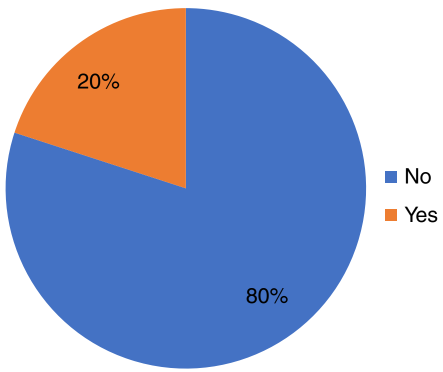


Figure 9.
Gobar gas plant owned by the respondents

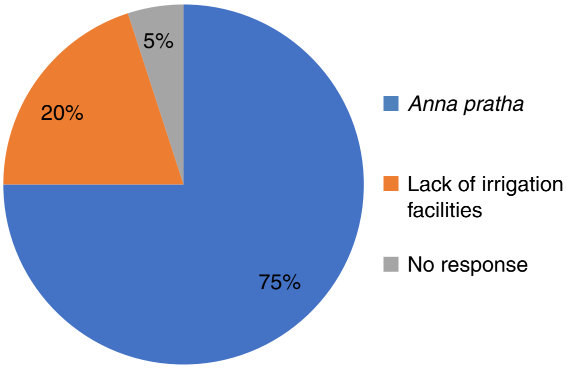


Figure 10.
Major problems faced by respondents in the surveyed area

cities due to long drought spell after selling their livestock to neighbours who are still residing there. The animals are not well-fed due to shortage of fodder, and many of them destroy the agriculture fields in search of fodder and food. Farm animals and agriculture are often interrelated and dependent on each other in the subsistence regions of India. Farm animals provide compost for agriculture, dung is used in biogas plant for energy and dung cakes are air dried and used as the source of energy for cooking. At the same time, agriculture residues provide animal feed both as green and dry fodder. However, due to lack of fodder and agriculture residues, the farm animals are worst hit.

5.9 Irrigation facility – lack of precision irrigation techniques

Being a drought-prone region, irrigation here is of paramount importance. Among the various types of irrigation systems like well water, reservoirs and canal irrigation systems, we found that almost all respondents use tube well water irrigation systems as the canal systems do not feed water when they needed it the most. In total, 80 per cent of the surveyed farmers had problem with irrigation facility and they reported the lack of sufficient water for their fields. The small and marginal farmers in this district are still backward and have limited knowledge about the modern agricultural technology like precision irrigation. There is also a feeling that small and marginal farmers have not adapted to modern techniques of irrigation in a productive manner due to the absence of infrastructure and capacity inputs. The application of newer tools and techniques such as drip irrigation and sprinklers has been limited to few areas only. The increasing costs of modern tools are also prohibitive forcing the famers to use traditional agricultural technologies with a mix of traditional knowledge and practices that are affordable to them. The lack of adequate training and awareness among the farmers about know-how of tools and techniques widens the information gap about the diffusion of new agricultural technology (Jha, 2018).

5.10 Awareness of government schemes and their utilisation

We also attempted to find out the awareness and utilisation among farmers regarding various farming-related schemes and institutions run by government. Details have been provided about KVKs, RKVY, GBY, NFSM, ATMA, Kisan Credit Cards (KCC) and Kisan SMS in Table II and Figure 11. From a public policy point of view, it seems that many schemes have been introduced in the last five years for addressing the problems of farming communities, and some of them have played a positive role in improving the well-being of the subsistence farm holdings. Policy makers have set out mandatory lending target for public and cooperative banks and they have been made to lend the farmers through soft loans. The agriculture sector has been given priority for lending, with 18 per cent of bank

