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Agricultural Mobile Apps used in India: Current Status and Gap Analysis

A. Balkrishna[1], J. Sharma, H. Sharma, S. Mishra, S. Singh, S. Verma, V. Arya 10.18805/ag.D-5140

ABSTRACT

Background: Agriculture plays a significant role in economic and social development in India. With the rapid development of Information and Communication Technologies, information and data can be effectively generated, stored and used by farmers to improve agricultural productivity. For this, smart farming technologies using mobile applications (apps) that help reduce costs, maximize yields and increase profits are being employed. Here, we present an overview of several mobile apps available for traceability in agricultural sectors, discuss their features, functions and how they are lacking in some domains.

Methods: In this study during Aug 2019-Sep 2019, several online databases were used for the survey according to the guidelines for Transparent Reporting of Systematic Reviews and Meta-Analyses. 73 agriculture mobile apps were selected based upon the hits using keywords like “mobile apps, agriculture mobile app, animal husbandry, *etc*. and with the inclusion criteria of a good review and proper up to date information. These apps were found to be used in different agriculture allied sectors in India.

Result: Among these 73 mobile apps used by Indian farmers in various agricultural sectors *viz*. farm management, fisheries, poultry, livestock and animal husbandry, food traceability and pure agriculture sectors; the respective availability percentage of apps were 12, 14, 14, 23, 23 and 14%. These apps are discussed here in detail along with their gap analysis and a new traceability mechanism has been proposed as well.

Key words: Agricultural traceability, Farmers, Information and communication technologies, Mobile apps, Smart farming technologies, Sustainable agriculture.

INTRODUCTION

Agriculture in India is growing with the introduction of the green revolution, white revolution, golden revolution and horticulture revolutions. Use of Information and Communication Technologies (ICT) to support the transmission of localized information and services for making farming socially, economically and environmentally sustainable, comprises under the ‘Digital Agriculture’. This digital change is acting as a tipping point for Indian agricultural system (KrishiJagran, 2019; Panda *et al*., 2019). Presently, farmers are receiving diverse facts or information about farming from various resources which are distributed on many different locations according to its origin, its processors, producers or vendors (Bentley *et al*., 2019) as shown in Fig 1.

Agricultural traceability can be described as the collection of data, its documentation, maintenance and application of information related to all processes in an aspect that provides guarantee to the end user and other stakeholders on the origin, location and life history of a product. In the last few years, demand for traceability in agriculture has been considerably expanded and due to this technological innovation are needed (Opara, 2003). Here, we present an overview of a number of mobile apps available for traceability in agricultural sectors, discusses their features, functions and how they are lacking in some domains.

An overview of the agriculture mobile applications

Mobile phone services for farmers comprise text message services, helplines and apps (Down to Earth, 2019). Mobile apps are helping to boost overall business performance and reducing negative environmental impacts of farming (Barh and Balakrishnan, 2018; Krishi Jagran, 2019; Vennila *et al*., 2018). The main advantages of mobile apps for farmers are that they give timely information in response to the farmer’s specific needs. Farmers can interact and get guidance from agriculture experts across the country *via* apps (Bhaskar *et al*., 2017). Different mobile apps are used globally as Kenya Agricultural and Livestock Research Organization (KARLO) launches 14 mobile apps to transform agriculture (FAO, 2019). Few of them are M-farm, iCow, MAMA, Olalashe, MedAfrica, M-Pesa *etc*. (JKUAT, 2019).

MATERIALS AND METHODS

The present systematic research review was conducted at Patanjali Research Institute, Haridwar, India in 2019,

Patanjali Herbal Research Department, Patanjali Research Institute, Haridwar-249 405, Uttarakhand, India.
[1]University of Patanjali, Patanjali Yogpeeth, Haridwar-249 405, Uttarakhand, India.

Corresponding Author: V. Arya, Patanjali Herbal Research Department, Patanjali Research Institute, Haridwar-249 405, Uttarakhand, India. Email: vedpriya.arya@prft.co.in

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according to the guidelines for Transparent Reporting of Systematic Reviews and Meta-Analyses (Moher *et al*., 2009). In this research review, specialized databases Google play store, App store, Food tank, Food quality and safety, IVRI and Predictive analytic today were used for the literature search in August and September 2019, using terms "mobile apps, agriculture mobile app, farm management app, fisheries app, livestock app, animal husbandry app as well as portal". The following inclusion criteria were applied with proper information, good review as well as related our agriculture field. The studies identified by the searches were combined and duplicates, not belong in our fields, insufficient data and not proper review were excluded (Fig 2).

RESULTS AND DISCUSSION

Here we examined about 73 agriculture mobile apps, used in different agriculture allied sectors. It is found that out of these 73 apps, there are about 14% of apps avail for pure agriculture, while 12% for farm management including geo-tagging. In fisheries and poultry sectors 14% app are used for each, moreover, 23% apps used for livestock and animal husbandry field as well as 23% apps are found to be applicable for food traceability sector (Fig 3). However, in India, different mobile apps are available to help in sustainable agriculture development, but their practice is still limited.

