



TOWARDS A MOBILE APP TECHNOLOGY-ENABLED SUSTAINABLE AGRICULTURE IN INDIA

Neeta Raj Sharma^{1*}, Shashi Sharma², Deepansh Sharma³

¹School of Bioengineering and Biosciences, Lovely Professional University, Phagwara, India

²Department of Agriculture and Food, Western Australia, South Perth, WA 6151

³Amity institute of Microbial Technology, Amity University, Jaipur, India

* Author for correspondence: neeta.raj@lpu.co.in

Abstract

India has made excellent economic progress in the first two decades of 21 century and this trend is likely to continue in years ahead. Global trends in mobile Apps in agriculture indicate enhanced emphasis on simple to use features although customization is on the rise as it offers flexibility to perform a choice-based farming tasks. Apps are usually designed with primary focus on usability. They are proving to be an excellent tool for enabling community learning to reduce the knowledge and skill gap of agrarians. Geography and space related information is managed, processed and visualized by geospatial applications and mobile Apps provide farm and situation specific advice and offer information on market prices, farming techniques, weather forecasts, rural health initiatives, fertilizer availability, crop and field management, soil health management, farmers connect and services and many more. An exploratory survey was conducted in Phagwara District of Punjab State in northern India to determine the awareness of farmers about mobile apps as tools for seeking relevant information relating to various aspects of farming. It was shocking to learn that only 4% farmers were aware about the Apps and their use in agriculture. Punjab is a leading state in agriculture in India if this is the state of farmers awareness of mobile APPs in Punjab it can be deduced that the level of nation-wide farmers awareness is dismal. The policy makers should explore the possibilities for outreach the farmers with local authorities, agriculture industries which can channeled farmers for promoting the digital mobile based interfaces.

Keywords : Mobile Technology, Agri Apps, Smart Phone

Introduction

India has made excellent economic progress in the first two decades of 21 century and this trend is likely to continue in years ahead (Yun Zhang *et al.*, 2016; Alagh, 2016, Singh, 2016). With a population of over 1.2 billion, India has emerged as a global player and witnessed tremendous progress in agriculture sector (Joshi, 2016, India Country Overview 2011, World Bank). Central Statistics Office estimated that the share of agriculture including allied sectors was 15.35 per cent of the Gross Value Added (GVA) during 2015–16 at 2011–12 prices (Dahlman and Utz, 2005). There is tremendous scope to further enhance the productivity and profitability of agriculture sector in India. In many developed countries, web-enabled Apps have become integral tools for information, communication and decision making in agriculture sector (Figure 1) and this trend must catch up in India to enable millions of farmers and agricultural practitioner to access farming information, markets trends, and financial schemes from government and banking sector, formerly inaccessible to them (Hudson, 1995; Duncombe, 2016). Global trends in mobile Apps in agriculture indicate enhanced emphasis on simple to use features although customization is on the rise as it offers flexibility to perform a choice-based farming tasks. A report of International Telecommunication Union (ITU) has revealed that there are already over six billion mobile subscriptions in the world (Downs *et al.*, 2015; Bhagat *et al.*, 2004). The popularity of mobile devices is on the rise worldwide. Recent data indicate an exponential increase in the number of mobile Apps, reaching more than 2.5 million. There is enormous increase (400%) in mobile Apps in last five years according to the report from Statista Inc.

Apps are usually designed with primary focus on usability. They are proving to be an excellent tool for

enabling community learning to reduce the knowledge and skill gap of agrarians. Geography and space related information is managed, processed and visualized by geospatial applications and mobile Apps provide farm and situation specific advice and offer information on market prices, farming techniques, weather forecasts, rural health initiatives, fertilizer availability, crop and field management, soil health management, farmers connect and services and many more (Mishra and Arunachalam, 2015; Misra, 2005).