Govt. scheme	Introduced in year	Mandate
Krishi Vigyan Kendra (KVKs)	1974	To conduct technology assessment and refinement, knowledge dissemination and provide critical input support for the farmers with a multidisciplinary approach
Kisan Credit Card (KCC)	1998	To enable farmers to meet their production credit requirements in a timely and hassle-free manner
Gramin Bhandaran Yojna (GBY)	2001–2002	Creation of scientific storage capacity with allied facilities in rural areas to meet the requirements of farmers for storing farm produce
Agricultural Technology Management Agency (ATMA)	2005–2006	Making extension system farmer driven and farmer accountable by way of new institutional arrangements for technology dissemination
Rashtriya Krishi Vikas Yojna (RKVY)	2007	To incentivise states to draw up plans for their agriculture sector more comprehensively
National Food Security Mission (NFSM)	2007	Increasing production of rice, wheat, pulses and coarse cereals through area expansion and productivity enhancement in a sustainable manner in the identified districts of the country

Source: Compiled from various sources

Table II. Government schemes related to enhancing productivity of farming

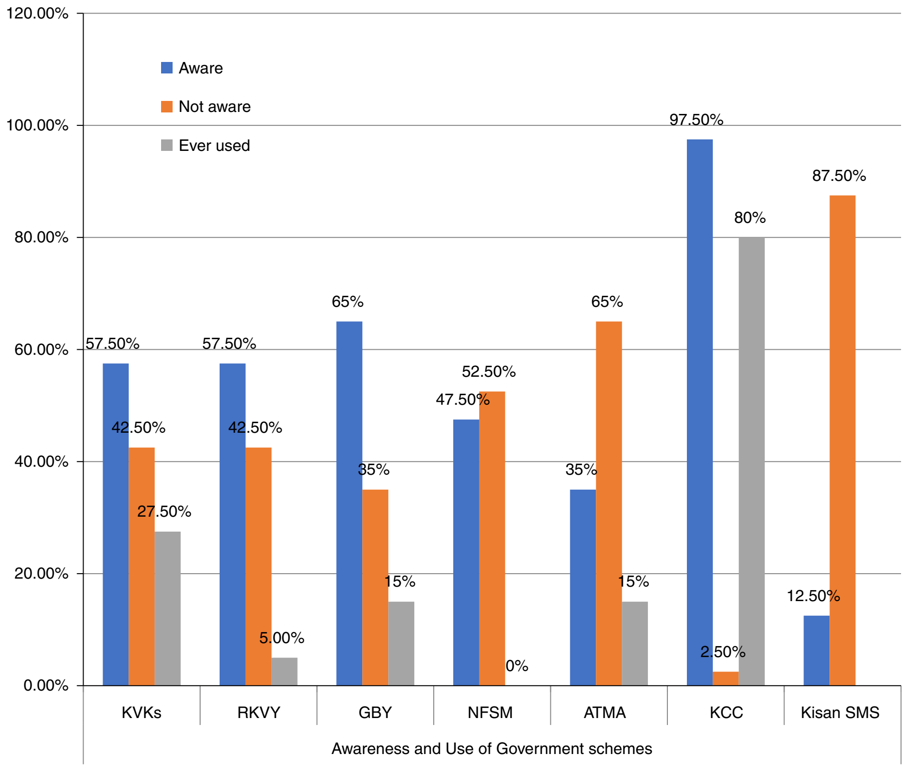


Figure 11. Awareness and use of Government schemes among respondents

credit earmarked for it. Within this 18 per cent, target of 8 per cent has been set out by RBI (2016) for small and marginal farmers. In total, 65 per cent of the respondents took loan from nationalised banks and 20 per cent from cooperative banks. In total, 95 per cent of respondents heard about farm loan-waiver schemes but none of the farmers ever got benefitted from this scheme. The impacts of KCC (a special credit card for farmers) were evident as some of the farmers got subsidy in the loan and did not repay it back due to loan-waiver scheme introduced in 2018. However, some farmers complained of high interest rates being charged by the banks providing the loan. Unfortunately, only 12.5 per cent farmers were aware about Kisan SMS facility – a service provided through the phone for various agri-services. The farmers cited several challenges for availing crop insurance – a common challenge was lack of information and support provided by the banks and cooperatives. Only 7.5 per cent of the respondents were members of any cooperative society. The NSSO Report (July 2012–June 2013) had indicated that a very small share of agricultural households engaged in crop production activities were insuring their crops. There is a need to raise awareness about crop insurance among agricultural households. In this background, the Pradhan Mantri Fasal Bima Yojana (Prime Minister Crop Insurance Scheme) that is an yield index-based crop insurance scheme launched in 2016 and can play a significant role. It has made substantial progress with more ground coverage compared to erstwhile schemes; however, due to the lack of awareness among the farmers, the benefits of the schemes could not be diffused to large segments.

