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ICT Driven Decision Support & Information Dissemination (DSID): A Comprehensive Technical Appraisal of DSID Systems in Indian Agriculture

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Abstract*: Sustainable growth of the agricultural production system demands the availability of right technical inputs about the weather, crop, land, fertilizers, and irrigation at the right time. To disseminate useful information to farmers in an effective and timely manner, many research initiatives have been undertaken by various government and private agencies' in India to develop decision support and information dissemination (DSID) systems. This paper appraises fifteen number of such systems that are developed in India in the last decade. The appraisal discusses the (i) user information (type of users, participation method and level of skill level), (ii) system information (developing agency, system type, interface, supported application domain and outcome), (iii) system design specification (input/output, data collection method, architecture, user connectivity means), (iv) system development technologies (development technologies and tools), (v) system response (support delivery method, recommendation mechanism, response time) and, (vi) system services (user response, social and economic benefits). Considering all the above mentioned factors, summary sheets have been prepared and analyzed on the basis of normalized weights assigned to each aspect. As a result of analysis, criteria/method for evaluation of system quality (on the basis of support, satisfaction and perceived usefulness) has been formulated. Furthermore, the paper also investigates various challenges that need to be addressed to build effective and efficient DSID systems. Considering the fact that the presented appraisal is somewhat more focused towards technical, social and user oriented aspects, the authors believe that this appraisal will help technologists, researchers, and developers to understand the research initiatives and associated challenges that need attention with respect to the Indian context.

Keywords: Decision Support and Information Dissemination Systems, Information and Communication Technologies (ICT), Technical Appraisal, Indian Agriculture

I. INTRODUCTION

Despite the economic boom centered towards the service sector in cities, the agriculture sector is still the primary source of livelihood for about 58 % of India's population [1]. Agriculture and allied sectors share about 15.87% of the country's Gross Value Added (GVA) and 15.45 % of Gross Domestic Product (GDP) respectively in the year 2018-19 [2]. The contribution of the agriculture sector in the Indian economy is much higher than the world's average (6.4%) [2]. In the past decade, agricultural production has evolved into a complex business that requires the accumulation and integration of knowledge and information from many diverse sources such as soil testing labs (STL), agro-experts, web portals and various forums and communities run by govt. and private agencies. More specifically, the farmer requires relevant and timely information in his daily routine tasks related to seed selection, crops to be grown, fertilization and irrigation needs. For most of these needs, the farmers often rely on the experts or extension agents or crop advisors to provide useful information they require to make effective decisions at right time and assess the possible benefits that could arise from the additional investment required in adopting the technology [3]. In most of the cases, the assistance of expertise is not always available on time [4], which leads to some severe losses such as degradation in natural resources as well as financial losses. Poor agro information delivery mechanisms and lack of right technical inputs at the right time are two critical challenges that are faced by the farmers in India [4]. To address the challenges, efforts have been made by Indian govt. in collaboration with various agricultural and technical research institutes to enhance the reachability of technology and information to farmers through portals, forums, broadcast media, bulletins, periodical magazines, newspapers, seminars and through IVR and mobile telephony. IFFCO Kisan Sanchar Ltd (IKSL) [5] is one example of such IVR based system that provide very generic, pure voice-based advisory to farmers through telephones. Digital Mandi [6] provides access to commodity pricing and RML [7] offers up to date, local and customized commodity pricing information, news and weather updates on mobile phones through informative SMS in the local language that helps the farmers to improve the productivity and crop yields of wide range of products such as onions, cotton, soybean, pulses, pomegranates, and oranges. Nokia Life Tool [8] and Lifelines [9] are mobile phones based advisory systems where the former provides information about weather and market prices on Nokia mobile phones whereas the later brings critical information right to more than 50 different fields of agriculture and allied activities.

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This service responds to this need of farmers/users 24x7 through agro-advisory and livelihood information.

Digital Green [10] is a nonprofit organization that works through a video-based platform that supports the existing extension services of its NGO partners. Agrisnet [11] is an agriculture research information system network to facilitate rural agricultural extension services and agribusiness activities. Many other web portals like Agrmarknet [12], Agropedia [13], eKrishi [14], Agriwatch [15] and iKisan [16] also provide useful information on agricultural services and market activities to the farmers and crop growers'. Most of the above mentioned systems/research projects are government initiatives with public-private academia-industry research collaboration aiming at providing timely and quality information to farmers. Few projects were study projects that were entitled to understand the impact of technology intervention in agriculture. Others are either non-profit projects providing free of cost service to farmers or commercial project giving paid services. Region-specific advisories and one way (from an advisory system to farmers) communication are few of the limitations of these systems which causes issues in resolution of queries as user feedback is rarely used in these systems. As most of these systems are based on one to one interaction and it is impossible to serve the big population of India in one to one manner. One biggest challenge is the accessibility of the internet and computer to farmers. Along with these issues, another hurdle is multi-level literacy. Such methods are not meeting the expectations of the farmers due to the lack of coverage, accountability, timeliness, and personalization. Rao et. al. [4] explored the four well established and proven decision support and information dissemination systems namely eSagu [17-24], Agrocom [25], Reuters Market Light (RML) [26-28] and mKrishi [29] to assess and understand the impact of these systems in enhancing sustainability of Indian agriculture. All the four systems were compared on the basis of numerous metrics such as adopted technologies, communication processes (input and delivery), information mode, service delivery, benefits, and implementation issues. In the similar manner, Kumbhar et. al [30] has also presented a study DSS applications in agriculture in Indian context. The study was more focused on existing expert systems and simulation aids that simulate and analyze the crop behavior by taking into crop, water, and other required conditions into account. With recent technological advancements in sensing, embedded systems and communication technologies, more research projects were undertaken to contribute towards sustainable growth of Indian agriculture. This paper assesses 15 case studies of ICT driven decision support cum information dissemination systems that handles content management and information delivery process for sustainable growth of Indian agriculture. These case studies were chosen for study because of their focus on usage of ICT to deliver right information to farmers at right time whenever they needed it the most. This paper is a result of the explorative contextual analyses of ICT based ventures, which are effective in efficiency, lessening the expense of generation and by expanding gainfulness. The study attempted to concentrate on the utilization of ICT in farming advancement for financial improvement and profits. The examination is explicit to India to see deliberately and authoritatively to investigate a portion of the complexities associated with the intercession of ICT based frameworks. The undertakings are intentionally choosing in light of the fact that every one of them fit into general classifications of ICT activities worked in. Table-1 gives the basic insight of all the 15 case studies of Decision Support System (DSS) cum Information Dissemination system [31]. This paper explores all the initiatives mentioned in table-1 and presents a comprehensive technical appraisal of these systems on the basis of various metrics such as (a) project information, (b) user information that caters user types, interaction mode, feedback mechanism and operational needs, (ii) system information like type, support details and adaptability, (iii) technical aspects like data capture method, architecture, connectivity, information delivery mechanism and technologies/tools used for development (iv) other features like response time and mechanism, support, user response and economic aspects. Since the appraisal is more inclined towards technicalities involved in the development of these systems, hence this appraisal will help technologists, researchers and developers to understand the research initiatives and associated challenges that need attention concerning the Indian context.

