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Farmers' perspectives as determinants for adoption of conservation agriculture practices in Indo-Gangetic Plains of India

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ABSTRACT

Understanding the farmer's perspective has traditionally been critical to influencing the adoption and out-scaling of CA-based climate-resilient practices. The objective of this study was to investigate the biophysical, socio-economic, and technical constraints in the adoption of CA by farmers in the Western- and Eastern-IGP, i.e., Karnal, Haryana, and Samastipur, Bihar, respectively. A pre-tested structured questionnaire was administered to 50 households practicing CA in Western- and Eastern-IGP. Smallholder farmers (<2 ha of landholding) in Karnal are 10% and Samastipur 66%. About 46% and 8% of households test soil periodically in Karnal and Samastipur, respectively. Results of PCA suggest economic profitability and soil health as core components from the farmer's motivational perspective in Karnal and Samastipur, respectively. Promotion and scaling up of CA technologies should be targeted per site-specific requirements, emphasizing biophysical resource availability, socio-economic constraints, and future impacts of such technology.

Introduction

Indo-Gangetic Plains (IGP) witnessed the green revolution and is amongst the world's most fertile alluvium. IGP of South Asia has continuous rice-wheat cropping in an area of 13.5 million ha with intensive tillage resulting in over-exploitation of resources, a declinein productivity, and loss of soil fertility and biodiversity, rapid deterioration of resource use efficiency (Bhan and Behera, 2014). Periodic extreme weather events, such as increased temperature, floods, and droughts, led to a significant portion of cropland remaining uncultivated affecting crop yield intensity of IGP (Jat et al., 2016). Furthermore, burning crop residues, soil degradation, growing labour costs, and fuel prices worsen the scenario of the conventional agricultural system (Sidhu et al., 2015). Such events lead to greater instability in food production and threaten the livelihood security of millions of farmers of the IGP (Chhetri et al., 2016; Jat et al., 2016). It is expected that the implementation of CA practices and technologies could improve crop yields, bring abandoned land under cultivation, provide resilience against extreme events and increase the income of households. Modern CA concept includes interlinked three principles, i.e., (i) minimizing mechanical soil disturbance and seeding directly into untilled soil to improve soil organic matter (SOM) content and soil health; (ii) enhancing SOM using cover crops and crop residues (adoption of CA protects the soil surface, conserves water and nutrients, promotes soil biological activity, and contributes to integrated pest management); and (iii) diversification of crops in associations, sequences, and rotations to enhance system resilience (FAO, 2011). CA started in the early 1990s in India, aiming to (a) eliminate unsustainable elements (monocropping, soil degradation, straw burning) from tillage-based agriculture systems and (b) adopt the characteristics of CA that make the production systems more profitable and ecologically sustainable (Erenstein et al., 2012; Abrol and Sanger, 2006). CA offers an opportunity for arresting and reversing the downward spiral of resource degradation, diminishing factor productivity, decreasing cultivation costs, and making agriculture more resource-use efficient, competitive, and sustainable (Abrol and Sanger, 2006; Jat et al., 2013; Bhan and Behera, 2014). Thus the

Abbreviations: IGP, Indo-Gangetic Plains; CA, Conservation agriculture; SOM, Soil organic matter; CRs, Crop residues; ICT, Information and communication technology; PCA, Principal cmponent analysis.

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adoption of CA seems promising for enhancing sustainable food production and a viable option for improving the livelihood of smallholder farmers. More than 80% of farmers in India are small landholders with less than 2 ha farm size and contribute above 50% of total agricultural output by cultivating 44% of farmland and supporting millions of people's livelihood and food security (Chhetri et al., 2016). While several programs were initiated in the last two decades to promote CA in the entire stretch of IGP for achieving sustainable farming systems, unfortunately, there is a general paucity and split of literature that clarifies the adoption and extent of CA in Indian IGP. Understanding the drivers and determinants of CA adoption that are influencing the dynamics of the extension and then up-scaling the process are very decisive in explaining adoption (Ngwira et al., 2014).