6. Discussion

Bundelkhand region has been one of the most backward regions in all agricultural and allied indicators (Raman and Kumari, 2012) Bundelkhand region, though rich in resources like forest and minerals, is a region in distress and crisis. Agriculture forms the backbone of the rural economy in Bundelkhand. However, the soil and semi-arid climatic conditions of the region characterised by recurrent floods as well as drought make cultivation an extremely difficult occupation with uncertain returns for the farmers. Reasons for present unviable agriculture should be sought in the historically determined social relations of production, the intimate correlation between caste and land ownership in the region as well as the neglect of traditional water management systems and push towards cultivation of water-intensive commercial crops. Crops like wheat are unsuited for agro-climatic conditions of Bundelkhand region. Bundelkhand was known as the bowl of pulses for India. Both the red and the black soils found across the region have poor organic content. The red soil has poor phosphate and nitrogen content that makes it unsuitable for farming. Most of the cultivation is rainfed in nature (PERSPECTIVES, 2010).

Indian agriculture sector has been guided by different policy reforms. Institutional changes, formidable agrarian reforms, development of irrigation projects, abolition of intermediary landlordism and imposition of land ceiling, etc., were main objectives of pre-green revolution period. The second phase of agricultural policy was marked by green revolution to attain food security. Intensive and technology-led cultivation replaced subsistence farming in India. Liberalisation was initiated in 1991 in India including new international trade accords that posed new challenges and opportunities in this sector. The Government of India came up with National Agriculture Policy to fill the policy vacuum in 2000 which was first ever-released agricultural policy by Indian Government. Sustainable Agriculture, Generation and Transfer of Technology, Inputs Management, Food and Nutritional Security, Investment in Agriculture, Incentives for Agriculture, Risk Management and Risk Management were the main objectives of National Agricultural Policy. "Rainbow Revolution" was envisaged through this policy that promises to cover all aspects of the farm sector (Dhoot, 2006). Indian agricultural policy has long been characterised by border and domestic interventions aimed at protecting farmers from international price volatility (Mullen *et al.*, 2005).

Urbanisation, rising incomes, changing relative prices of cereals and non-cereal foods are leading to diet diversification away from cereals and towards high-value agriculture (Mullen *et al.*, 2005). Farming community in drough-prone areas needs adequate investment, local-specific technology, better quality inputs, real-time information on weather and most importantly latest know-how for sustaining commercial and cost effective sustainable agriculture. Topography, climate change, variations in resource endowments and historical institutions and socio-economic factors made Indian agriculture very diverse. Nature of technology that became available over time and policies announced by government reinforced some of the variations resulting from natural factors (DACFW, 2017). These variations have led to uneven agricultural production in different geographical locations that further leads to regional disparities. Rainfall pattern, fertilizer use, levels of irrigation and diversification towards high-value horticultural crops have been identified as some factors that may be responsible for variation farm production (Chand *et al.*, 2011). Agriculture in India has reached a point where it must seek new directions. Relevant policies and actions have to be adopted to find way forward. Considering that there is a wide variation in socio-economic situations, soil and climate, it is obvious that technologies have to spread and evolve considering local settings and in a particular manner (Abrol and Sangar, 2006). The state expects R&D institutions to come up with technologies that can address the irrigation-chemical intensive paradigm (Raina and Shankar, 2011). Findings from the study highlight that majority of the farmers were small farmers. It is a challenge to maintain food security in a sustainable way without addressing issues related to small-holding farmers in developing countries (McIntyre *et al.*, 2009). According to Van De Poel, farmers as technology practitioners are regarded as outsiders, those who are not involved in the design of and decision making about a technology. Directly, they are not able to influence technical development due to the lack of resources. However, they may articulate modes of acceptance for a technology successfully. In the realm of alternative technologies, they play a crucial role (Van De Poel, 2000). He further argues that outsiders may trigger radical technical change that transforms existing technological regimes.