The structure of this paper is as follows: Section-II explores all the case studies and gives a brief description of all selected systems. In addition, it gives a background to examining the content in ICT (Information and Communication technology) initiatives. Section-III presents the comprehensive appraisal and analysis in tabular form where each parameter is analyzed and discussed in detail. The results of analysis are discussed as key findings in section-IV. The essential conditions for the development of efficient decision support cum information dissemination system will be discussed in section V and the last section i.e. section-VI concludes the paper with final remarks.

II. OVERVIEW OF SELECTED CASE STUDIES

This section shall briefly describe fifteen case studies. Table-1 has already summarized the basic details of each of the selected system by taking in to account the most relevant information like development year and involved agency, supported crop, and main application domain supported by each project. The brief description of each system is as under:

1. aAQUA[32] is a documented multilingual interactive media question answer based correspondence framework, which signifies "all inquiries replied". It is an online exchange and warning gathering giving choice help devices to dynamic ranchers.
2. This gathering chips away at the income producing plan of action. The administrations gave to ranchers, comprehensively incorporate, restricted – remote yield analytic arrangement; sound incited direct application (in English/Marathi/Hindi); remote harvest and land properties based infection diagnostics; smaller scale climate data (temp, overcast spread, precipitation); SMS empowered enlist and question instrument; online survey for enrolled clients; spam, search, rank highlights; and administration is accessible on GSM and CDMA systems. This gathering is a critical thinking framework devoted to discover answer for issues presented by Indian

ranchers (little and enormous land holder both). The inquiries identified with horticulture, is settled in 24 to 72 hours relying on the unpredictability of issue. A group of around sixty specialists from assorted specialized topic frames the master gathering to answer the inquiries. AQUA utilizes the three level web design which is fueled by an open source, simple to utilize, simple to arrangement dialog discussion giving a total start to finish arrangement assembled by utilizing Java innovation (Java Server Pages/Servlets). In light of the standard MVC (Model View Controller) design, aAQUA is good with any Servlet. A comment on sample screen of system compartment underpins JSP1.2 and Servlet2.3. It is inside the servlet holder (Catalina) of the Tomcat Web Server.

3. CommonSenseNet (Community based management of natural resources through sensor networks) [33-34] is a DSS specifically designed for resource poor farmers using WSN technology (temperature and humidity (Sensirion SHT11), ambient light (TAOS TSL2550D), and barometric pressure (Intersema MS5534AM)) for environmental monitoring to provide direct support to resource poor farmers of semi-arid regions for yield improvements at local level. CSN uses a centralized data-collection model, where individual wireless sensor nodes perform minimal data processing and send back the data via a base station (a node connected to a computer) to a single server where they are processed. The WSN (Wireless Sensor Network) has been designed and implemented for extensive data to validate and adapt existing models for particular soil and climate conditions. In semi-arid regions the amount of rainfall affects crop yields, disease and pest incidence. The DSS supports farmers in various risk management strategies (choice of crop varieties, sowing and harvest period, prevention of pests and diseases, efficient use of irrigation water). In situations of uncertain output, the use of DSS gives information on the benefits and risks of all available options will help resource poor farmers to make informed choices on the best strategies. The environment monitoring data provided over time and space by sensors can be used to validate and calibrate existing models. In case such models are not available, this data can help develop and validate simple models by using the state-of the art expertise available. A reliable DSS is a component of a deficit irrigation system that seeks to maximize the effects of irrigation on crop yield while minimizing the intake of water. For poor farmers, this could mean applying new strategies of partial irrigation, such as transporting water from community tanks on carts, renting rich farmers' wells, and other strategies. The complete system is developed based on iterative participatory method.
4. GramyaVikas [35] which means 'rural development' is a modular and query based prototype Geo-ICT model for distributed collaboration systems developed with easily customizable and open source platforms such as Plone (content management system) and ALOV (open source Geographical Information System (GIS)), MapServer[], p.mapper[] and PostgreSQL[] to assists the novice rural community in their planning processes and mutual collaboration. It offers a secure and interactive geo-information service for better visualization, decision making and user-friendliness to user community. Since the system is designed with open source resources, therefore it reduces the cost of installing costly database analysis system in old machines. The system facilitates user to share their ideas, plans, issues, methodologies, problems through the webmail/blog/chat/intra/inter communication. It supports multiple languages like Hindi/English/Telgu. It is basically an attempt towards shifting Geo-ICT technology from doer to user with a motto of 'do-it-yourself. GramyaVikas is built on server side strategy where the clients can share/recover the information/data; impart for taking shared basic leadership and make basic inquiries to distinguish competitor towns/ different elements, (for example, bundles, watersheds, and so on.) for different provincial improvement plans.
5. GeoSense [36-46] is a multimode (ZigBee/Wi-Fi/3G/ WebGIS), multi-level ICT, GIS based real time DSS with dynamic information and modelling services, to support decision making on precision agriculture applications through Geo-ICT, GeoSense cloud services and ZigBee based WSN named Agrisense (AS) with weather, crop and soil sensors). Geo-Sense is a Indo-Japan collaboration and it can be used for precision irrigation, yield modelling, integrated pest management and pest counting, real-time DSS, energy balance sheet, primary climate change analysis and pest and disease forecasting. The location based service in Geo-Sense is provided by the open source GIS ALOV. AS has three main components such as Field Server (FS), Field Twitter (Open Field server) (FT) and Field based towers (FLTs). AS is a two-tier hierarchical topology based predefined closed-loop system which automatically sense the data at user defined intervals that meets the requirements of data sampling. The AS software has data monitoring, data conversion and user friendly GUI for data visualization. WAMP server and MySQL databased has been utilized to implement server requirements and database has been designed with phpMyAdmin.
6. Any authorize user can obtain the DSS services as a cloud service. In conclusion, the push based DSS has been developed to cater the requirements of rural
7. community/farmers to support decision making in their day to day decision making needs.
8. It uses Hargreaves Evapotranspiration (ET) estimation and Simplified process (SIMRIW) and CERES Rice simulation model for irrigation scheduling and rice crop prediction respectively. Physio-chemical analysis of soil properties of experimental site is done by conventional methods.
9. E-Agromet[47-48] is an ICT enabled agro metrological advisory system, which helps in improving the efficiency of preparation and dissemination of agro-met advisory bulletin .the advice preparation include weather prediction based on minimum or maximum temperature ,relative humidity rainfall, cloud cover, wind speed and wind direction followed by preparation of advisory bulletin and its dissemination to stakeholders such as farmer Krishi Vigyan Kendra (KVKs) non-governmental organization (NGOs) through press release, email and telephone. E Agromet consist of search tool advisory assistant that prepares advisory bulletin based on region specific data and weather deviation. Its prototype has been developed for rice and cotton crop and weather simulation in Telangana region.