Agriculture apps generally used in India

Different mobile apps are installed and popularly used, in India related to farming sector. Some of them are Kisan suvidha, Pusa krishi, Crop insurance, Agri market, IFFCO kisan, Khetibadi, Organic farming, Farm-o-pedia, mKisan *etc*. (Agrovistaprofits, 2019; ICAR, 2017; KrishiJagran, 2019). Review of the apps available for agriculture sector mainly focused on soil testing ability along with some other application detailed in (Table 1). Moreover, in India, number of apps are widely used by farmers but they vary in number of users (Fig 4).

Mobile apps used for farm management on the basis of geo-tagging

Geo-tagging is the process of adding geographical identification metadata to various media such as a geotagged photograph or video, websites, SMS messages, QR Codes or RSS feeds and is a form of geospatial metadata (Finjanmobile, 2019). Some of the mobile apps used for geo-tagging, are mention in (Table 2).

Importance of mobile application in fisheries

Mobile applications give valuable angling tools such as solunar, tidal charts, advanced weather reporting, including radar maps, forecast and incident reporting, GPS advanced tracking, sea depth and potential fishing zones, *etc*. (Table 3). All the essential characteristics are grouped into one as a unique mobile application helpful for fishermen. Fishing mobile apps strive to fill the gap between data deficiency and effective fisheries management (Amrita and Karthickumar, 2016).

Trends of mobile application when applied to poultry, livestock and animal husbandry sectors

Particularly, mobile is used to spread timely information regarding livestock diseases, exotic and indigenous breeds, livestock rearing and government schemes on animal husbandry (Belaker *et al*., 2017). Detailed information of livestock, poultry and animal husbandry apps are given in (Table 4).

Apps related to food traceability

Now mobile apps are being used as professional tools in a number of businesses, including the food industry (Food Quality and Safety, 2019). Food crisis have been with human beings in the past few years and lead to economic loss because of indirect costs of product recall. Therefore, much attention has given to food traceability in food supply chain. In order to satisfy the customer's demand for variety of the food attributes and comply with the government rules, food companies have to implement traceability systems (Zhang and Zou, 2017). List of apps applied for food traceability system with their gap analysis are given in (Table 5).

Most utilized E-portal of agriculture in India

Farmers' portal

This portal is an effort to create one stop shop for assemblage all informational needs relating to agriculture, fisheries, animal husbandry and sectors production of an Indian farmer. Here, a farmer gets all relevant information on specific subjects around his village/block/district or state (Fig 5). The portal gives information of package of practice with crop name, NARP zone and also provides the farmer friendly activities as booklets (1487 books), videos (903), best practice video and handbooks. As the data showed in 2002 most of the states of India are affected by drought (383), while in 2016 only 36 states are affected. Portal provides soil fertility map includes 19 states. It also provides information related to soil health card and numbers of soil testing labs around for example, 3887 total labs in 35 states (Farmers' portal, 2019).

Gap analysis of Farmers' portal

- In input details of seeds, no any variety name is filled by dealer.
- In providing IPM package, portal includes only 92 crops till now.
- Soil preparation video are blocked and not opened for farmers.
- There is an error in the find machine option of the portal.
- Some error also finds in the manufacture and dealer details of machine.
- In most of the state's crop POP (Package of Practices) not available.
- In POP, language option is only Hindi.
- Not avail the complete information of storage either cold storage or any others.

mKisan portal

mKisan SMS portal for farmers enables all Central and State

Table 1: Agriculture apps used in India.

Apps name	Features	Gap	References
Soil Health Card Mobile App	The app launched by the Union Minister of Agriculture Shri Radha Mohan Singh. It benefits field-level workers by taking GIS coordinates automatically. Users: 10000+.	This app is only for the government officials and concerned person, who are working in soil health card scheme.	(Google Play, 2019; Soil Health Card, 2019).
Fertilizer Calculator Goa App (ICAR - Central Coastal Agricultural Research Institute, India)	It is completely offline app for making soil test based fertilizer recommendations to important crops of Goa. The results would help to use the fertilizer in appro--priate amount and in a balanced way. Users: 5000+.	The app has limited access, i.e. it allows to calculate fertilizer doses for the crops in state of goa only.	(Google Play, 2019; ICAR-CCARI, 2019; Soft112 Goa, 2019; Vota, 2019).
Kisan Suvidha	This app provides information on fertilizers, seeds with some other facts as current weather, forecast for the next five days, market prices of commodities/crops in the nearest town, machinery etc. Users: 500000+.	Information is not available in regional languages. App is not updated. This app is not reliable for weather.	(Claro, 2015; Google Play, 2019; Livemint, 2019; Vikaspedia, 2019).
Mridaparikshak	It is a digital mobile quantitative minilab/ soil test kit to provide soil testing service at farmers' doorsteps. It is highly compatible with soil health card.	-	(Government of India -Press Information Bureau, 2015).
Kheti Bari	It is a farmer guide app, aims to promote and support 'organic farming' and provide important information/issues related to farmers. Users: 100000+.	Some of the issues include lack of farming information, lack of logistics support and lack of demand forecast.	(APKPure, 2019; Klipinterest, 2016).
Farm-o-pedia (CDAC Mumbai)	The app is targeted for rural Gujarat and is useful for farmers and anyone involved in agriculture business. The app can be used to get suitable crops as per soil and season, crop wise information. Users: 11623+.	The app is state specific.	(Gandhian Young Technological Innovation Award, 2015; Mobile Seva Appstore, 2019; Sarkariyojana, 2019).
RceXpert (ICAR-NRRI)	This app provides information on insect pests, nutrients, weeds, nematodes and disease-related problems, farm implements for different field and post-harvest operations. Users: 10000+.	The effort is appreciable but lot of improvement is required. *It is better if it includes disease forecasting in rice.	(Google Play, 2019; ICAR-NRRI, 2019).
Plantix (Agriculture and Horticulture Department of the Government of Andhra Pradesh, India)	In India, it is also called mobile crop doctor. Plantix is reliable partner for best practices in agriculture, disease control and yielding better crops. Plantix already cooperates with international research institutes and inter-governmental organizations such as ICRISAT and CABI. Users: 5000000+.	This app forced on a very limited collection of crops.	(Google Play, 2019; Plantix, 2019).
Farm Calculater (University of Agricultural Sciences, Karnataka, India)	The app is used by the farming community to save costs by calculating exact quantity requirement of fertilizers, pesticides and seeds required for farm for sustainability in farming. Users: 100,000+.	Can't able to find different formulations for different crops.	(Google Olay, 2019).
IFFCO Kisan	The user can access a variety of informative modules including agricultural advisory, weather, imagery, audio and videos in the selected language at profiling stage. The app also offers helpline numbers to get in touch with Kisan Call Centre Services. Users: 500,000+.	Assam and entire North-East is excluded in the app.	(Claro, 2015; Google Play, 2019).