Farmers generally take decisions by their traditional knowledge that when integrated may help in better understanding of the farming conditions. Due to rising uncertainty in weather conditions, this integrated knowledge approach may help us in achieving the goal of sustainable and resilient agriculture. Lybbert and Sumner (2012) argued that for nearly two centuries, research and innovation have played a pivotal role to policies related to agriculture often with the goal of increasing production per unit of land, labour or other input. Improving micronutrient density and negative environmental impacts is more recent agriculture research objectives (Lybbert and Sumner, 2012). Plant diseases are one of the major concerns for farmers. Government has been trying to ensure that farmers get disease-free planting material. When crops get destroyed due to any plant disease, it causes distress among the farmers because they have to repay the loan and also look their families. Government has introduced many schemes crop insurance schemes to protect farmers in such conditions. STI measures that can be taken in this regard can be plant disease forecasting. Plant disease forecasts assist growers in timing disease management activities and can improve farm production efficiency while reducing pesticide applications (De-Wolf and Franel, 1997). National Commission on Farmers in its report listed land reforms, technology fatigue, quality and quantity of water, access, adequacy and timeliness of institutional credit as major causes of farmers' distress (Swaminathan, 2006).

Following STI interventions are urgently required to tackle the challenges of recurrent droughts:

(1) Completion of pending major and minor irrigation projects – many irrigation projects are still pending and a faster completion of these projects would ensure equitable distribution of water in the command control area.

(2) Restoration and renovation of traditional water bodies – this area was once known for many large water storage ponds meant to meet the water demand in

lean seasons. Due to carelessness and ignorance, many of such water storage structures are in bad shape and need immediate restoration. In addition to this, check dams, bunds, farm ponds, tanks etc. can be made within the watershed for maximum storages of rainwater. There is a need of developing secondary storage structures especially at tail end of canal system where water availability is a problem.

(3) Efficient water irrigation system – drip irrigation, sprinklers, precision irrigation etc can achieve higher irrigation efficiencies with low input cost and could be used for both very small and large-sized holdings. It is important to mention here that adoption and use of such technologies by small and marginal farmers would depend heavily on the supply of information and materials for installation as well as subsequent maintenance services.

(4) Using remote sensing and Geographical Information System (GIS) techniques – satellite pictures can be used to identify critical areas for adopting water recharge structures such as check dams, bunds, farm ponds and tanks. With drainage map, sites can be identified where water can be effectively stored during rainy seasons for use in dry periods (Figure 12). A systematic identification, planning and implementation of watershed projects in drought-prone areas can provide long-term solution to water scarcity.

(5) Adoption of improved water saving farm practices – water requirements of various crops can be significantly reduced in semi-arid regions with adoption of farm practices such as increased use of organic manure, vermin-composting, mulching, crop rotation and the use of bio-pest control measures. These measures not only reduce the evaporation losses from the soil but also increase the water use efficiency of plants.