There is a need to reverse the top-down approach where the extension agent places CA demonstrations in a farmer's field and expects farmers to adopt. Instead of this method, a more participatory system is required where farmers are enabled through the provision of equipment and training to experiment with the technology and find out for themselves whether it works, and if not, then what sort of fine-tuning is needed to make it successful on their area (Bhan and Behera, 2014). This study provides insight into the factors that determine the adoption of CA and explains variability in the extent of CA amongst different households. Understanding the farmer's perspective has traditionally been critical to influencing the adoption and up-scaling of CA-based climate-resilient practices. The objective of this study was to investigate the biophysical, socio-economic, and technical constraints in the adoption of CA by farmers in the Western and Eastern IGP. Our findings were visualized to identify the averse-to CA adoption and the limitations of CA adoption and doing a better business module between scientists, farmers, extension agents, policymakers, and other stakeholders in the private sector for developing and promoting new CA technologies.

Materials and methods

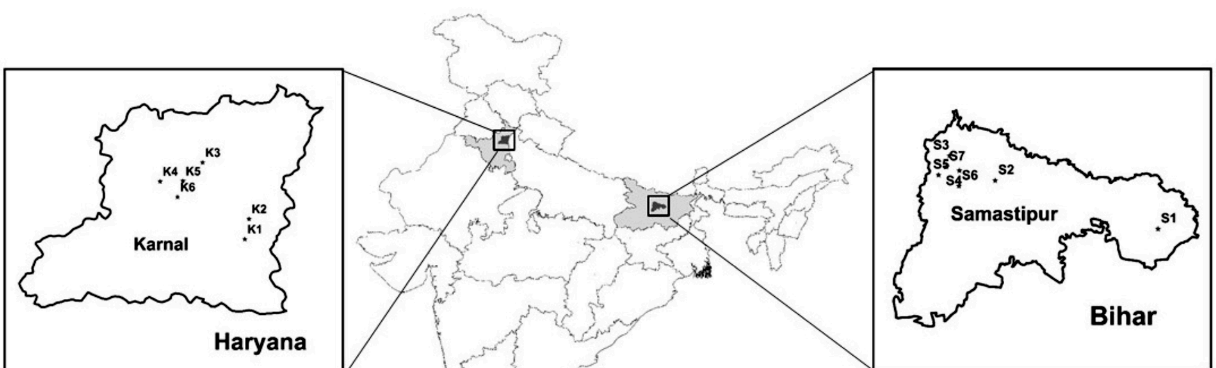
Study area and description

This study was conducted in the Karnal district of Haryana (Western-Gangetic Plains) and Samastipur district of Bihar (Eastern Gangetic Plains) based on variability in agro-ecology, socio-economic, population density, and cropping intensity (Fig. 1). Karnal district lies between 29° 09′ 50″ and 29° 50′ N and 76° 31′ 15″ and 77° 12′ 45″ E (240 m MSL). The climate of the area is semiarid, with an average annual rainfall of 700 mm (75–80% of which is received during June–September), a daily minimum temperature of 0–4 °C in January, a daily maximum temperature of 41–44 °C in June, and relative humidity of 50–90% throughout the year (Kumar et al., 2013). Samastipur district lies between 25° 84′ 09″ and 25° 88′ 09″ N and 85° 80′ 88″ and 85° 74′ 11″ E (56 m MSL). The site's climate is characterized by hot and humid summers and cold winters with an average rainfall of 1200 mm, 70% (941 mm) of which occurs during July-September (Jat et al., 2014). Frequent droughts and floods are common in this region.

Haryana has a total geographical area of about 4.42 m ha; the cultivable area is 3.7 m ha, 84% of the state's geographical location, out of which 3.64 m ha, i.e., 98% is under cultivation. On the other hand, Bihar has a total geographical area of about 9.36 m ha, the cultivable area is 7.95 m ha, which is 85% of the state's geographical location, which is 5.60 m ha, i.e., 70% is the net cultivated area (Agriculture Census, 2014). Haryana and Bihar have 185% and 138% cropping intensity, respectively. The Karnal and Samastipur district has a population density of 598 and 1465 inhabitants/km^2. In addition, the population growth rate in Karnal and Samastipur districts was 18% and 25% over the decade 2001–2011 (Agriculture Census, 2014).