government organizations in agriculture and allied sectors to give information/services/advisories to farmers by SMS in their language (Fig 6). It was inaugurated by the Hon'ble President of India Mr. Pranab Mukherjee on July 16, 2013. Around 20 web based services as Kisan call centre, agromet advisories, buyer seller interface and dealer market prices, NeGP-A roll-out *etc*. across the country are integrated with this SMS portal and many more are in the queue (mKisan, 2019).

Gap analysis of mKisan portal

- It is difficult to add or remove the farmers list along with detail of crop.
- The database is managed at DAC, New Delhi, the service provider doesn't have right to delete the beneficiary farmer, instead it is being informed over phone/e-mail to the head quarter for elimination.
- In addition, keeping the static database of officials and farmers, advisories are pushed without the prior

Table 2: Farm management apps.

Apps name	Features	Gap	References
Connected Farm Scout (Trimble Inc.)	The app uses phone's GPS for mapping field boundaries, marking flags and entering scouting information for points, lines and polygon areas. It is flexible to use with any crop such as corn, wheat, soybeans, cotton, rice, vegetables and more.	App have some account verification problem. The app cannot synchronize data.	(Google Play, 2019; Growing Solutions, 2014; Trimble, 2019).
CropIn (Cropin technology)	This app technology used for complete farm management. Improve sales team productivity by miles. This app includes 265 crops, 30 countries and 2.1 million farmers globally.	Login issues. New users registration problem.	(Cropin, 2019; Google Play, 2019; The Hindu, 2019).
FarmHelp (PureForce)	The app gives Filipino farmers access to any information about plant and animal diseases, weather forecast. It also provide automatic geo-tagging which will immediately pinpoint the exact location of the farmer sending the message.	-	(Sunstar Philippines, 2019).
NaPanta (FarmGreenAgritech India Private Limited)	App is used to access real-time market prices, crop management techniques, cold storage services, soil testing etc. and also for crop geo-tagging. About 150000+ farmers across the state of Andhra Pradesh and Telangana used this app.	No search bar option. Language issues (not in English)	(Google Play, 2019).
eFARM (ELCOM PRIME)	The app used as a unified sensing tool to observe the timely information from the field, in terms of crop cover, crop growth *etc*.	Language problem.	(Google Play, 2019; Yu *et al*., 2017).
CROPX'S Soil Monitoring System (CropX Inc.)	CropX produces hardware and software systems tells farmers when and how much to irrigate the field.	App crashes often. GPS not pick given location.	(Google Play, 2019; Linklabs, 2017).
FARM app (Department of Agriculture (DA), Philippine.)	App has a geo-tagging system to identify the location of the farmer. Through this, farmers, fishers and other citizens can easily communicate with the DA.	Region specific. Not worldwide.	(Agriculture Training Institute, 2019; Google Play, 2019).
MapPt app (Takor Group)	App helps in field and farm mapping, land surveying, vegetation management, forestry planning and environmental management.	Registration and license are must. Not free.	(Google Play, 2019).
Scoutdoc - Farm Field Scouting (AgNition Inc.)	App allows users to open a GPS map, document field information and save information collected when scouting or inspecting field crops. GPS-enabled maps allow the user to document weeds/diseases/ insects in the field.	Poor performance.	(App Store, 2019; Google Play, 2019; Growing Solutions, 2014).

Table 3: Fisheries apps.