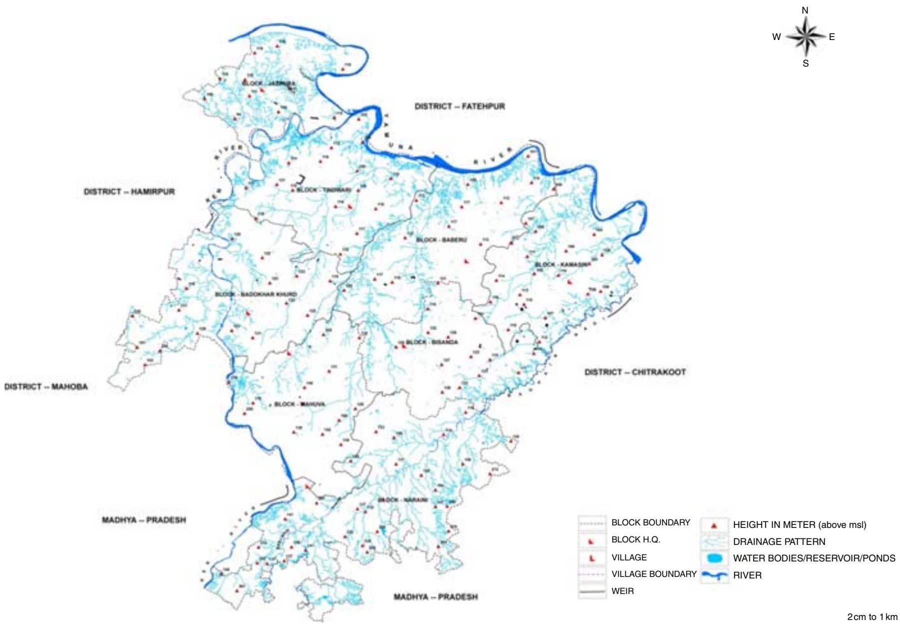


Figure 12.
River network and other water bodies in Banda district

7. Conclusion

Due to occurrence of several drought years in India's arid and semi-arid regions, the importance of STI interventions for improving farm productivity and raising the quality of life of farmers is a topmost priority. Understanding the existing agricultural practices in a particular agro-climatic zone is important for understanding the dynamics of technical and social change. It helps us in analysing how and why different cropping patters are adopted by farmers and what consequences they may have in future. Technologies, when developed considering farmers at the centre and as most important stakeholders may bring the desired outcome. Economical, cultural and social parameters play a major role in successful implementation of STI measures. Findings suggest that majority of farmers are small or marginal farmers so it is very crucial to come up with such STI interventions that cater to the needs of such farmers.

Few recommendations have been made based on the survey findings. It has been observed that farmers are practising monoculture in the surveyed area. So mixed cropping pattern has to be promoted in the area. Local chickpea varieties can be grown along with wheat crop. Drought resistant varieties of the traditionally grown crops have to be developed. Awareness regarding crops that are suited to this particular agro-climatic zone has to be made. This can be made by linking this awareness with scientific evidence. Another area that needs due attention is the sustainable irrigation practices. STI interventions have to be designed considering the interest of small and or marginal farmers. As shown in Table I, the lack of resources, inferior soil and irrigation practices are the limitations that can be tackled through STI interventions. Such technologies that work well within small farms have to be developed. There is need to integrate advance technologies with farmers' cultural, economic and social perspectives. Farmer's school or on farm training school have to be initiated to integrate farmers' traditional knowledge with modern knowledge systems. Farming community in drought-prone areas such as Bundelkhand needs adequate investment, local-specific technology, better quality inputs, real-time information on weather and most importantly latest know-how for sustaining commercial and cost effective sustainable agriculture.

It is also recommended to improve R&D in agriculture innovation particularly for manufacturing tools for small and marginal farmers which are needed to sustain agricultural productivity growth in the long-term. The PDS system should be strengthened because an effective PDS is necessary to provide foods during drought events particularly to the vulnerable sections of the society. There is a need to increase employment options for farmers through effective implementation of public programmes such as Food for Work Programme, Integrated Rural Development Programme and through droughts control programmes like Drought Prone Area Programme.

References

Abrol, I.P. and Sangar, S. (2006), "Sustaining Indian agriculture – conservation agriculture the way forward", *Current Science*, Vol. 91 No. 8, pp. 1020-1025.

Agarwal, B. and Agrawal, A. (2017), "Do farmers really like farming? Indian farmers in transition", *Oxford Development Studies*, Vol. 45 No. 4, pp. 460-478.

Anuja, A.R., Kar, A., Kumar, P., Jha, G.K. and Singh, B.K. (2018), "Analysis of factors triggering distress migration in Bundelkhand region of central India", *Economic Affairs*, Vol. 63 No. 4, pp. 1055-1059.

Census (2011), *District Census Handbook*, Census of India, Banda.

Chand, R., Raju, S., Garg, S. and Pandey, L. (2011), "Instability and regional variation in Indian agriculture", available at: www.ncap.res.in/upload_files/policy_paper/pp26.pdf (accessed 12 July 2018).

Chaturvedi, A., Patil, N.G. and Goswami, S.N. (2011), "Reorienting land use strategies for socio-economic development in Uttar Pradesh", *Economic and Political Weekly*, Vol. 46 Nos 26&27, pp. 169-173.