Sampling procedure and data collection

This study was conducted in 6 (Sagga, Kutail, Unchsmana, Taraori, Baloo, and Sambhali) villages in Karnal and 7 villages (Srirampur Ayodhya, Kubauliram, Bishanpur Dimangra, Repura, Waini, Shahpur



Codes	Villages
K1	Kutail
K2	Uncha Siwana
K3	Taraori
K4	Sambhli
K5	Sagga
K6	Baloo

Codes	Villages
S1	Chandauli
S2	Bishanpur Dimangra
S3	Srirampur Ayodhya
S4	Shahpur Baghauni
S5	Kubouliram
S6	Repura
S7	Waini

Fig. 1. Map of study locations (villages) in Karnal and Samastipur districts of IGP, India.

Baghauni and Chandauli) in Samastipur that adopted CA-based management practices. More than 50 CA adopted farmers were randomly selected from each Western and Eastern IGP, respectively, for the survey. The structured questionnaire had open-ended and closed questions to obtain quantitative data from the sampled respondents. The survey was used to collect demographic, CA adoption, agronomic practices, weed and pest control, irrigation, crop production and marketing, socio-economic, livelihood, livestock, soil health, and climate change factors from the sampled respondents. The questionnaire was pre-tested by crucial informants and 5 households, making corrections before its final field observation. Key informants' interviews were conducted to fill the gaps in the questionnaire survey and verify the results. The study involved a wide range of stakeholders i.e., farmers, key village and ward leaders and officials, district leaders and officials, and NGO members to capture holistic purview of CA. These stakeholders are actively involved in various operations and programs related to agriculture development in the region, therefore, we tried to understand their mindset for adoption and scaling of CA.

Statistical analysis

Descriptive analyses were used to determine factors that influence the adoption. The questionnaire survey data were analysed using SPSS statistical package ver. 19 (SPSS Inc., Chicago, USA). The Principal Component Analysis (PCA) and Mann-Whitney U test were used to discover the significant factors affecting the adoption and scaling of CA. The Mann-Whitney U test is used to compare differences between two independent groups when the dependant variable is either ordinal or continuous, but not normally distributed. PCA was performed by transforming the original variables into a smaller linear combination called principal components (PC).

Results and discussion

Descriptive statistics of household and farm characteristics

The basic social structure in Western and Eastern-Gangetic plains is presented in Table 1. Globally case studies have indicated that farm size, farm income, and human capital are correlated to the decision to adopt CA (Chhetri et al., 2016-India; Pedzisa et al., 2015-Zimbabwe; Ng'ombe et al., 2014-Zambia; Giller et al., 2009-Africa; Fujie 2015-Japan; Tosakana et al., 2010-United States; Ngwira et al., 2014- Malawi, Erenstein et al., 2012-South Asia, Mexico, and Southern Africa; Kahimba et al., 2014-Tanzania). Therefore, social structure and demographic characteristics such as farm size, farm income, age, and education of the farmers, are relevant to the adoption decision. The farm size variable represents less than 2.5 acres as small-scale farming; our survey results suggested that only 10% and 66% of Karnal and Samastipur households are categorized as smallholder farmers. The average farm size of the whole sample in Karnal and Samastipur is 13.1 and 3.4 acres, respectively. Smallholders are less able to invest in new equipment and are more risk-averse than large-scale farmers (Ngwira et al., 2014). In Karnal and Samastipur, 46% and 72% of the sample households have bigger family sizes (>5 adults (>18 years of age) members). The ratio of elderly farmers (over 50 years old) is 12% and 22%, respectively, which is an essential factor for taking the risk of a newly developed innovation (Sapkota et al., 2015) because family conditions force farmers' to search for a new source of income. Allocation of land in CA increased with the duration of practice (CA experience) with a statistically significant correlation ($r = 0.55^{**}$) in Samastipur, suggesting increased knowledge, skill, and experiences gained in CA, might be the likelihood of allocating more land to CA, as farmers' respond to yield gains, labour savings, and soil quality improvement (Ngwira et al., 2014). About 46% of households get the soil tested periodically in Karnal. However, the soil awareness and inspection are much lower in Samastipur, i.e., 8%. Such results also significantly contribute to the lower adoption and allocation of land in CA (Chhetri et al., 2016).