Apps name	Features	Gap	References
Fisheries (Dhwan Rural Information Systems Pvt. Ltd.)	Record the income of small scale fishermen in the coastal region of the country. Users: 500+.	Large scale fishermen not included. No traceability.	(Google Play, 2019).
mKRISHI® Fisheries (ICAR CMFRI Mumbai Research Center - TCS mKRISHI® Productivity).	Provide information and advisories in local language. Track and monitor various data to analyze the pattern contains geo-coordinates. Users: 1000+.	This service is available to only those people who are registered to use the service and belong to the organizations such as TCS, ICAR or CMFRI. Data not loaded timely.	(Google Play, 2019).
Thoondil (Department of Fisheries, Tamil Nadu govt.)	Showing weather warning messages, GPS location, emergency number and moreover potential fishing zone. Uses offline maps to show the nearest harbor locations for rescue. Users: 5,000+	Sometime problems in registering the boat owner name.	(Google Play, 2019).
FFMA- The Pan India Fisher Friend Mobile Application (M.S Swaminathan Research Foundation Mapsand Navigation).	Having GPS for navigating directly to the potential fishing zone (PFZ) and traditional fishing route / zones. Ocean State forecast information. Disaster alerts.	Not updated properly. Gives only deep sea fishing information. Not available in Hindi and Kannada languages.	(Google Play, 2019).
Fisheries touch (Xsense Information Service Co., Ltd.)	Vessel monitoring system. Update maps key. Users: 1,000+.	Support two languages, Thai and English. No other language option.	(Google Play, 2019).
DIUSAGAR (Fisheries Department, Diu)	App helps department and vessel owners to monitor their fishing trips related information effectively. Users: 1000+	No proper guidance about this app. Need some updates to add one or more ship (boat).	(Google Play, 2019).
APFisheries GIS (APTOnline Limited)	Involved geographic information system. Users: 500+	Limited to a particular state.	(Google Play, 2019).
ABALOBI (ICT4Fisheries)	Fishers record various oceanic, atmospheric and fisheries parameters.	Helpful for small-scale fisher only.	(ABALOBI, 2019).
SONA.rBall (hardware device with mobile application)	App provide sonar view, water temperature, depth and detects the potential fishing zones.	-	(Amrita and Karthickumar, 2016).
Fish Hunter-Pro	Provide GPS advanced tracking and mapping, catches log book.	-	(Amrita and Karthickumar, 2016).

Table 4: Poultry, livestock and animal husbandry apps.

Apps name	Features	Gap	References
Poultry Farming (Dev Galaxy Store)	Monitoring the conditions inside the chicken houses, including temperature, humidity and air quality. Users 50000+.	Should be works offline because every person not be able to get internet all the time.	(Google Play, 2019).
Cluck-ulator (Chicken Waterer.com)	Helps to choose chicken breeds and manage flock. Users 5000+.	Egg estimator shuts down the app when go to change breed every time. It is not properly work in any phones.	(Google Play, 2019; Hobby Farms, 2019).
iHatch-Chickens (iHatch-Apps)	To track of growing chicks, iHatch-Chickens allow to manage multiple hatches.	-	(Hobby Farms, 2019).
Poultry Pal (Southern States Cooperative Inc.)	App provide tracking system. This is not the app for the small-scale farmer planning on making a living raising poultry, but it's perfect for urban/suburban dwellers with backyard micro flocks.	-	(Hobby Farms, 2019).

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Poultry Farming (Starkode Limited Company)	App is designed for tracking eggs, feed consumption and performance right on the poultry farming.	Not compatible for android phone.	(App Store, 2019).
FeedMix (Frenik Marketing Group)	To determine the nutritional quality of a particular feed and ingredients. Users 10,000+.	All the ingredient is not listed. Not user friendly.	(Akinbobola, 2019; Google Play, 2019).
Poultry Batch Manager (SideWorks)	App provide sales, mortality, feeding records, vaccination schedules with reminder. Works entirely off line. Users 5,000+.	Changed currency format. User activity tracking not available.	(Google Play, 2019).
Poultry Manager 2.0 (Samuel T. Mbugua)	Provide flock management. Option for eggs types is not available. Users 50,000+.	Date is not editable.	(Akinbobola, 2019; Google Play, 2019).
Poultry Enteligen (Cargill, Incorporated)	It is an integrated analytics platform for poultry producers. Manage and track important communication from farm to farm. Users 1000+.	E-mail link not connected directly.	(Google Play, 2019).
Kukoochku Poultry (LogicalDNA Solutions)	App is used by line and lifting supervisor, doctors. Users 500+.	iOS devices not supported.	(Google Play, 2019).
Ranch Manager	Track animal and herd performance including basic accounting capabilities for managing expenses, profit and loss.	Lack of inventory management for livestock.	(Predictive Analytics Today, 2020).
Chetu	Includes cattle management with other dairy herds. Weather tracking system.	-	(Predictive Analytics Today, 2020).
Cattle Max	It is a complete herd management software for commercial and registered beef cattle operations to track production, performance and marketing records.	Specifically used for cow-calf ranches. Internet connection must.	(Predictive Analytics Today, 2020).
Livestock Manager (Cabral Tech Ltd.)	App is flexible to handle multiple identifications while tracking treatments, animal movements, milk production etc. Users: 100+.	Used for commercial enterprise.	(Google Play, 2019).
Tambero Free Cattle Management (Top Farming)	It's a dairy and beef cattle management app. Includes a complete animal database support, with different species of livestock.	No language support. Updation issue.	(Google Play, 2019).
Cattle Expert System (TANU Coimbatore and C-DAC, Hyderabad)	Covers feeding, breeding Management for cattle and buffalo. User: 10,000+.	Doesn't cover topics like physical injury as fracture and broken bones. Lack of solution of cow problems.	(Google Play, 2019).
Farmtree-Dairy Cattle Management App (OPC Private Limited).	Track breeding activities, record milking and farm expenses. Users: 5,000+.	Log in issue. Problem in registering person which are outside India.	(Google Play, 2019).
Organic Livestock Farming (ICAR -Indian Veterinary Research Institute)	Provide information about characteristics of ideal organic farm and requirements of feeding, breeds and breeding. Users: 1,000+.	-	(Google Play, 2019).
MyFarm (Cabral Tech Ltd)	App used for weaners, milk and meat tracker, pedigree generator. Users: 10,000+.	Sometimes not responding. App crashing. Paid Subscription not effective.	(Google Play, 2019).
BovControl (BovControl Inc.)	Keep tracking of daily activities going on in farm through dashboard. Users: 10,000+	Login issue. Effective in small and medium farms only.	(Google Play, 2019).
Pasture Map (PastureMapInc)	Track pastures health over time with photos in the field. Users: 1,000+.	Lack of inventory management for livestock movements and measurable.	(Google Play, 2019).
IVRI-PashuPrajanan (Animal Reproduction) App (ICAR-IASRI)	Gives information about animal husbandry. Provides basic information on artificial insemination in cattle and buffaloes. Users 5000+.	Should be in more languages.	(IVRI, 2019).