10. BitVillage [49] It is one of portal like system IVIS (Integrated Village information system). It is the combination of several well managed databases driven systems with producible information as output to improve yield of crop production. The system output will help the farmers and researchers for several aspects like, DSS, automation of farm, microform planning of cost for the future plantation, crop prediction and fertilizer usage calculator. The inputs to the system are survey data from local farmers, physical and chemical properties of soil via soil health card (SHC)[], weather reports, fertilizer accumulation, water availability, past crops and their yields. One of the important component of BitVillage is its' cost and fertilizer calculator that calculates approximate cost and fertilizers usage on the basis of on statistical analysis and past data. It provides commodities, fertilizer recommendation, weather and other related information to every user through SMS in Gujrati and English language.
11. KrishiSense[50] is a semantically aware web enabled WSN that was designed specifically to monitor citrus crop. By incorporation of Open Geospatial Consortium (OGC) specified Sensor Web Enablement (SWE) standards on sensing, the system has enabled the interoperability between different standardized sensing systems. The system facilitates the human participative sensing by interconnecting different users through distributed web based platforms and multiple protocols. It is based on client server architecture where the clients communicate with server via multiple protocols (Hyper Text Transfer Protocol, IEEE 802.11, FTP, etc.) and multi-modal communication platforms such as mobile and internet. It is a sensor and application independent system that has flexible sampling facility which ensures the energy conservation and configuration as per field experiment needs.
12. UAgri [51] It is a pilot ubiquitous agriculture system (WSN based DSS) for advisory models related to pest and disease management of groundnut crop. The system has configurable used interface to configure WSN whose integrated sensors sense various parameters like relative humidity, soil moisture content, relative humidity, leaf wetness, solar radiation, rain fall, wind speed and direction and forward the sensed information to remote administration system (RAS). The RAS analyses the received information and analyses the same to generate forewarning advisories (T/H index, leaf-wetness index, ground degree day models) for groundnut pest and disease. Increasing the coverage of advisories is still a challenge for the system.
13. KrishiBharti[52] is an interactive system where the user can interact with the system via icons and get the desired information via text and spoken language. To get the desired information users have to query the system through the iconic interface. The interface also integrates a text to speech system to provide the textual query in spoken form. The locally searched information by the user is stored in the repository and available for user by text content receiver. The system also provides speech base interaction for users who are language illiterate and also provides the features like addition of letter-to-sound, speech to text and vice-versa and syllabification rules, selection of text corpus to be recorded and to be played in the sound, speech synthesis and translation of text from Hindi to English and vice-versa. Support for only Hindi and English languages is a limitation for the system.

mAsk [53] is an agricultural advisory system that has been built with the aim of bridging information gaps between farmers and agriculture knowledge workers (such as agricultural scientists and extension workers). The function of this system is to serve a small group of farmers by providing them with personalized agricultural advisories. It is based on the call centre approach for resolving the queries raised by the farmers. A particular information containing UI gets pop up whenever a registered user calls for a query. The UI interface consists of complete details such as crop details/soil test reports/age of crop, seed treatment, nutrient history and weedicide history. Expert gives the advice on analyzing the query based on the information collected and the call is also gets recorded for future reference and expert can also set a date for follow up and it is the duty of the expert to follow up the farmer to know whether the farmer has followed the advice or not and why if no. The farmers can also take photographs with a tool provided on the mobile application Pest and Disease Upload (PDIU) of their pest/disease infected crop and upload it to mASK system. Two-way knowledge capturing, improvement in PDIU, development of Interactive Voice Response Systems (IVRS), mobile application for data
14. collection/uploading, pest disease predictive model and scalability in the system are the few areas that needs attention.
15. AgriDaksh[54] is an instrument for building of an expert system framework which is utilized as a way to disseminate the information of IPM rehearses for various crops. It has highlights for issue recognizable proof, knowledge model creation, knowledge securing, knowledge recovery, pose an inquiry to the specialists. It is equipped with user specific role oriented operations like the domain expert can add/edit/ update the details of crops, pest, stage wise pests and disease and IPM practices into database and user (farmer and extension workers) can retrieve the information (nematodes, weeds, insects and diseases) in form of report containing (name of crop stage, stages (Seed/Nursery stage, main crop, vegetative stage, flowering stage, maturity stage and all stages), disease insects, nematodes and weeds occurring at this stage even without logging into the system. The report also gives information on available IPM practices that should be followed by farmers to control the diseases and pests as mentioned in the report.
16. DEAL [55] is a multimedia stage for creation, sharing and spread of agricultural data among farmers and experts. It gives farming related information in different progressively composed classifications. It is a substance conglomeration and association structure, which helps in actualizing language independent of rural data. It is essentially a sound blog for the farmers where they can record their inquiries on kiosk in their voice and post on the site in Hindi and specialists responded to the inquiries. In this project, Ontology based agricultural vocabulary database in Hindi with more than 28,000 agricultural terms has been created under this project. It displays

information both Hindi and English.