Table 1
Variable description and summary of household information.

Variable	Definition	Karnal Mean	Karnal Std. Dev.	Samastipur Mean	Samastipur Std. Dev.
Household and Farmers information					
Farm size	1 if >2.5 acres of land, 0 otherwise	0.90	0.30	0.44	0.50
Family size	1 if >5 members are there in a household, 0 otherwise	0.46	0.50	0.72	0.45
Farmer's age	1 if the farmer's age is >50 years, 0 otherwise	0.12	0.33	0.22	0.42
Education	1 if the passed secondary school, 0 otherwise	0.74	0.44	0.74	0.44
CA practice experience	1 if >3 years of CA practice, 0 otherwise	0.66	0.48	0.18	0.39
Extent of CA	1 if proportion of land under CA divided by total cultivated land is >33%, 0 otherwise	0.98	0.14	0.52	0.50
Soil fertility monitoring	1 if farmer inspect soil periodically, 0 otherwise	0.46	0.50	0.08	0.27
Farmer's perspective and awareness					
Economic profitability	1 if CA saves input cost without compromising with the yield, 0 otherwise	0.90	0.31	0.87	0.33
Environment friendly	1 if CA saves water, improves soil health and reduces straw burning consequences, 0 otherwise	0.88	0.31	0.71	0.34
Frequency of interaction with CA knowledge providers	1 if CA promotion agents comes frequently, 0 otherwise	0.82	0.39	0.82	0.39
Quality of information from the Agent	1 if the farmer is satisfied by the input provided by the CA agent, 0 otherwise	0.78	0.42	0.72	0.45
Role of ICT Sources	1 if ICT sources helpful in CA extension, 0 otherwise	0.82	0.39	0.46	0.50

Farmers' perspective and awareness

CA was found economically profitable and eco-friendly as per the survey result (Table 1). Farmers also appreciate the role of CA promotion agents and the valuable advice from the agents to improve CA and government schemes related to CA and subsidy. Access to change agents' input support can help overcome the challenges and constraints of adopting CA. Pedzisa et al. (2015) and Fujie (2015) also reported similar results. ICTs played a crucial role in disseminating comprehensive information about the innovation. In Samastipur, with low access to ICTs, only 46% of the farmers understand that ICTs are helpful in the adoption and extension of CA. Our results confirm with previous studies by Bellotti and Rochecouste (2014).

CA technology-based determinants affecting adoption and diffusion

CA practices are both management and knowledge-intensive and complex, requiring more planning than tillage-based systems. It cannot be reduced to a technology package, as adoption requires both change and adaptation based on experiential learning (Kassam et al., 2014). This study investigated four CA-based management practices, i.e. zero/minimal tillage, crop diversification, residue recycling, and permanent raised beds. Zero tillage under wheat is primarily practiced in

Western and Eastern IGP (Fig. 2). However, IGP s a long history of rice-wheat cropping system,which is why diversification seems to be a challenge.

In contrast, the small household farmers of Samastipur diversified their cropping system to generate income and sustain livelihood. In IGP, over 297.5 Mt of agricultural residues are produced yearly, 47.9% of the total crop residues (CRs) generated in India. However, 61.6 Mt of residue is burnt annually in IGP, which is about 62.5% of the total CRs burnt in India, leading to severe air, soil, and water pollution (Jain et al., 2014). In Karnal, only 48% of the household utilizes CRs as mulch, however, in Samastipur, 92% of CRs is used as livestock feed and the rest is for mulching (Table 2). Pulses were introduced in the rice-wheat cropping system to fix nitrogen naturally and maintain soil health. Maize is being proposed as a crop gaining more attention in water stress conditions for diversifying cropping systems and grown on permanent raised beds. About 62% of households adopted permanent raised bed planting of maize crop in Samastipur, but still, it is under concern in Karnal. There is a subsidy on the water in Karnal, not in Samastipur. Chhetri et al. (2016) and Sapkota et al. (2015) also observed similar findings.