Table 4: Continue...

Table 4: Continue...

IVRI-Pig Farming App (ICAR-IASRI) Haryana.	It gives information about commercial pig farming. Users 1000+.	Should be in more languages.	(Google Play, 2019).
i"kvk e ijthoh fu;=.k ICAR-Indian Veterinary Research Institute)	Provides original pictures incorporated for specific diseases, to the veterinary officer's colleagues, in correlating their observations recorded while working with an animal. Users 1000+.	It developed only in Hindi language. Should be many more languages.	(Google Play, 2019).
Farm Management Pro (SMARTFARM SOFTWARE.COM)	Record all animal details-date of birth to date of Sale. Users 10000+.	Should available free of cost.	(Google Play, 2019).
Apiary Book (Bogdan Iordache)	It provides hive details and information on the number, health and maintenance of each bees' family *etc*. Users 100000+.	-	(Google Play, 2019).
BoxyBEE (HiveTech Solutions)	Addressing all categories of beekeepers through the three working procedures. Showed the graphical representation. Users 1,000+.	Unable to schedule tasks with reminders. Unable to log historic information. No check for bees aggression level.	(Google Play, 2019).

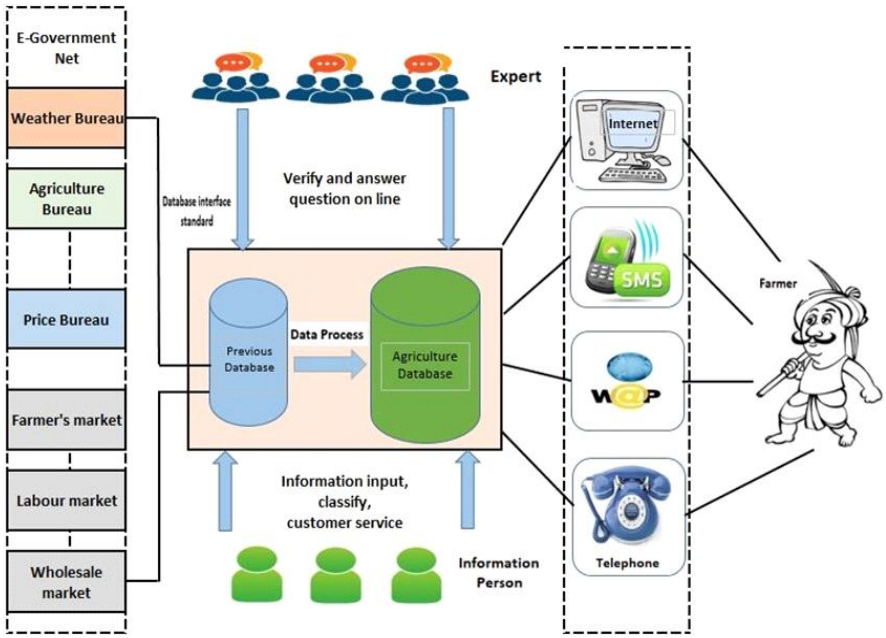


Fig 1: Diagrammatic representation of E-Agro android application. Source: Sharma *et al.* 2015.

knowledge of need assessment and also lacks in two-way communication.

- More efforts need to be taken on providing IVRS based solutions, dynamic database of adding the farmer's name, crop details, change of mobile numbers and advisory needs also.
- Data Central for DACNET projects and now for NeGP-A is being used for providing these service. No additional hardware/software tool have been procured especially for this project.