The objective of this article is to review the global scenario on availability and use of mobile Apps in agriculture sector in different parts of the developed world and assess the availability and use of this tool for farming community in India. The review was supplemented with an exploratory study conducted in Phagwara village of Punjab in northern India to assess the current status and uptake of mobile App technology. The available mobile Apps for agriculture sector were assessed for their number of downloads, availability, users' rating and remarks (Table 1). Brief information on Apps used in different agricultural fields is presented here:

Apps on Crop and Farm Management

The utility of crop and farm management Apps is to offer farmers to organize and access easily all the information related to the crops at centralized location very easily. The Apps available on crop and farm management are AgStudio MAP, Dekalb Plant Population Calculator, Farm book, NPIPM Soybean Guide, Farmware, Field Tracker Pro, Harvest Yield and TractorPal.

AgStudio MAP, originated in USA, is designed for precision agriculture by automation and tracking of data to create better plans and field management including crops, fertilizers, plantation, scouting and harvesting. Dekalb Plant Population Calculator, a crop specific tool, which was

developed in Canada, generates specific planting recommendation for maize and soybean crops. This application uses pre-populated information to choose soil type and row width and further recommends seeds requirement for planting. Another application originated from Canada is 'Field Tracker Pro' which records seed, fertilizer, spray requirements ahead of time. Application on crop and livestock management named as 'Farm book' provides one-touch access to the best varieties of crops to grow and livestock to nurture. Farmers acquire the best farm practices and products to maximize crop yields using this application. NPIPM Soybean Guide developed by South Dakota State University in USA provides management options for arthropods pests, specifically insects, which affect soybeans grown in North Dakota, South Dakota, Nebraska, Iowa, Minnesota and Kansas regions. A multifaceted farm management web application 'Farmware' records completed activities and plan of future activities. Entire farm data can be accessed on smartphone. This versatile application records over 40 different crops and field activities covering cultivation, harvest, testing, monitoring, repairs and construction. It also maintains storage of inventories for chemicals, commodities and fertilizers. Recording of sales, purchases, transfers and usage of stored items is also available. In addition, it records activities for storage locations such as pest identification and cool store observations along with diary entries for general farm records and provides calendar view of planned and completed farm. Further in the series of globally developed Apps, 'HarvestYield' records all farm work with GPS and non GPS. It keeps record of pesticides and fertilizers use, auto detection of field where user is working, calculation of field area, calculation of work cost and billing amount, support for offline use, supports weather flow, wind meter device for wind speed measurements. Information regarding key maintenance of agriculture machinery and its accessories is provided by TractorPal, a very important and useful application developed by two farmers in South Dakota, USA.

E -Apps on crop health management are though very small in number yet cover the broad areas such as information on optimization of spray providing details on quick and easy selection of proper spray tip for a given application just by entering speed, tip spacing and target rate followed by the selection of the droplet size category is available through Spray Select App developed by TeeJet Technologies. Simplot Spray Guide originated by Precision Laboratories and Simplot, and guides about process of mixing, spraying and record keeping.

Apps facilitate sharing of data immediately on products sprayed, along with weather conditions and location. Even e Application named as Mobile Farm Manager enables users to quickly and easily choose the proper spray tip for a given application.

'Apache on the Go' developed by 'Equipment Technologies' provides all details of each Apache sprayer model through spec, photos and videos.

Apps on Farmer Connect and Services

These Apps enable farmer connectivity with various services like marketing, monitoring and advisory. 'Connected Farm' App assists in improving operational efficiency and helps farmers to manage farm data. Apps such as 'Farm Progress' and 'Agrinews' guide farmers to correct

local websites and keep farmers updated on farm news and success stories of farmers. 'City Farmer' App guides users about growing food in the urban areas, compost the waste and plan their home landscape in an environmentally responsible way. Farmers can use 'Ag Weather' App for achieving improved operational planning with the help of farm-level forecasts and advanced information on weather risks and can sell their products effectively by using 'Totheself' App.