Kassam et al. (2014) emphasized four basics for higher adaptation of CA amongst farmer (i) use of well-adapted good quality seeds (ii) enhanced and balanced crop nutrition, based on and in support of healthy soils (iii) integrated management of pests, diseases and weeds and (iv) efficient water management. Our study also tried to determine the availability of such resources in Trans and Eastern IGP. Quality seed, irrigation, mechanization, weedicide, and pesticide are critical to CA's success and significantly affect the decision-making process for CA adoption and extension (Table 2). Samastipur faces challenges about quality seed availability, irrigation facility, pest and disease control, and modern seeding and fertilizer application equipment, but Karnal has an advantage over these challenges.

Table 2
Influence of CA-based management technologies adoption amongst households.

Variables	Definition	Karnal Mean	Karnal Std. Dev.	Samastipur Mean	Samastipur Std. Dev.
CA technologies practice					
Zero tillage	1 if farmer employed ZT, 0 otherwise	0.96	0.20	0.92	0.27
Crop diversification	1 if farmer employed CD, 0 otherwise	0.44	0.50	0.94	0.24
Residue recycling	1 if farmer employed CI/R, 0 otherwise	0.48	0.50	0.08	0.27
Permanent raised beds	1 if farmer employed PB, 0 otherwise	0.04	0.20	0.60	0.49
A portion of crops in CA					
Rice	1 if farmer cultivates rice in CA, 0 otherwise	0.34	0.48	0.08	0.27
Wheat	1 if farmer cultivates wheat in CA, 0 otherwise	0.94	0.24	0.92	0.27
Maize	1 if farmer cultivates maize in CA, 0 otherwise	0.10	0.30	0.62	0.49
Pulses	1 if farmer cultivates pulses in CA, 0 otherwise	0.44	0.50	0.38	0.49
Resource availability for CA					
Quality seed	1 if farmer get easily from the market, 0 otherwise	0.58	0.50	0.26	0.44
Irrigation	1 if irrigation facility available by their own, 0 otherwise	0.74	0.44	0.28	0.45
Mechanization	1 if zero tillage machine available easily, 0 otherwise	0.58	0.50	0.32	0.47
Weedicide and pesticide	1 if farmer get easily from the market, 0 otherwise	0.72	0.45	0.32	0.47

Motivations for adoption and scaling of CA

Principal component analysis (PCA) simplifies the complexity in high-dimensional data while retaining trends and patterns. It does this by transforming the data into fewer dimensions, which act as summaries of features. There are several factors/components that governs the adoption of CA and it varies with the region, our idea is to identify the key factors/components that affects adoption and scaling of CA in both the study sites. In this study, farmers' motivations toward CA are summarised into PCA factors based on their observations and opinions that critically support in decision-making (Table 3). In Karnal, the first principal component strongly correlates with 6 of the original variables (high return, soil health, soil moisture retention, easeof weeding and fertilizer application, water-saving and reluctance to water lodging). On the other hand, in Samastipur, the first principal component is strongly correlated with four original variables (soil health, high return, easeof weeding and fertilizer application and water saving). Furthermore, we found that the first principal component correlates most strongly with the increased recovery and soil health in Karnal and Samastipur, respectively. The first principal component is primarily for economic profitability ($r = 0.843$) and soil health ($r = 0.806$) in Karnal and Samastipur, respectively, based on the highest correlation (Table 3). Our findings are corroboration by Fujie (2015) and Ngwira et al., al.(2014).

In contrast, the strongly correlated parameters for PC2 are timely sowing, labour saving, and reluctance to water lodging in Karnal, signifying the importance of agronomic practices and profitability; however, in Samastipur, PC2 is strongly correlated with labour-saving timely sowing and soil moisture. In Samastipur, PC2 is negatively related to soil moisture retention. This may be due to low mulching, as