Apps data sharing

The USDA's agricultural research service (ARS) recently released the first two of a suite of mobile phone apps known as 'LandInfo' and 'LandCover'. These apps connect agricultural producers around the world and provide them with shared knowledge to increase their land's productivity while protecting its resources for future generations (Sourcetrace, 2019).

Proposed mechanism of traceability

Traceability is a key pillar in providing a perception of safety for sustainable agriculture. Implementation of effective traceability systems improves the ability to implement verifiable safety and quality compliance programs. Effective traceability systems significantly reduce response times by

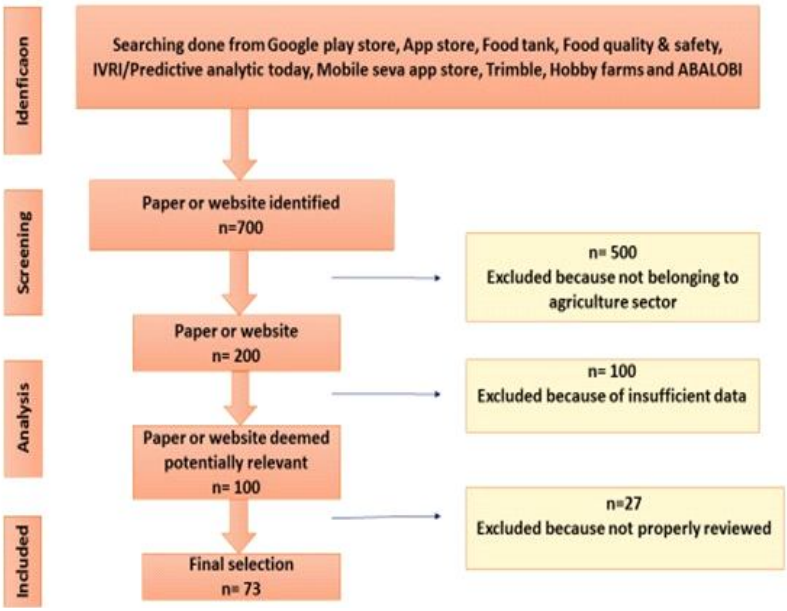


Fig 2: Flowchart for the literature searching and screening of agriculture related apps.

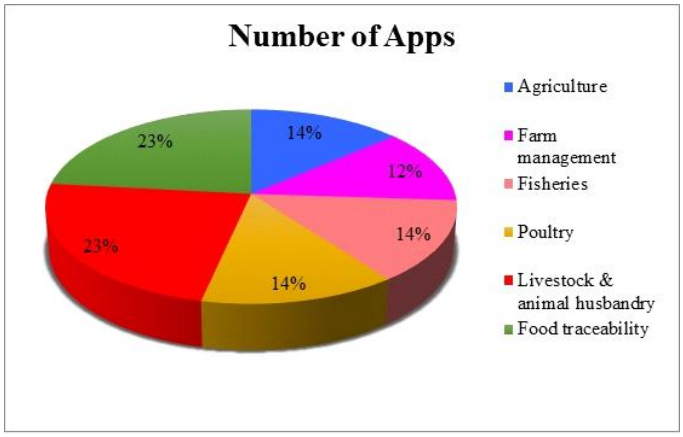


Fig 3: Comparative illustration of apps used in different areas of agriculture.

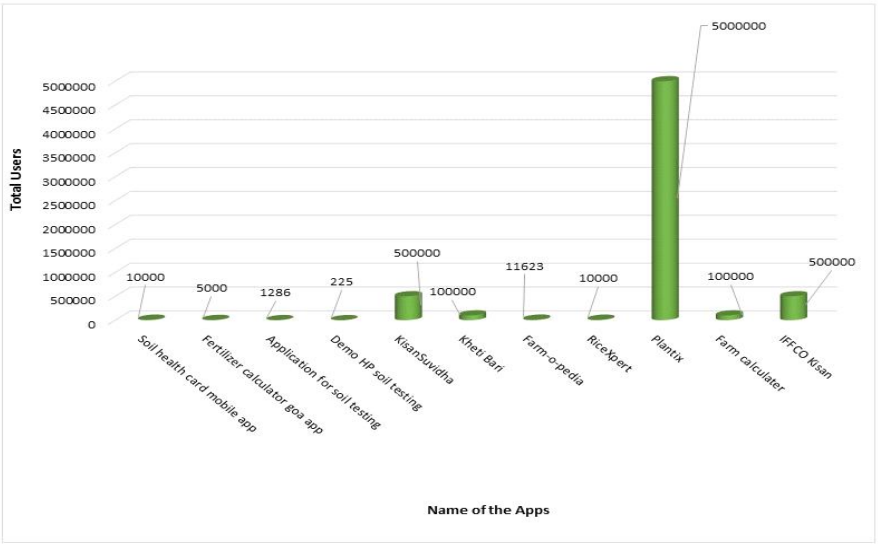


Fig 4: Comparative graphical representation of total users in various agricultural apps in India.