17. AgroSense [56] is a ZigBee based wireless Mesh sensor network for precision agriculture where real time data of the climatological and other environmental properties are sensed and relayed to a central repository. The data in the repository is analyzed and actuations are generated for actuation devices that are used to control irrigation, fertigation and pest control to avoid the adverse conditions. The system also generates reports at the monitoring station which can be accessed via web-based software having user friendly GUI.
18. WSN-ASP [57] is a WSN based DSS for the prediction of Apple Scab prevention(ASP). The WSN sense temperature and leaf wetness measurements and logged the same in extremal processing unit (EPU) via access point. The logged information is analyzed by EPU application with Mills tables to identify the infection prone periods for timely prevention. In case the sensed values match with the readings in the Mills tables, an alarm is generated by the system. By responding to alarms, the farmer can then workout the schedule for spraying.
19. m4agriNEI [58] is a forum developed for farmers of North East, India for seeking, discussion and sharing of information. In this initiative the mobile phones are provided to the village coordinators who capture the images of the problems and also understand their issues and report the same back to lab for providing the required solution. The main objective of the project is to empower the farmers by providing right information on right time by implementing a 'Mobile Based Agricultural Extension System'.

III. COMPREHENSIVE APPRAISAL AND DISCUSSION

In order to get the deep insight of the fifteen nos. of ICT driven decision support cum interactive advisory systems, the systems were studied on different types which are broadly categorized into (1) user information, (2) system information, (3) system design specification, (4) system development technologies, (5) system response and, (6) system services and feedback. Each category has different aspects and associated features. Each of the fifteen nos. of systems have been assessed on the basis of different features as mentioned in table-II to table-IV. Each feature is recorded in table if it is supported by the system being assessed. To get the overall assessment of all the system, following steps have been adopted:

Step-1: Each feature that is supported by the system being assessed is recorded by a tick and if not supported by the system, the entry is recorded as a cross.

Step-2: Total no of positive ticks will be added w.r.t. each feature and this process is repeated for each entry.

Step-3: Normalized weights (NW) is assigned to each feature w.r.t. each selected aspect in each category.

Step-4: A threshold value for weight is defined however this threshold is separately defined for every category

Step-5: if the weight value is very less than the threshold value then the feature is lacking in all the system, if it is moderately higher than it then the corresponding feature needs improvement and if it near to maximum value of weight of the feature then the feature is best across all the systems.

Table-V to Table-X gives the details of weights of each and every feature for each respective category.

Table- V: User Information

Aspect	Features (Nos. of Positive Entries)	NW
Users	Farmers (14)	**0.35**
	Advisors/Experts (6)	0.15
	Extension Agents/Workers (11)	**0.28**
	Researchers (8)	0.20
Participation Span	Development (0)	**0**
	Trials/Testing (8)	**1**
Interaction Interval	Daily/Regular Interval (1)	0.07
	Weekly/Fortnightly (0)	0
	Monthly (0)	0
	No Information/Need Basis (13)	**0.92**
Interaction Method	Manual (One to One) (4)	**0.36**
	Phone/Pager (2)	0.18
	Others/Portal/Forum/Chat (5)	**0.45**
Feedback Mechanism	One-to-One (Manual) (4)	**0.33**
	E-Mail (1)	0.08
	Phone/IVR/Portal (2)	0.16
	SMS/Text (5)	**0.41**
Operational skills	Highly Skilled (5)	**0.34**
	Semi-Skilled (10)	**0.66**

Table-V depicts that most of the systems are developed for user specific needs as most of the systems have targeted farmers and extension agents/coordinators or workers. However, the users have been involved in trial/testing phases and their participation prior and during the system development is lacking to a great extent. The direct interaction with the users is also very low. Only one or two systems like CommonSenseNet promotes user interaction from the beginning of the project till end. Whatever the interaction is there it is one to one which is good for the users as well as the system developers. The user feedback mechanism is supported by the one-to-one (manual) feedback by text/SMS and e-mail/phone were not preferred which is beneficial in Indian context due to lower computer literacy rate of farmers. The operational skills required for most of the systems users are high which is again challenging for Indian context as training is required to be given to each and every farmer to operate the system. There is no information given on interaction interval with users for every system considered for appraisal.

Table- VI: System Information

Aspect	Features (Nos. of Positive Entries)	NW
Project Type	Research Oriented (6)	**0.40**
	Public Domain (9)	**0.60**
Support Type	Site Specific (6)	**0.31**
	Crop Specific (7)	**0.36**
	Others (6)	**0.31**
Supported Crop	Cereals (6)	**0.31**
	Vegetables (3)	**0.15**
	Others (10)	**0.53**
Operational Behavior	Online (14)	**1**
	Offline (0)	**0**
Interface Type	Only Hardware (6)	**0.28**
	Only Software (15)	**0.72**
System Outcome	Crop Specific Irrigation (7)	**0.21**
	Crop Specific Fertilization (4)	0.12
	Pest or Weed Control/Disease (7)	**0.21**
	Yield Prediction/Yield Goal (5)	**0.15**

	Soil Nutrient Management (2)	0.06
	Others/Weather Prediction (8)	**0.24**

Coming to system information, it is understood from table-VI, a good number of systems are online software based systems that are developed for public domain and support site/crop specific advisories for cereals, vegetables and other crops. Most of the system gives recommendations for crop specific irrigation, pest /weed and disease control and other purposes like weather prediction. Only few gives advisories on yield prediction and targeted goals however the systems that gives decision support on soil nutrient management and crop specific fertilization are very less and it is one of the challenging issue for sustainable growth of Indian agriculture.

Table- VII: System Design Specifications

Aspect	Features (Nos. of Positive Entries)	NW
Inputs	Soil Info. (Soil Test Reports) (5)	**0.13**
	Crop Info.(3)	0.08
	Climate/Environment Info.(9)	**0.24**
	Farmer/Extension Agent Inputs (8)	**0.21**
	Technical/Scientific Literature (2)	0.05
	Field/Crop Images (3)	0.08
	Historical Data (Crop/Yield/ Climate) (7)	**0.18**
Data Capture Method	Real-time/Near Real-time (7)	**0.46**
	Non-Real-time (8)	**0.54**
Architecture	Layered/Hierarchal (10)	**0.59**
	Distributed (7)	**0.41**
Connection Type	Wired (5)	**0.41**
	Wireless(7)	**0.59**
Input/output Connectivity Methods	Internet (11)	**0.36**
	Bluetooth (0)	0
	Wi-Fi (3)	0.1
	GSM/CDMA/3G (10)	**0.33**
	ZigBee (5)	**0.16**
	6LowPan (0)	0
	Others (1)	0.03

In reference to the table-VII, most of the systems takes soil and climate information along with the user inputs and past data of crop/yield/climate information as inputs where both real-time and non-real-time methods of data capturing are used. Most of the systems are connected wirelessly to sensors/WSNs and data analysis centre through internet and GSM technologies. Most of the systems are technologically competent to handle the data given by the users and sensors/systems. So availability of technology is not an issue for system implementation as technology is available however the usage of technology will help the users in achieving the sustainability is one of the question that needs answer as usage of new-age communication technology in already developed systems and their upgradation with state of art technologies still need attention.