Apps on Soil Health and Content Management:

The University of Illinois and the Illinois Council on Best Management Practices (CBMP) developed MRTN

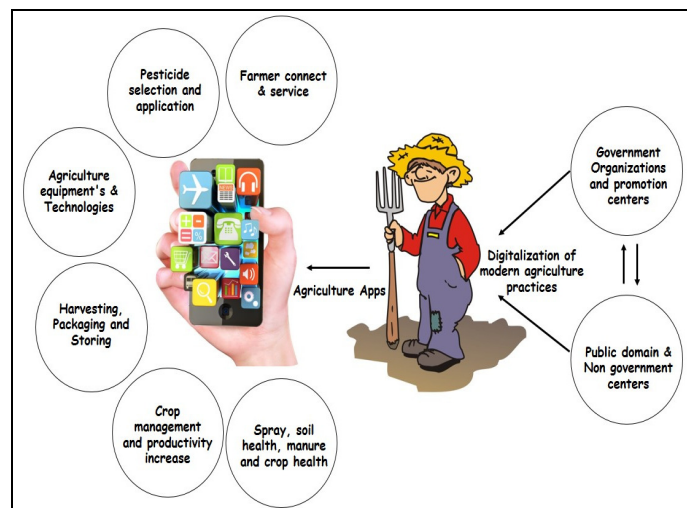


Fig. 1 : Agri Apps for farmers

(maximum return to nitrogen) App to calculate optimum nitrogen rate as per the need of nitrogen supply to the maize and to plan split application of nitrogen to improve nitrogen use efficiency. 'FieldNET' App enables users to monitor and control their irrigation equipment remotely. 'PureSense' App enhances farmers' ability to increase crop yields by optimizing the use of water. Soil types in different geographical locations can be retrieved by 'SoilWeb' App. 'Mix Tank' App, developed by Precision Laboratories, assists farmers with appropriate tank mixing sequence. This iPhone app also facilitates a series of training videos on appropriate mixing sequence from the experts of Precision Laboratories. Monsanto offered weed manager PLUS app to control weed by crop and region. Farmers can control grain loading from inside the cab using 'LoadOut' App, developed by Lextech, and maximize the yield by optimizing irrigation by using 'Optimizer 2.0', developed by Advanced Ag Solutions LLC.

Trend in use of Mobile Apps in Agriculture in India

About 700 million people in rural areas have access to information technology and it is growing rapidly (TRAI, 2009). Number of agriculture Apps has been growing and Government of India has taken steps to facilitate farming using mobile Apps through smart phones and tablets (Makwana and Goyal, 2013). This review has assessed the available Apps based on their download records, remarks and comments made by the users. Highly rated Apps are listed in Table 1.

GPS Fields Area Measure

A measuring App with high accuracy and easy to use is GPS fields area measure. Over 18,000 users rated the App as 4.4 on a 1 to 5 (best) scale with some mixed reviews. This

App has also been used successfully by insurance industry however scope for further improvement is suggested. It has been described as the best App to measure distance and area with 100% accuracy. The total download of this App so far is over one million.

Farming Simulator

A popular App designed to control the farm harvesting and equipments has shown one million downloads and 4.3 rating from over 100,000 participants. Suggestions from users are regarding flashing of fields on the mini map, which are ready to harvest.

Kisan Suvidha

Kisan Suvidha App is developed by Government of India. Farmers can retrieve the weather alert even 5 days in advance. It also provides information on market price status of nearby area and of other states of India to empower farmers to get the best possible decision. Over 100,000 downloads of this App are in record along with 4.3 rating by over 2000 participants.

Users recommended that chat based interaction with agro advisories in addition to more elaboration on advanced farming techniques and inclusion of audio visual aids could make this App more effective. To make it more popular among farmers, the detailed updated information about all the major crops should also be available through this App.

Shetkari Masik Android App

A low price popular magazine is available now in the form of App, which is developed and hosted at Science and Technology Park in Pune (Maharashtra State). It carries information about field crops, animal husbandry, fishery, forestry, poultry and agro industry. There are over 100,000 downloads. The App is rated 4.3 by over 2500 users.