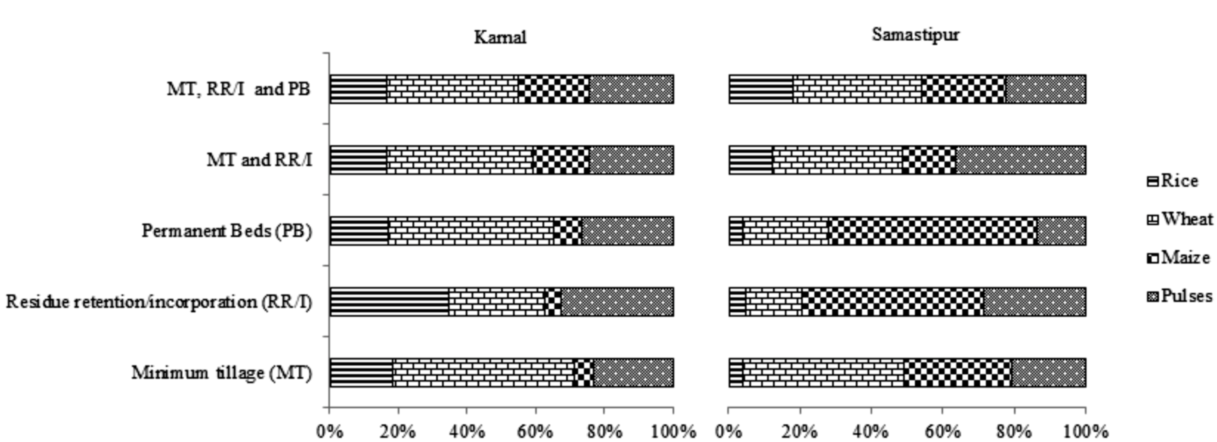


Fig. 2. The proportion of crop types grown under different CA technologies in Karnal and Samastipur.

Table 3
Principal component analysis on the motivational aspect for the adoption of CA.

Variables	Karnal		Samastipur	
	PC 1	PC 2	PC 1	PC 2
High return	*0.843*	0.171	*0.789*	-0.069
Soil health improvement	*0.827*	0.006	*0.806*	-0.037
Soil moisture retention	*0.796*	-0.205	0.293	*-0.434*
Ease to weeding and fertilizer application	*0.729*	0.264	*0.682*	-0.008
Water saving	*0.629*	0.268	*0.681*	0.060
Timely showing	0.114	*0.857*	0.141	*0.804*
Labour saving	-0.025	*0.739*	0.141	*0.804*
Reluctant to water lodging	*0.458*	*0.489*	0.389	0.129
Cumulative explained variance (%)	42.9	51.4	31.1	49.8
Rotation method	Varimax			
Kaiser-Meyer-Olkin test	0.656		0.661	
Cranach's alpha	0.792		0.647	
The principal component is classified regarding PC loading (>0.4)				

the crop residues are utilized as livestock feed. Many researchers (e.g., Gathala et al., 2011; Saharawat et al., 2011; Erenstein et al., 2012; Kumar et al., 2013; Jat et al., 2014; Sapkota et al., 2014; Chaudhari et al., 2015) have demonstrated short-term and long-term economic and environmental benefits of CA in the IGP of South Asia.

Challenges in adoption and scaling of CA

Despite CA's economic, agronomic, and environmental benefits, its adoption and extension are still slower in South Asia (Sapkota et al., 2015). Various agro-technological, socio-economic and other interlinked factors are responsible for CA's slow adoption and scaling up in IGP. CA is highly knowledge-intensive and requires skills to gain better outcomes. Although the basic CA principles are common and have global applicability, actual practices towards these desirable objectives can vary across agro-ecosystems and socio-economic conditions (Erenstein et al., 2012; Sapkota et al., 2015; Kassam et al., 2015). Factors extracted from PCA for determinants of practical limitations and challenges in fastening adoption and scaling up of CA in the IGP are given in Table 4. In Karnal, the PC1 is strongly correlated with three original variables (low return, expensive and low seed germination). This component indicated low net profitability due to a lack of agro-technological skills and agronomic practices. However, in Samastipur, the PC1 is highly correlated with four variables (e.g. low return, expensive, low seed germination and lack of timely irrigation). Samastipur has a smaller farming household and would not be able to manage expensive seeds, fertilizer, pesticides and irrigation. On the contrary, irrigation is not a constraint for farmers as the state government provides subsidies for electricity.