Table- VIII: System Development Technologies

Aspect	Features (Nos. of Positive Entries)	NW
	GIS	0.04
	Remote Sensing	0
	Sensors or WSN	0.04
	Database	**0.12**
	Knowledge Modelling	0.07
	Statistical Modelling	0.04
	Scientific Analysis	0.07
Technologies and Tools	Soft Computing Methods/Tools	**0.11**
	Artificial Intelligence (AI)	0
	Data Analytics/Data Mining	0.05
	World Wide Web (www)/SWE	**0.10**
	Speech/Audio Processing	0.01
	Global Positioning System (GPS)	0.04
	Image/Video Processing	0.01
	Natural Language Processing	0.04
	Data Security	0.01
	Desktop User Interface	**0.12**
	Mobile User Interface	0.04

Looking at information on technologies and tools given in table-IV reveals that most the existing Indian systems are web and desktop user based systems that analyze the sensory, manual information from the database using soft computing techniques/ and statistical models/tools and knowledge modeling technologies. Only a few support GPS, NLP and speech processing technologies. Data security, artificial intelligence, natural language processing (NLP), mobile computing, image and video processing is still grey technologies in Indian agriculture

Table- IX: System Response Details

Aspect	Features (Nos. of Positive Entries)	NW
Information Delivery Method	One-to One Manual (12)	**0.37**
	E-mail (0)	0
	Report via Post/Extension Worker (4)	0.12
	SMS (Text/Voice) (3)	0.09
	Phone Call (1)	0.03
	Mobile Application (2)	0.06
	IVR/Chat via Web (10)	**0.31**
	Audio/Video guide (0)	0
Support Method	Real-time/Near Real Time (8)	**0.57**
	Non-Real-time (6)	**0.43**
Recommend Type	Zone Specific (5)	0.12
	Crop Specific (10)	**0.25**
	Based on Crop Stage (5)	0.12
	Season Time Based (3)	0.07
	Time Bound/Periodic (2)	0.05
	Field Specific (6)	0.15
	Others/Query Response (8)	**0.20**
Response Time	Immediate (7)	**0.28**
	Day to Day (2)	0.08
	Weekly (2)	0.08
	Fortnightly (1)	0.04
	Monthly or more (2)	0.08
	On Request (11)	**0.44**

The table-IX gives the information on responses of the systems w.r.t. to various aspects. In most of the existing systems are IVR based systems that can be easily accessed by the users themselves to get one-to-one feedback in form of advisories and necessary decision support in real as well as non-real-time. Numerous existing systems gives crop specific recommendation automatically or respond on the query made by the user. Only a few systems give crop stage and time bound advisories as per cropping cycle. The response time is immediate for IVR based systems whereas few systems also respond to the queries of farmers as and when they require it.

Table- X: System Services & feedback

Aspect	Features (Nos. of Positive Entries)	NW
User Interaction Features	Text/Chat Via Web (12)	**0.70**
	Voice (3)	0.17
	Image (2)	0.11
User Response	Up to Expectation (7)	0.14
	Relevant to Needs (14)	**0.28**
	Trust/Privacy (5)	0.10
	Yield Enhancement/Prediction(5)	0.10
	Economic Benefits (10)	0.20
	Effectiveness (8)	0.16
Economic/ Environmental Aspects	Paid Service (1)	0.03
	User Registration (8)	**0.29**
	Overall Cost High (✓)/Low(×) (2)	0.07
	Adaptability (9)	**0.33**
Services	Local and Customized Service (4)	0.14
	Periodic Update/add-on service (3)	0.11

The various services provided the various systems that are assessed in this paper, includes the user interaction via text/chat over web and only a few gives voice assisted support. As far as the user response is concerned, the user is satisfied w.r.t. the relevance to needs, economic benefits are also observed by the users in terms of yield enhancement through the advisories given by the system. All the systems are providing cost effective solution to their users as most of the systems are Govt. initiated projects that requires no registration cost. Hardware and software cost also lies with Govt. therefore requires no or minimum cost from users. Most of the systems are giving local and customized service to its user and the user found the systems both adaptive and effective. Trust and privacy are the few issues that need to be addressed in the research domain. Table X depicts the brief summary of the services given by various existing systems.

IV. RESULTS AND DISCUSSION

From the fifteen number of systems assessed in this paper, it is found that there exists a good amount of research and public domain initiatives that are developed by various research institutes with industrial academia collaboration with Indian as well as foreign collaborators' to provide right information to farmers at right time. Few systems are WSN based systems whereas others are IVR based systems or web based portals that gives answers to queries raised by the farmers and systems auto generate suggestions or give answers to queries raised by the farmers. The key findings of the appraisal can be summarized in form of drivers and barriers.

a) Drivers

- Collegial Participative Approach
- Rural Appraisal Approaches
- User Centered Design
- Input based farming (Specialized seed, fertilizers, pesticides and herbicides in uncertain water conditions
- Meeting centered approach to get user needs
- Specialized training and support to farmers'/extension agents
- Region and Farmer/farm Specific Information Delivery/ Personalized advice
- Voice and Image based Information exchange
- Right Information at right time
- Expert Visits and Effective Feedback Mechanism
- Updated database of farms/farmers
- Mechanism for two-way communication
- User friendly and interactive interface
- Local Language Support

b) Barriers

- Significant danger in raising the expectation of farmers
- Insufficient user participation in system development
- Primary focus on technology not on user needs
- Unclear target users
- Low adoption of systems by users due to distrust in technology
- Lack of location aware spatio-temporal information via WSNs
- Lack of user centered and application oriented DSS for farmers
- Danger in raising the expectation of farmers with use of technology
- Lack of attention to user needs
- No-Local Language Support
- Lack of training on computer literacy and domain specific knowledge
- No or less use of latest technologies like artificial intelligence and machine learning techniques.