IFFCO- Kisan

Unique feature of IFFCO Kisan is to acquire the need based information and to take informed decision because of the facility of customized agricultural information. This Kisan Suvidha App enables farmers to obtain information on weather report, market rate guide, best practices of farming, agriculture experts' advisory and agriculture updates and government's policies/schemes. It is rated as 4.2 by over 1000 users. There is over 100,000 downloads of this App.

Smart Krishi

This App is designed to empower farmers in Nepal with major emphasis on organic and profitable farming. The App offers several features on farm best practices, market rating, packaging, etc. Over 600 users rated this App 4.1, which has over 100,000 downloads. Users have demanded updated information on crops.

Agri App

Agri App was developed initially in Malayalam language and focussed on organic farming and cultivation of pesticide-free vegetables, fruits and crops. There are nearly 50,000 downloads with 4.3 ranking by over 1,500 users. Users are recommending this App in other languages also and need to know all the details of vegetables and fruits cultivation throughout the year.

Kisan Yojna

An App exclusively offers knowledge about government schemes on agriculture for farmers in different states of India. The App is being considered for translation into all regional languages. It has over 50,000 downloads and rated 4.1 by about 1000 users.

Kisan Mitra

This App was developed in Gujarati language and covers very wide domains including horticulture, agriculture and veterinary. This App is downloaded more than 10,000 times and is rated 4.5 by over 600 users.

Although agriculture Apps have been categorized under different sections (Patel *et. al.*, 2012) such as business apps, conference apps, diseases and pests apps, farm management apps, learning and reference apps, location-based apps, market data apps, weather apps, yet popularity of Apps mentioned above under different sections indicates the choice of users and their specific comments on those for further improvement.

Case Study: A Brief Survey on Awareness about Agriculture APPs

An exploratory survey was conducted in Phagwara District of Punjab State in northern India to determine the awareness of farmers about mobile apps as tools for seeking relevant information relating to various aspects of farming. Fifty farmers, selected randomly for this study, cultivated wheat, maize, sunflower, rice and seasonal vegetables throughout the year. The age group of the participating farmers ranged between 22 and 75 years and their education level was mainly elementary (Table 2). All the farmers were male and they were asked to respond to a questionnaire designed to seek information about their level of awareness/information regarding agriculture mobile Apps and their enabling use.

Only 4% farmers were aware of mobile Apps for use in agriculture (Table 2).

Smart phones are the basic technical interface from where the farmers usually access the agriculture Apps. The first question was just to rule out the participants on the basis of smart phone usage and to know about the popularity whether the farmers are aware of usage of smart phones. Out of 50 farmers 34 (68%) were using smart phones and qualified for the further question designed for the survey. The elementary question of survey predicted that if the participated farmer was aware of the smart phone interfaces, might be aware of the agriculture Apps.

It was shocking to learn that only 4% farmers were aware about the Apps and their use in agriculture. Punjab is a leading state in agriculture in India if this is the state of farmers awareness of mobile APPs in Punjab it can be deduced that the level of nation-wide farmers awareness is dismal. In present survey the responding farmers informed that they rely mainly on local newspapers for information regarding any technology and product for use by the farmers. All the farmers expressed keen interest in use of APPs for getting information on soil testing, weather, seeds, hybrid seeds, insecticides, pesticides and crops. Proper information sharing and awareness creation is needed.

Table 1: Listing of Popular E apps based on Total Downloads and Users' Rating (Ref: Google Play till 25th Sept., 2016).