DACFW (2017), "Annual Report 2016-17", Department of Agriculture Cooperation & Farmers Welfare, Government of India, New Delhi.

De-Wolf, E. and Franel, L.J. (1997), "Neural networks that distinguish infection periods of wheat tan spot in an outdoor environment", *Phytopathology*, Vol. 87 No. 1, pp. 83-87.

Dhoot, S. (2006), "National agriculture policy – a critical evaluation", CUTS International – briefing paper, Jaipur.

FAO (2018), "India at a glance", available at: www.fao.org/india/fao-in-india/india-at-a-glance/en/ (accessed 29 May 2019).

Gautam, R.C. and Bana, R.S. (2014), "Drought in India: its impact and mitigation strategies – a review", *Indian Journal of Agronomy*, Vol. 59 No. 2, pp. 179-190.

GoI (2018), "Economic survey 2017-18", Ministry of Finance Department of Economic Affairs Economic Division, Government of India, Vol. ii, New Delhi, January.

Gupta, A.K., Tyagi, P. and Sehgal, V.K. (2011), "Drought disaster challenges and mitigation in India: strategic appraisal", *Current science*, Vol. 100 No. 12, pp. 1795-1806.

Gupta, A.K., Nair, S.S., Ghosh, O., Singh, A. and Dey, S. (2014), *Bundelkhand Drought: Retrospective Analysis and Way Ahead*, National Institute of Disaster Management, New Delhi.

Gupta, S.D. (2019), *Class, Politics, and Agricultural Policies in Post-liberalisation India*, Cambridge University Press, London.

Jha, R. (2018), "The great Indian agrarian crisis and tales of two villages: comparative studies", *Journal of Agricultural and Environmental Ethics*, Vol. 31 No. 1, pp. 31-37.

Kundu, A., Denis, D.M. and Patel, N.R. (2015), "Evaluation of the meteorological drought over the Bundelkhand region using geo-spatial techniques", *Climate Change*, Vol. 1 No. 4, pp. 418-424.

Lybbert, T.J. and Sumner, D.A. (2012), "Agricultural technologies for climate change in developing countries: policy options for innovation and technology diffusion", *Food Policy*, Vol. 37 No. 1, pp. 114-123.

McIntyre, B.D., Herren, H.R., Wakhungu, J. and Watson, T. (2009), "Agriculture at a crossroads", global report. IAASTD, Island Press, Washington, DC.

Mullen, K., Orden, D. and Gulati, A. (2005), "Agricultural policies in India: producer support estimates, 1985-2002", MTID Discussion Paper No. 82, International Food Policy Research Institute, Washington, DC.

NPI (2017), National Portal of India, Government of India, New Delhi, available at: www.india.gov.in/topics/agriculture (accessed 16 April 2019).

NRAA (2009), *Drought Management Strategies – 2009 Draft*, National Rainfed Area Authority, Ministry of Agriculture, India.

NSSO (2005), "Situation assessment survey of farmers: some aspects of farming", NSS 59th Round (Report No. 496 (59/33/3))NSSO, Ministry of Statistics and Programme Implementation, New Delhi.

Pandey, S. and Bhandari, H. (2009), "Drought: economic costs and research implications", Drought Frontiers in Rice: Crop Improvement for Increased Rainfed Production, pp. 3-17.

Paroda, R.S. (2018), *Reorienting Indian Agriculture: Challenges and Opportunities*, CABI, New Delhi.

PERSPECTIVES (2010), "Drought by design: the man-made calamity in Bundelkhand", *Economic and Political Weekly*, Vol. 45 No. 4, pp. 33-38.

Planning Commission (2014), "Databook", December, available at: http://planningcommission.gov.in/data/datatable/data_2312/DatabookDec2014%202.pdf (accessed 16 April 2019).

Raina, R.S. and Shankar, P.S.V. (2011), "Rainfed agriculture: enabling new rules of the game", SIID Policy Options, No. 1, Centre for Policy Research, New Delhi, December.

Raman, R. and Kumari, R. (2012), "Regional disparity in agricultural development: a district level analysis for Uttar Pradesh", *Journal of Regional Development and Planning*, Vol. 1 No. 2, pp. 71-90.