V. ESSENTIAL CRITERIA FOR SYSTEM IMPLEMENTATION

The essential criteria derived for the development of DSS cum advisory system is as under (Figure-1):

- Survey/Meeting/Seminar of for farmer needs
- Iterative method of design and development as per user needs
- User centered design that is easy to use with less or minimum intervention of user in system operations
- Real-time sensory information should be captured
- User participation in trial and testing
- Reliable information dissemination
- Use of AI techniques in agriculture
- Reliable information dissemination via state of art technologies
- Field testing and validation
- Support in local language

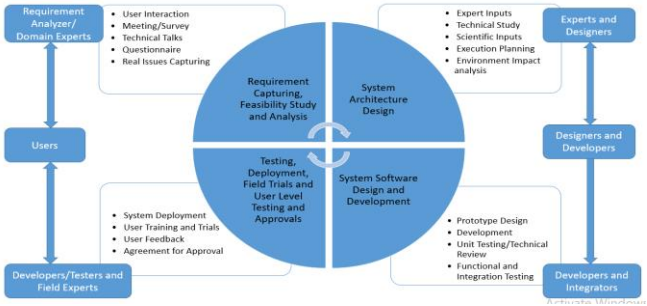

Figure 1 Essential Criteria for System Design

Figure-1 gives the depiction of essential steps to build a user-centric system for decision support and information dissemination. The system design should start with requirement capturing and analysis. Requirements must be captured via continuous and deep interaction with the user through surveys, meetings, questionnaires, demonstrations. Once the requirements are captured, the analysis of the same should be done by domain experts, system and software designers followed by the design of the system after continuous discussion and iterations as per the feedback of experts. Once the system design is approved, the software designer should design the architecture of the software and forward the functional and non-functional requirements to the developer team who develop the user needs into the system and finalize the requirements after proper unit level, functional testing. After the software is qualified, the integrators should integrate different software modules of entire software on dedicated hardware. Now the user should be involved in the deployment, functional testing, trials and user's feedback must be incorporated into the system by following the same development process. This iterative process should 'continue until the user gives final approval. Iterative design and development methodology with user participation will lead to a system that meets the user requirements.

VI. CONCLUSION

This study undertakes the appraisal of fifteen well known and popular systems that have already proven their potential in the Indian agriculture domain. Most of the systems show the use of technology and science in meeting the information needs of farmers. All the existing systems are based on push and pull-based services to provide need specific information to farmers but only a few give language support. This appraisal paper gives deep insight into different features and technical aspects of the appraised systems. The key drivers and barriers to efficient system development have been identified. The barriers can be treated as research gaps for reference to researchers in their future work.

The key findings of the paper cover essential criteria for future system development must cover proper requirements analysis through surveys/meetings with actual users citing their needs/faced challenges in their daily work routines, the participation of users in the entire development life cycle with iterative design and development methodology (Figure-1) meeting user's need. Users must be involved in each step of system development will lead to better system design and outcome. Although the usage of technologies has already been started however the basic requirement in many developing countries like India is the availability of systems that are user-centric and user-friendly and focus on meeting the user requirements/needs. Therefore, systems must deliver right information at right time.

Usage of artificial intelligence-based methods in analytics of future DSID systems and support to users in their local language by incorporating natural language processing will solve many challenges of farmers. Therefore, these can be taken as research challenges. Through this technical appraisal work, the authors believe that this work will help technologists, researchers, and developers to understand the research initiatives and associated challenges that need attention in the Indian context. It would be beneficial to researchers involved in the domain of ICT based data-driven decision support cum advisory systems.

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Table- I: Project Information of Selected Case Studies

Name[Ref]/Year	Type	Application Domain	System Objective/ Supported Crop	Development Agency
aAqua[32]/2003	Question & Answer Community Forum	Agriculture Information Delivery	To find solutions to problems posed by Indian farmers - small and large/ Any Crop	Media Lab Asia, IIT Bombay, India
CommonSenseNet[33-34]/ 2007	DSS using WSN	Environmental Monitoring/ Irrigation Management	Agriculture Risk Management/Yield prediction Improvement & disease Control/ Groundnut	NCCR-MICS, Lausanne Switzerland, IISc Bangalore, India
GramyaVikas[35]/2008	Distributed collaboration model	Rural development planning	To assist the user communality in personalized decision making processes/NA	CSRE,IIT Bombay, India
GeoSense[36]-[46]/2012	DSS using WSN	Precision Agriculture (irrigation, crop yield modeling, pest management, energy flux, & climate risks)	Dynamic information & modeling services for precision agriculture/ Three Crops (Groundnut, maize, and rice)	CSRE, IIT Bombay, India, ISAS, University of Tokyo, NARO, NARC, IIT and, ANGRAU, Hyderabad, India
E-Agromet[47][48]/2012	ICT-enabled agro metrological advisory System	Weather related risk mitigation measures	Weather Prediction, Weather Information Dissemination/ Regional & Seasonal Crops	IMD, Govt. of India, IIIT Hyderabad, ANGRAU, Hyderabad
BitVillage[49]/2012	Integrated Village information system	Calculations for cost prediction and fertilizer input details	Generate producible information to improve yield of crop production/NA	BITVIRTUAL, HNGU, Patan, Gujarat, India
KRISHISENSE [50]/ 2014	Semantically aware web enabled WSN	Precision Agriculture	Interconnection between multiple users facilitating human participatory sensing/ NA	CSRE,IIT Bombay, India
UAgri[51]/2014	Forewarning Model using WSN	Weather based Pest and Disease Management	To investigate the effects of microclimate on Pest and Disease in Groundnut and provide forewarning Advisories/ Groundnut	C-DAC and CRIDA Hyderabad India
KrishiBharti[52]/2014	Interface for Indian farmer to access urgent information without internet	Speech based interaction in Indian languages	text to speech (TTS) engine to access the agricultural information from the internet's global repository for Indian farmer community/NA	UPES, Dehradun, IIT Kharagpur, India
mAsk[53]/2014	Advisory System	Personalized agricultural advisories	bridging information gaps between farmers & agriculture knowledge workers/ NA	IITM's RTBI,IIT Madras, India
AGRIdaksh[54]/2015	Online Expert System	Integrated Pest Management (IPM)/Crop Protection	Pest & Disease Control/dissemination of IPM practices/Four Crops (Maize, Tomato, Corn, Mushroom, Mustard)	IASRI, Delhi
Deal[55]/20XX	Portal, Online Information Dissemination System	Personalized agricultural advisories	Information creation, creation, sharing and dissemination of agricultural information among farmers and experts.	NAIP, ICAR, IIT Kanpur, India
Agro-Sense[56]/2008	WSN based Advisory	Irrigation and Fertilization Control	climatological and environmental properties are sensed via WSN, analyzed for actuation and decision	Indian Institute of Management Calcutta , India
WSN-APS[57]/2014	WSN based Advisory	Apple Scab prevention	Dielectric Leaf Surface Wetness and Leaf Temperature are sensed via WSN, analyzed with Mills tables for decision on spray schedules for timely prevention of apple scab.	Indian Institute of Technology, Mandi, Himanchal Pradesh, India
m4agriNEI[58]/2018	Mobile Based Agro Advisory System	Seeking information, its processing, sharing and dissemination	To empower the farmers by providing right information on right time by implementing a 'Mobile Based Agricultural Extension System'.	Central Agricultural University (CAU), Imphal and the Media Lab Asia, New Delhi