S. No.	E App	Total Downloads (Till July 2016)	User Rating (out of 5)	Total Users Participated in Rating	Web site/Developer
1	GPS Fields Area Measure	10,00000	4.4	18,050	Studio Noframe, Kaunas, Lithuania http://noframe.lt
2	Farming Simulator 14	10,00000	4.3	102420	GIANTS Software GmbH, Switzerland http://www.farming-simulator.com/mobile-support.php
3	Kisan Suvidha	10,0000	4.3	2346	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
4	Shetkari Masik Android App	10,0000	4.3	2287	Real IT Services Pvt. Ltd. http://www.realit.co.in/
5	IFFCO- Kisan	10,0000	4.2	1231	IFFCO Kisan, New Delhi, India http://www.iksl.in
6	Smart Krishi	10,0000	4.1	582	Smart Krishi, http://smartkrishi.org
7	AgriApp	50,000	4.3	1659	Criyagen, India http://www.criyagen.com
8	Kisan Yojana	50,000	4.1	920	AMN Organization, Gujarat, India http://www.annindia.com/
9	Kisan Mitra	10,000	4.5	618	Navsari Agricultural University, Gujarat
10	Krishi app	10,000	4.5	945	Philosan technologies
11	Kisaan Market	10000	4.4	380	Rikwaa Tech lab
12	ICAR-NRCP	10,000	4.3	385	NRCP
13	Farming's Future	10,000	4.3	84	Bayer Ag, Germany https://www.cropscience.bayer.com
14	Kheti Badi	10,000	4.2	379	Tetarwalsuren, India http://www.allexamgk.com
15	Crop Info	10,000	4.2	265	Nirantara Livelihood Resources Private Limited, Bangalore, Karnataka.
16	Mandi Trades (Farmobi technologies Pvt. Ltd.)	10,000	4	141	
17	Agricultural Business	10,000	4.0	49	Freshvine (Nonprofit Membership Software) http://www.agribusinessinfo.com/
18	Vegetable Farming	10,000	4.1	124	Qitmir , Indonesia
19	Horticulture	10,000	4.0	136	
20	AgriMarket	10,000	3.9	151	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
21	Digital Mandi India	10000	3.9	289	Appkiddo
22	Pusa Krishi	10000	3.9	273	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
23	Mix Tank	10000	3.9	55	Precision Laboratories
24	Agriculture Anastore	10,000	3.6	56	
25	Crop Insurance Android App	10,000	3.4	145	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
26	Fieldnet apps 5000/4.2/50	5000	4.2	50	Lindsay Corporation
27	Organic Farming	5,000	4.2	40	XENON NATION, Indore, India
28	Pashu Poshan	5000	3.9	185	Agriculture Ministry, Government of India
29	Farm -O-Pedia	3361	NA	NA	CDAC, Govt. of India http://apps.mgov.gov.in/descp.do?appid=587
30	ICAR-NIANP feed chart	1000	4.6	62	ICAR-NIANP