In Karnal and Samastipur, PC2 represents three standard variables, i.e., lack of quality seed, fertilizer, and higher infestation of weeds and pests. Furthermore, PC2 for Samastipur was highly correlated with lack of equipment ($r = 0.618$) and the gap in knowledge and training ($r = 0.452$). Due to these limitations, CA's adoption, extension, and scaling up in Samastipurwere low. On the contrary, this can be overcome by making a farmers' group in Karnal. Availability, advancement, and site-specific modification in equipment and related skills/training are crucial for adopting and scaling CA (Kassam et al., 2014; Sapkota et al., 2015). The finding is consistent with results reported earlier (Chhetri et al., 2016; Pedzisa et al., 2015; Ng'ombe et al., 2014; Ngwira et al., 2014; Kahimba et al., 2014).

Table 4
Principal component analysis for visualization of practical challenges in CA adoption.

Variables	Karnal		Samastipur	
	PC 1	PC 2	PC 1	PC 2
Low return	*0.915*	-0.016	*0.894*	-0.001
Expensive	*0.780*	0.026	*0.777*	-0.006
Poor germination	*0.773*	0.149	*0.739*	0.064
Lack of timely irrigation	0.262	-0.258	*0.581*	0.083
Lack of quality seed	0.002	*0.780*	0.089	*0.815*
Lack of fertilizer	-0.218	*0.725*	0.172	*0.805*
Infestation pest and weeds	0.329	*0.724*	0.080	*0.715*
Lack of equipment	0.176	-0.263	0.146	*0.618*
Gap in knowledge and training	0.060	-0.168	0.069	*0.452*
Cumulative explained variance (%)	31.3	53.7	24.9	45.4
Rotation method	Varimax			
Kaiser-Meyer-Olkin test	0.638		0.587	
Cranach's alpha	0.701		0.480	
The principal component is classified regarding PC loading (>0.4)				

Change agents and information and communication technology (ICT) in the promotion and up-scaling of CA

The diffusion of innovations model identified access to information as the critical factor determining adoption decisions (Rogers, 2003; Kahimba et al., 2014; Ngwira et al., 2014). Change agents (e.g., extension agents, researchers, NGOs, and the private sector) and ICT play a crucial role in disseminating and accelerating innovation to farmers. Our study tried to find the frequency of these agents visiting the farmers and the support/advice for better adoption and scaling up CA (Table 5). The change 'agents' frequency of visits and advice to farmers were used to identify the differences amongst the study sites. The frequency of visits by the extension agents and NGOs was statistically significant ($p < 0.01$***).

Furthermore, the researcher's visit was also statistically significant ($p < 0.1$*). Our results were consistent with the findings of others (Ngwira et al., 2014; Kassam et al., 2014; Kahimba et al., 2014). The intervention by extension and NGOs agents was relatively higher in Karnal than in Samastipur except for one case by the private sector, including farmers' society and networking. That could be why Karnal highly adopted and extended land area under CA compared with Samastipur (Fig. 3).

The change agents advised farmers on agronomic practices, weather information, government policy/training, market, buyers, pests and diseases, CA technologies, and livestock husbandry. Comparing the study area, advice related to weather information and livestock husbandry was statistically significant ($p < 0.01$***), and on, market and buyers and pest and diseases substantial ($p < 0.1$*). This result implied a higher risk of failure amongst smallholders due to weather and livestock, market and pest and disease, and they are averse to adopting decisions.

The role of ICT in the dissemination and extension of CA technology to remote areas cannot be ignored, particularly in India, as the impact of

Table 5
Determinants of CA adoption and extension amongst the households.

Frequency of visits by change agents to the household			
Variables	Karnal (n = 50)	Samastipur (n = 50)	*U*
Extension agents	64.0	37.0	574***
Researchers	55.4	45.6	1003*
NGOs representatives	58.2	42.8	864***
Private sector	53.0	48.0	1127
A) *Advice from change agents to the household*			
Agronomic practices	51.5	49.5	1200
Weather information	59.5	41.5	800***
Government policy/ workshop/ training	51.0	50.0	1225
Market and buyers	54.0	47.0	1075*
Pest and diseases	55.0	46.0	1025*
Improvement of CA	52.0	49.0	1175
Livestock husbandry	59.5	41.5	800***
A) *Role of ICT*			
TV	64.0	37.0	575***
Mobile	47.0	54.0	1075**
Radio	49.5	51.5	1200

Mann-Whitney U test; * $p < 0.1$,** $p < 0.05$ and *** $p < 0.01$.