Table- II: User and System Information for Selected Case Studies

Aspect		Parameters	[32]	[33]-[34]	[35]	[36]-[46]	[47]-[48]	[49]	[50]	[51]	[52]	[53]	[54]	[55]	[56]	[57]	[58]
User Information	Users	Farmers	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓
		Advisors/Experts	✓	✓	×	×	✓	×	✓	×	×	×	✓	×	✓	×	×
		Extension Agents/ Coordinators	✓	✓	✓	✓	✓	✓	✓	×	✓	×	✓	✓	×	×	✓
		Researchers	✓	✓	×	✓	×	✓	✓	×	✓	×	×	×	✓	✓	×
	Participation span	Development	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
		Trials/Testing	×	✓	×	×	✓	×	×	✓	×	✓	✓	✓	×	✓	✓
	Interaction Interval	Daily/Regular Interval	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
		Weekly/Fortnightly	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	×
		Monthly	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
		No Information/Need Basis	✓	✓	✓	×	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	✓
	Interaction Method	Manual (One to One)	×	✓	×	×	×	×	×	×	×	×	✓	✓	×	×	✓
		Phone	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	✓
		Others/Portal/Forum/Chat	✓	×	✓	×	×	✓	×	✓	×	×	×	✓	×	×	×
	Feedback Mechanism	One-to-One (Manual)	✓	✓	×	×	×	×	×	×	×	✓	✓	×	×	×	×
		E-Mail	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
		Phone/IVR/Portal	✓	×	×	×	×	×	×	×	×	×	×	✓	×	×	×
		SMS/Text	×	✓	✓	×	✓	×	×	✓	×	✓	×	×	×	×	×
	Operational skills	Highly Skilled User Required	×	×	×	✓	×	×	✓	×	✓	×	×	×	✓	✓	×
		Semi-Skilled	✓	✓	✓	×	✓	✓	×	✓	×	✓	✓	✓	×	×	✓
System Details	Project Type	Research Oriented	×	✓	×	✓	×	×	✓	×	✓	×	×	×	✓	✓	×
		Public Domain	✓	×	✓	×	✓	✓	×	✓	×	✓	✓	✓	×	×	✓
	Support Type	Site Specific	×	✓	×	✓	×	✓	✓	×	×	✓	×	✓	×	×	×
		Crop Specific	×	×	×	✓	×	×	✓	✓	✓	×	✓	✓	×	✓	×
		Others	✓	×	✓	×	✓	×	×	×	×	×	×	✓	✓	×	✓
	Supported Crop	Cereals	×	×	×	✓	✓	×	×	✓	×	✓	✓	✓	×	×	×
		Vegetables	×	×	×	×	×	×	×	✓	×	×	✓	✓	×	×	×
		Others	×	✓	✓	×	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓
	Operational Behavior	Online	✓	✓	✓	✓	✓	✓	✓	✓	✓	×	✓	✓	✓	✓	✓
		Offline	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	Interface Type	Only Hardware	×	✓	×	✓	×	×	✓	×	✓	×	×	×	✓	✓	×
		Only Software	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Outcome	Crop Specific Irrigation	×	✓	×	✓	×	×	✓	✓	×	×	×	✓	✓	×	×
		Crop Specific Fertilization	×	×	×	×	×	✓	×	✓	×	×	×	✓	✓	×	×
		Pest or Weed Control/Disease	×	×	×	✓	×	×	✓	✓	✓	×	✓	✓	×	✓	×
		Yield Prediction/Yield Goal	×	×	×	✓	×	✓	✓	×	×	✓	×	✓	×	×	×
		Soil Nutrient Management	×	×	×	×	×	×	×	✓	×	×	×	✓	×	×	×
		Others/Weather Prediction	✓	×	✓	×	✓	✓	×	✓	×	×	×	✓	×	✓	✓