RBI (2016), "Priority sector lending – targets and classification", Reserve Bank of India, New Delhi.

Samra, J.S. (2004), "Review and analysis of drought monitoring, declaration and management in India", Working Paper No. 84, International Water Management Institute, Colombo.

Shakeel, A., Jamal, A. and Zaidy, M.N. (2012), "A regional analysis of food security in Bundelkhand region (Uttar Pradesh, India)", *Journal of Geography and Regional Planning*, Vol. 5 No. 9, pp. 252-262.

STIP (2013), "Science, Technology and Innovation Policy 2013", Ministry of Science and Technology, Government of India, New Delhi.

Suthar, S.K. (2018), "Bundelkhand development package, drought and the development question in India", *Social Change*, Vol. 48 No. 3, pp. 398-416.

Swaminathan, M.S. (2006), "Swaminathan report: National Commission on Farmers", available at: www.prsindia.org/administrator/uploads/general/1242360972~~final%20summary_pdf.pdf (accessed 21 August 2018).

UN (1990), "What can be done about drought? International decade for natural disaster reduction", IDNDR Secretariat, Geneva.

Van De Poel, I. (2000), "On the role of outsiders in technical development", *Technology Analysis & Strategic Management*, Vol. 12 No. 3, pp. 383-397.

Further reading

C-DAP (2018), "Comprehensive – district agriculture plan", available at: http://agriculture.up.nic.in/WriteReadData/CDAP-RKVY/Banda.pdf (accessed 16 April 2019).

NAP (n.d.), "New agriculture policy", available at: http://rrtd.nic.in/agriculture.html (accessed 25 August 2018).

About the authors

Dr Venkatesh Dutta brings distinctive synthesis of environment, social and agricultural innovations from academic debate to action-oriented policy landscape in India. He is Associate Professor of Environmental Sciences at the Babasaheb Bhimrao Ambedkar (Central) University, Lucknow. He is also Programme Coordinator of DST Centre for Policy Research that works on agriculture, water and public health. Venkatesh's interests lie in water resources management, river systems, science and technology policy, and planning theory, with a particular focus on the interactions between environment, society and technology. He is a Fulbright Fellow and a British Chevening Scholar. He did his postdoctoral research at the School of Public Policy, University of Maryland, USA and doctoral work at the Faculty of Policy and Planning, TERI School of Advanced Studies, New Delhi. His writing has provoked responses that include the restoration of smaller streams and wetlands and revamping of the ground water management programs in the state of Uttar Pradesh. He has mentored five doctoral scholars and has several publications to his credit. Dr Venkatesh Dutta is the corresponding author and can be contacted at: dvenks@gmail.com

Dr Manoj Vimal comes from an interdisciplinary background covering both natural and social sciences. He has obtained MPhil and PhD Degrees in the area of Science, Society and Development from Central University of Gujarat. Earlier he worked at Centre for Policy Research, New Delhi as Consultant. He has visited the UK and Netherlands for academic pursuits. His research interests lie at the interface of STI and society. He worked at DST-CPR, BBAU, Lucknow in the thematic area of agriculture during May 2017 to March 2018 and is currently working as Postdoctoral Research Fellow at School of Social Sciences, Nanyang Technological University, Singapore.

Sonvir Singh is Field-cum-Technical Assistant at DST Centre for Policy Research that works on agriculture, water and public health and holds graduate degree in Agriculture.

Professor Rana Pratap Singh is Faculty Member of Environmental Science and is also Dean of Academic Affairs at Babasaheb Bhimrao Ambedkar (Central) University, Lucknow (India). He has worked as Head of the Department of Environmental Science and Dean, School for Environmental Sciences and School for Management Studies. He has worked as a member of an MoEF nominated committee, State Expert Appraisal Committee, UP at Directorate of Environment, Lucknow for a period of three years during 2011–2013. Presently he is the Chairman of State Expert Appraisal Committee, UP. He has 30 years teaching, 35 years of research and 7 years of administrative experience in the Indian Universities and has 3,729 citations, H index of 33 and i10 of 79 to his credit for his research.