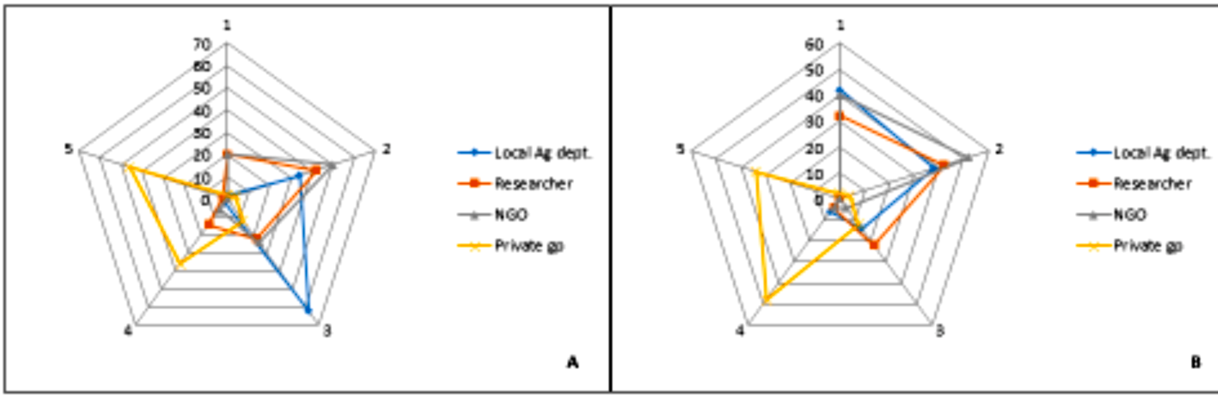


Fig. 3. Visit frequency of different extention agents to the farmers to promote CA systems in the region. Where, 1- Never visited; 2- Once in a year; 3- Once in 6 month; 4- Once in a month and 5- Once in a week. A: Karnal and B: Samastipur.

TV ($p < 0.01$***) and mobile ($p < 0.05$**) on adoption was statistically significant. Using more TV and mobile phones, Karnal has an advantage over Samastipur in gathering more information on better ways to up-scale CA technology.

Conclusion

A holistic paradigm shifts from conventional to CA requires a total transformation of farmers' traditional mindsets and beliefs. Farmers of Trans and Eastern IGP who are now transitioning from conventional to CA need policy support, better skills, frequent visits, and detailed advice on every component of CA. The risk factor was more pronounced in Samastipur as they have small landholding and are more susceptible to technology failure, requiring more assurance in terms of risk coverage. Initial expenditure, low visible return, quality seed availability, fertilizers, and irrigation facility were typical constraints to the adoption and extension of CA in IGP. However, Eastern IGP needs more training and knowledge, area-specific technology for smallholding, and support from a change agent to initiate the second green revolution.

Ethical approval

This manuscript has not been published in any form or language and this peace of work is not under submission anywhere.

Consent to participate

In the given work, prior consent has been taken from the interviewer (Farmers and key informants) and from the authorised institutions.

Consent to publish

Prior content has been taken for the publication of this work as this work is from the first author's PhD thesis.

Authors contributions

Ajay Kumar Mishra: proposed the research, structure development and manuscript preparation

Hitoshi Shinjo and Shinya Funakawa supervised the work

Hanuman Sahay Jat, Mangi Lal Jat Raj Kumar Jat and Jhabar Mal Sutaliya facilitated the survey, helped in the analysis and reviewed the manuscript

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H.S. Jat: Supported in data collection and analysis

M.L. Jat: Supported in data collection and analysis and improving the manuscript

R.K. Jat: Supported in data collection and analysis

S. Funakawa-Helped in analysis and curated the manuscript

J.M. Sutaliya- Assisted in data collection and analysis

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Ajay Kumar Mishra reports financial support was provided by Kyoto University.

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: Not applicable

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