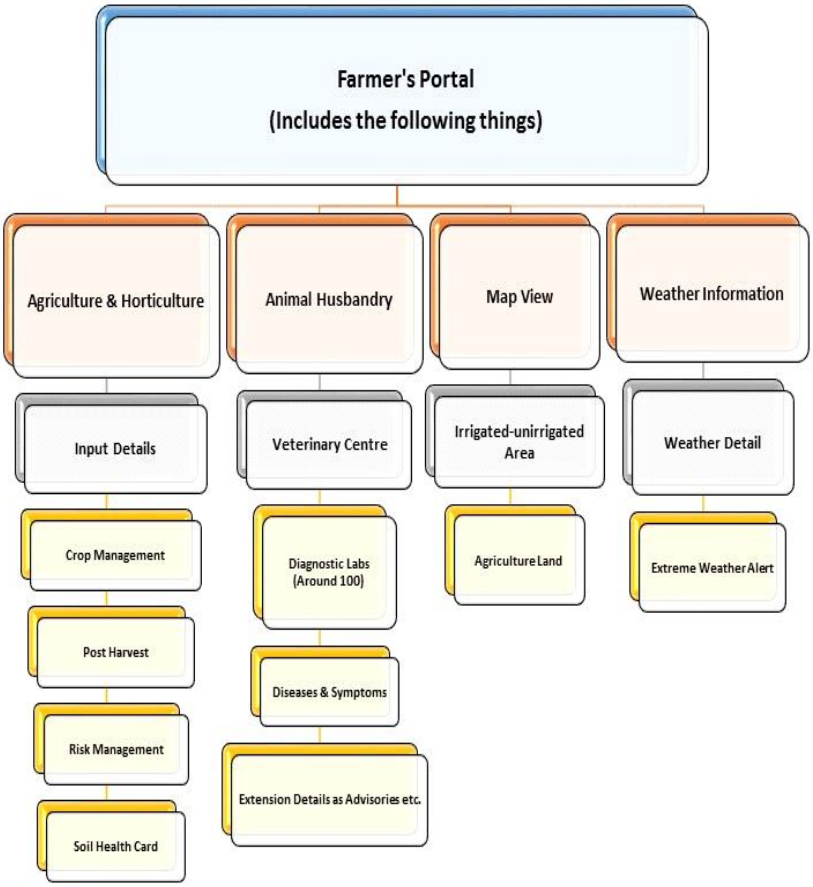


Fig 5: Flow chart of different areas covered by Farmers' portal. Source: Farmers' portal, 2019.

Table 5: Food traceability apps.

Apps name	Features	Gap	References
Food Safety Connect (Food Safety and Standards Authority of India)	This app allows the consumers to report any malpractices pertaining to food safety along with its related images. Provides a direct link to the FSSAI complaint redressal system. Track the status of concern. Users: 10,000+.	App crashes. Difficulty in registering complain.	(Google Play, 2019).
FBO10 (Food Safety India, Pune)	Gives the access to various legislations, acts, regulations, notifications. Helps to food business operators to get the latest information in the field of food safety. Users: 50+.	-	(Google Play, 2019).
Smart Consumer (Ministry of Consumer Affairs; Food and Public Distribution in association with GS1 India)	App connects consumers digitally with manufacturers/suppliers using their customer care contact details for speeding redressal of complaints. Users: 50,000+.	So many fields are blank as date of expiry is blank. Gives only the details of the manufacturers. No MRP *etc*.	(FSSAI, 2017; Google Play, 2019).
Food Safety app (DOST-NCR)	Provides information on potential biological hazards associated with particular food materials and recommendations to prevent and control these hazards. Users: 500+.	Sometime not working.	(Google Play, 2019).

Table 5: Continue...