Table- III Technical Information for Selected Case Studies

	Aspect	Parameters	[32]	[33]-[34]	[35]	[36]-[46]	[47]-[48]	[49]	[50]	[51]	[52]	[53]	[54]	[55]	[56]	[57]	[58]
System Design Details	Inputs	Soil Info. (Soil Test Reports)	×	✓	×	✓	×	✓	✓	×	✓	×	×	×	×	×	×
		Crop Info.	×	×	×	✓	×	✓	✓	×	×	×	×	×	×	×	×
		Climate/Environment Info.	×	✓	×	✓	✓	✓	✓	×	✓	✓	×	×	✓	✓	×
		Farmer/Extension Agent Inputs	✓	✓	✓	×	×	✓	×	✓	×	×	✓	✓	×	×	✓
		Technical/Scientific Literature	×	×	×	✓	×	×	✓	×	×	×	×	×	×	×	×
		Field/Crop Images	✓	×	×	✓	×	×	×	×	×	✓	×	×	×	×	×
		Historical Data (Crop/Yield/Climate)	×	✓	×	✓	✓	✓	×	×	×	✓	✓	✓	×	×	×
	Data Capture Method	Real-time/Near Real-time	×	✓	×	✓	✓	×	✓	×	✓	×	×	×	✓	✓	×
		Non-Real-time	✓	×	✓	×	×	✓	×	✓	×	✓	✓	✓	×	×	✓
	Architecture	Layered/Hierarchal	✓	✓	×	✓	✓	×	✓	×	✓	✓	✓	×	✓	✓	×
		Distributed	✓	×	✓	×	×	✓	×	✓	×	✓	×	✓	×	×	✓
	Connection type	Wired	✓	×	✓	×	×	×	×	✓	×	×	✓	✓	×	×	×
		Wireless	×	✓	×	✓	×	×	✓	×	✓	×	×	×	✓	✓	✓
	Input/ Output Connectivity Methods	Internet	✓	×	✓	✓	×	×	✓	✓	×	✓	✓	✓	✓	✓	✓
		Bluetooth	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
		Wi-Fi	×	✓	×	✓	×	×	✓	×	×	×	×	×	×	×	×
		GSM/CDMA/3G	✓	✓	×	✓	×	✓	✓	×	✓	✓	×	×	✓	✓	✓
		ZigBee	×	×	×	✓	×	×	✓	×	✓	×	×	×	✓	✓	×
		6LowPan	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
Development Technologies	Technologies and Tools	GIS	×	✓	✓	✓	✓	✓	✓	×	×	×	×	×	×	×	×
		Remote Sensing	×	×	×	×	×	✓	×	×	×	×	×	×	×	×	×
		Sensors or WSN	×	✓	×	✓	×	×	✓	×	✓	×	×	×	✓	✓	×
		Database	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Knowledge Modelling/Discovery	✓	×	✓	✓	✓	✓	×	✓	×	×	✓	✓	×	×	✓
		Statistical Modelling	×	✓	×	✓	×	✓	×	×	×	×	×	×	✓	✓	×
		Scientific Analysis	×	✓	×	✓	✓	✓	✓	×	✓	×	✓	×	✓	✓	×
		Soft Computing Methods/Tools	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	×
		Artificial Intelligence (AI)	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
		Data Analytics/Data Mining	×	✓	×	✓	×	×	×	✓	✓	×	×	×	✓	✓	✓
		World Wide Web (www)/SWE	✓	✓	✓	✓	✓	✓	✓	✓	×	×	✓	✓	✓	✓	✓
		Speech/Audio Processing	×	×	×	×	×	×	×	✓	×	✓	×	×	×	×	×
		Global Positioning System (GPS)	×	✓	×	✓	×	✓	×	×	×	×	×	×	✓	✓	×
		Image/Video Processing	×	×	×	✓	×	×	×	×	×	✓	×	×	×	×	×
		Natural Language Processing (NLP)	×	×	✓	×	✓	✓	×	✓	×	×	×	✓	×	×	×
		Data Security	×	×	✓	✓	×	×	×	×	×	×	×	×	×	×	×
		Desktop User Interface	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
		Mobile User Interface	×	×	×	✓	×	×	✓	×	✓	✓	✓	✓	×	×	×

Table- IV System Services and Features for Selected Case Studies

Aspect	Parameters	[32]	[33]-[34]	[35]	[36]-[46]	[47]-[48]	[49]	[50]	[51]	[52]	[53]	[54]	[55]	[56]	[57]	[58]
Information Delivery Method	One-to One Manual	✓	✓	✓	✓	×	✓	✓	✓	✓	✓	✓	✓	×	×	✓
	E-mail	×	×	×	×	×	×	×	×	×	×	×	×	×	×	×
	Report via Post/Extension Worker	✓	×	×	✓	✓	×	×	×	×	×	×	×	×	×	✓
	SMS (Text/Voice)	×	✓	×	×	×	✓	×	×	✓	×	×	×	×	×	×
	Phone Call	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	Mobile Application	×	×	×	×	×	×	×	×	×	✓	×	×	×	×	✓
	IVR/Chat via Web	✓	×	✓	×	×	✓	×	✓	×	✓	✓	✓	✓	✓	✓
	Audio/Video guide	×	×	×	×	×	×	×	✓	×	×	×	×	×	×	×
Support Method	Real-time/Near Real Time	×	×	✓	✓	×	×	✓	×	×	✓	×	✓	✓	✓	✓
	Non-Real-time	×	✓	×	×	✓	✓	×	✓	✓	×	✓	×	×	×	×
Recommendation Type	Zone Specific	×	✓	×	×	×	✓	×	×	×	✓	×	×	✓	×	✓
	Crop Specific	×	×	×	✓	×	×	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Based on Crop Stage	×	×	×	✓	×	×	✓	×	✓	×	✓	×	×	×	✓
	Season Time Based	×	×	×	✓	×	×	✓	×	×	×	×	×	×	×	✓
	Time Bound/Periodic	×	×	×	×	✓	×	×	×	×	×	×	×	×	×	✓
	Field Specific	×	✓	×	✓	×	✓	✓	×	×	✓	×	×	×	×	✓
	Others/Query Response	✓	×	✓	×	✓	✓	×	✓	×	×	✓	✓	×	×	✓
Response Time	Immediate	×	✓	✓	✓	×	×	✓	✓	×	×	✓	×	×	×	✓
	Day to Day	×	×	×	✓	×	×	✓	×	×	×	×	×	×	×	×
	Weekly	×	✓	×	×	✓	×	×	×	×	×	×	×	×	×	×
	Fortnightly	×	✓	×	×	×	×	×	×	×	×	×	×	×	×	×
	Monthly or more	×	✓	×	×	×	×	×	×	✓	×	×	×	×	×	×
	On Request	✓	✓	✓	✓	×	✓	✓	✓	×	✓	✓	✓	×	×	✓
Services	Local and Customized Service	✓	✓	×	×	×	✓	×	✓	×	×	×	×	×	×	×
	Periodic Update/add-on service	×	×	×	×	×	×	×	×	×	✓	✓	×	×	×	✓
User Interaction Features	Text/Chat Via Web	✓	✓	✓	×	×	✓	×	✓	✓	✓	✓	✓	✓	✓	✓
	Voice	×	×	×	×	×	×	×	✓	×	✓	×	×	×	×	✓
	Image	×	×	×	✓	×	×	×	×	×	×	×	×	×	×	✓
User Response	Up to Expectation	✓	×	×	×	×	×	×	✓	×	×	✓	✓	✓	✓	✓
	Relevant to Needs	×	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Trust/Privacy	✓	×	✓	✓	×	×	×	×	×	×	×	✓	×	×	✓
	Yield Enhancement/Prediction	✓	×	×	✓	✓	✓	✓	×	×	×	×	×	×	×	×
	Economic Benefits	✓	×	×	✓	✓	✓	✓	×	✓	✓	✓	✓	×	×	✓
	Effectiveness	✓	×	×	✓	✓	×	✓	✓	×	✓	✓	×	×	×	✓
Economic/ Environmental Aspects	Paid Service	×	×	×	×	×	×	×	×	×	×	×	×	×	×	✓
	User Registration	✓	×	✓	✓	×	×	×	×	✓	✓	✓	✓	×	×	✓
	Overall Cost High (✓)/Low(×)	×	×	×	✓	×	×	✓	×	×	×	×	×	×	×	×
	Adaptability	✓	✓	✓	×	×	×	×	✓	✓	✓	✓	✓	×	×	✓

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