31	Karnataka Bhoomi	1000	4.5	93	
32	Tomato Kannada,	1000	4.4	26	Jailakshmi Agrotech
33	Papaya Kannada	1000	4.3	35	Jailakshmi Agrotech
34	Chilli Kannada	1000	4.3	4	Jailakshmi Agrotech
35	Banana kannada,	1000	4	50	Jailakshmi Agrotech
36	Pomegranate Kannada	1000	4	67	Jailakshmi Agrotech
37	Onion Kannada,	1000	4	33	Jailakshmi Agrotech
38	Daily Market Prices	1000	4	11	CDAC, Govt. of India
39	Arecanut Kannada,	1000	4.2	49	Jailakshmi Agrotech
40	Rice Kannada	1000	3.8	24	Jailakshmi Agrotech
41	Mkisan	1000	3.7	18	CDAC, Govt. of India
42	Goat Kannada	1000	3.7	43	Jailakshmi Agrotech
43	Sugarcane Kannada	1000	3.5	440	Jailakshmi Agrotech
44	Sheep Kannada	1000	3.4	25	Jailakshmi Agrotech
45	Agriculture Manager	500	4.8	22	Skaliotisdev, Athens http://skaliotisdev.com/
46	Grape Kannada	500	4.5	21	Jailakshmi Agrotech
47	Grape Kannada	500	4.5	21	Jailakshmi Agrotech
48	Pesticide Calculator	500	4.2	9	ICAR-CCARI
49	Agriculture Rural Technology	500	3.9	7	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
50	Kisan Calculator	100	5	7	Material tools
51	Oil seeds at a glance	100	4.0	5	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
52	Insecticides India	NA	4.3	100	WaterMarc Developers http://www.insecticidesindia.com/
53	Vossen Agriculture	NA	NA	NA	Maxime Vossen http://www.vossenmaintenance.com/
54	Agri Precision – Agriculture	NA	4.1	580	Rua Guaiçara, número 1029 Centro Jaciara - Mato Grosso
55	Harvest Crops Farming Sim	NA	3.8	217	http://mobileplusgames.com/
28	Pashu Poshan	5000	3.9	185	Agriculture Ministry, Government of India
29	Farm -O-Pedia	3361	NA	NA	CDAC, Govt. of India http://apps.mgov.gov.in/descp.do?appid=587
30	ICAR-NIANP feed chart	1000	4.6	62	ICAR-NIANP
31	Karnataka Bhoomi	1000	4.5	93	
32	Tomato Kannada,	1000	4.4	26	Jailakshmi Agrotech
33	Papaya Kannada	1000	4.3	35	Jailakshmi Agrotech
34	Chilli Kannada	1000	4.3	4	Jailakshmi Agrotech
35	Banana kannada,	1000	4	50	Jailakshmi Agrotech
36	Pomegranate Kannada	1000	4	67	Jailakshmi Agrotech
37	Onion Kannada,	1000	4	33	Jailakshmi Agrotech
38	Daily Market Prices	1000	4	11	CDAC, Govt. of India
39	Arecanut Kannada	1000	4.2	49	Jailakshmi Agrotech
40	Rice Kannada	1000	3.8	24	Jailakshmi Agrotech
41	Mkisan	1000	3.7	18	CDAC, Govt. of India
42	Goat Kannada	1000	3.7	43	Jailakshmi Agrotech
43	Sugarcane Kannada	1000	3.5	440	Jailakshmi Agrotech
44	Sheep Kannada	1000	3.4	25	Jailakshmi Agrotech

45	Agriculture Manager	500	4.8	22	Skaliotisdev, Athens http://skaliotisdev.com/
46	Grape Kannada	500	4.5	21	Jailakshmi Agrotech
47	Grape Kannada	500	4.5	21	Jailakshmi Agrotech
48	Pesticide Calculator	500	4.2	9	ICAR-CCARI
49	Agriculture Rural Technology	500	3.9	7	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
50	Kisan Calculator	100	5	7	Material tools
51	Oil seeds at a glance	100	4.0	5	CDAC, Govt. of India https://apps.mgov.gov.in/index.jsp
52	Insecticides India	NA	4.3	100	WaterMarc Developers http://www.insecticidesindia.com/
53	Vossen Agriculture	NA	NA	NA	Maxime Vossen http://www.vossenmaintenance.com/
54	Agri Precision – Agriculture	NA	4.1	580	Rua Guaiçara, número 1029 Centro Jaciara - Mato Grosso
55	Harvest Crops Farming Sim	NA	3.8	217	http://mobileplusgames.com/

Table 2: Data showing Awareness on Agriculture E Apps

Number of Participants	50
Age	22-75 year
Crops generally cultivated	Wheat, Maize, Sunflower, Rice, Animal Fodder, Potato and Seasonal vegetables