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Food Safety (Food and Environmental Hygiene Department)	User accesses the food safety information. Obtain notifications of food alerts, food safety news and publications. Users: 10,000+.	Sometime not open.	(Google Play, 2019).
FoSCoRIS (Food Safety and Standards Authority of India)	Enables in verifying the physical inspection taking place with features like geo-tagging, time framed inspections and real time verification. Users: 500+.	Sometime not function well. No offline connectivity.	(Google Play, 2019).
FoodKeeper (USDA Food Safety and Inspection Service)	The storage times listed in the app are intended as useful guidelines. Informative, extremely user-friendly and visually attractive. Users: 10,000+.	Notifications about recalls don't show full product description details. Need more items and search function.	(Google Play, 2019).
Best Before-Food Tracker (Peytu)	Track opened products and those close to expiry date. Product management by category and storage location. Users: 10,000+.	Need to enter few other features like searching your foods. App crashing.	(Google Play, 2019).
Punjab Food Authority (Punjab Food Authority, Lahore)	Provide registration of new food business license. Tracking the processing and delivery status of license. Users: 10,000+.	Not possible to sign up as pin verification SMS never received.	(Google Play, 2019).
Locavore (AgSquared)	App helps the consumers to find out what local foods are in season and locate the closest farmers markets that provide them.	Difficulty in downloading the app.	(App Store, 2019; Foodtank, 2019).
HarvestMark Traceability (YottaMark, Inc.)	Allows its users to trace their fresh food back to the farm. It's done by scanning any fruit or vegetable with the Harvest Mark logo on it and pulling up the item's information on the app. The app provides instant updates on any food recalls affecting Harvest Mark produce, They have made 2.3 billion food packages traceable thus far.	The downside is some foods that don't need packaging are not consumer ready for scanning.	(Foodtank, 2019; Wired.com, 2018).
Find Fruit (Neighbor--hood Fruit, LLC)	Users can search fruit trees in their area according to seasonality, type and proximity.	Only accessible for fruits not for other food items.	(Foodtank, 2019).
Seafood Watch (Monterey Bay Aquarium)	Makes sustainable choices in seafood easier. Offers recommendations along with information on optimal farming or fishing practices for sushi and seafood.	Used only for sea foods.	(Foodtank, 2019).
Wild Edibles (WinterRoot LLC)	It offers harvesting methods, preparation instructions and recipes and medicinal information for foraged plants.	App not download the images and crashes.	(Foodtank, 2019; Google Play, 2019).
In Season (Light Year Software, LLC)	Offers a guide for choosing the best fruits and vegetables at the grocery store and provides advice on the best storage practices for each item.	-	(Foodtank, 2019).
USDA MPI Directory (USDA's Food Safety and Inspection Service)	Used to access information on meat, poultry and egg production establishments. App requires no internet connection after initial download.	The app only applicable for meat and poultry product.	(Food Quality and Safety, 2019).
FoodSmartphone (RIKILT Wageningen University and Research and institutes).	The app is working to detect harmful substances in food at the touch of a button. It allows the tests to be uploaded by food inspectors on the app, providing faster information between inspectors, manufacturers and possibly consumers.	-	(Food Quality and Safety, 2019).

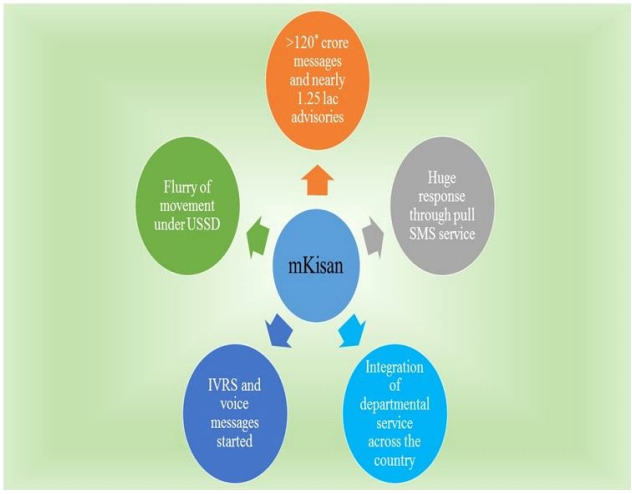


Fig 6: Features of mKisan portal. Source: mKisan, 2019.

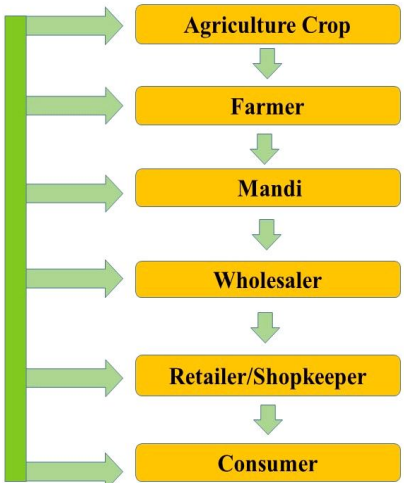


Fig 7: Flow chart of proposed mechanism for traceability in agriculture sectors.

providing more rapid access to relevant and reliable information that helps determine the source and location of implicated products. Thus, information at any point in the chain from farmer to consumer has become crucial. Traceability systems applied correctly, with supporting ICTs, enables agri-businesses to monitor and defend against risk in real time (International Trade Centre, 2015). So here, we proposed mechanism of traceability which includes following key points (Fig 7).

1. Government departments interlinked by this proposed mechanism.
2. The subsidy, loans and other benefits which are provided by government will go directly to the consumers in a transparent way.
3. This mechanism will make a strong check on food adulteration, wastage and spoilage.
4. It improves the soil fertility by promoting organic agriculture.
5. A strong check on corruption and middle man will be made by the proposed mechanism, so that benefits directly transfer to the genuine person.

CONCLUSION

Overarching benefits of ICT in agriculture includes that it can bring about product traceability along with disease and pest tracking. However, mobile apps are working as a boon for farmers and transforming agriculture but still they have some gaps which should be checked and removed. Either farmers unaware about the app or they have very limited users, because most of them are not user friendly. Only few apps work at the ground level. Even soil testing apps are not taking all the information from the fields of farmer and it was found that fertilizer information given but not according to soil testing. These are based on the data of soil type which is already given for India. Limited geo-tagging and geo-fencing are available in these apps and most importantly majority of these apps lack traceability mechanism. None of them provide information from crop to consumer and vice-versa. Proposed traceability mechanism is a novel approach which provides local language support, all types of fertilizer recommendation, satellite imagery based data, organic certification, tracking of Mandi rates, cloud based solution, soil moisture analysis, seed variety selection, geo-mapping and estimation of crop yield.

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