Survey questions	Yes	No.	Any Suggestion
1. Do you use Smart phones?	16	34	-
2. Are you aware of mobile agriculture Apps generally available for farmers?	2	48	-
3. From where do you get information about agriculture mobile Apps? (TV/Government/ Family/Friends/ Others)	1 (Others: Newspaper)	49	-
4. Which mobile agriculture App you are using presently?	1 (Accuweather)	49	-
5. Are you satisfied with the information shared on the mobile agriculture Apps?	2	48	-
6. Is the information regularly shared on agriculture mobile Apps?	1	50	-
7. How do you rate the reliability of information available on mobile agriculture Apps?	NA	50	-
8. Are you aware that information on soil testing, market rates, weather updates and fertilizers, pesticide and micronutrients availability can be had from government centers?	NA	50	-
9. Are you interested to use mobile agriculture Apps?	3	47	-
10. What kind of changes or modification you would like to have in current kind and type of mobile agriculture Apps?	3	47	Information should be available on soil testing, weather, seeds, hybrid seeds, insecticides, pesticides and crops
11. Would you like to use mobile Apps for getting timely information on soil testing, weather data, fertilizers prices and availability, market prices for produce, etc.	3	47	Availability and pricing of fertilizers, weather updates and soil testing

Conclusion

Wide adoption of new technology, particularly the web-enabled mobile technology in rural India would be the key to success and provide new opportunities that were unimaginable just a few years ago. Food and agriculture sector appears to have been lagging behind in technology adoption and this must change. Enabling government policies and regulations must underpin technology deployment and adoption in the agriculture sector. There is a

need to establish and strengthen linkages of agriculture sector with information and communication technology in various verticals especially in agricultural production, improving markets and building farmers' capacity and also research and development updates, to combat the situation of low productivity and poverty. Indian Government has commenced initiative to develop mobile agricultural applications and make them freely accessible to farming communities in most of the application domains such as crop protection, weather monitoring, soil management and pest

management. To take a giant leap in agriculture, rural societies need to have a strong and innovative intervention to adopt digitalized portals to explore market potential and innovation in agriculture. The challenges identified for limited use of mobile agriculture by farmers are affordability of smart phones, lack of knowledge of using smart phones to access agriculture applications, language, and acceptability in adopting new technologies in general and awareness in particular. The needs of the hour for success of agriculture mobile Apps depend on the penetration into the rural areas. The policy makers should explore the possibilities for outreach the farmers with local authorities, agriculture industries which can channelled farmers for promoting the digital mobile based interfaces. The curriculum of agricultural sciences needs to be enriched with the information about recent developments in the area of agriculture extensions to educate the end users. More so the measures should also be worked out to revive the strategies to popularize the agriculture mobile Apps and their implications.

References

- Bhagat, G.R.; Nain, M.S. and Narda, R. (2004). Information sources for agricultural technology. *Indian Journal of Extension Education*, 40(1-2): 109-110.
- Dahlmann, C. and Utz, A. (2005). *India: India and the Knowledge Economy, Leveraging Strengths and Opportunities*.
- Downs, S.; Shauna, M.; Thow, A.M.; Ghosh-Jerath, S.; Stephen, R. and Leeder, R. (2015). Identifying the barriers and opportunities for enhanced coherence between agriculture and public health policies: improving the fat supply in India. *Ecology of food and nutrition*, 54(6): 603-624.
- Duncombe, R. (2016). Mobile phones for agricultural and rural development: A literature review and suggestions for future research. *The European Journal of Development Research*, 28(2): 213-235.
- Hudson, E.H. (1995). *Economic and social benefits of rural telecommunications*. World Bank.
- Joshi, V. (2016). *Agriculture in India: A Perspective from 1st Principles*.
- Makwana, M. and Goyal, D. (2013). Extension education: A key for agriculture development in India. *Asian Journal of Research in Social Sciences and Humanities*. 3(12):184-191.
- Mishra, J.P. and Arunachalam, A. (2015). *Diversification of Agriculture in India: Challenges Ahead. Climate Change Modelling, Planning and Policy for Agriculture*. Springer, New Delhi, 13-24.
- Patel, H. and Patel, D. (2016). Survey of Android Apps for Agriculture. (2016). Survey of android apps for agriculture sector. *International Journal of Information Sciences and Techniques*, 6(1-2): 61-67.
- Zhang, Y.; Lei, W. and Yanqing, D. (2016). Agricultural information dissemination using ICTs A review and analysis of information dissemination models in China. *Information processing in agriculture*, 3(1):17-29.