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Conceptualization of a framework of decision support system for agriculture in hilly region

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सार – कृषि के क्षेत्र में निर्णय समर्थन प्रणाली (DSS) पैदावार को बढ़ाते हुए और सूचनाओं की लागत को कम करते हुए आर्थिक लाभ को अधिकतम करने की परिस्थिति के अनुसार उचित निर्णय लेने के लिए कृषक समुदाय की मदद करती है। DSS का प्रमुख उद्देश्य आवश्यकता पड़ने पर सूचनाओं को लागू करते हुए सूचना के उपयोग की क्षमता को बढ़ाना है। स्थानिक गति वाले क्षेत्र में पर्यावरण की स्थिति में काफी भिन्नता होने के कारण पहाड़ी क्षेत्रों के राज्यों के लिए DSS की आवश्यकता अधिक महसूस की जा रही है। मौसम की चरम घटना की संभावना के बढ़ने के साथ जुड़े जलवायु परिवर्तन से DSS की आवश्यकता और अधिक बढ़ गई है। पहाड़ी क्षेत्रों के राज्यों के लिए DSS का उपयोग/ विकसित करने के लिए पहले कई प्रयास हो चुके हैं। भारतीय स्थितियों में कृषि प्रोद्यौगिकी अंतरण के लिए निर्णय समर्थन प्रणाली (DSSAT) के सही ट्यूनिंग द्वारा इस दिशा में गंभीर प्रयास आरम्भ किए गए। DSSAT फसल के चयन, बुवाई का समय, सिंचाई, उर्वरक और फसलों की कटाई पर उचित निर्णय लेने के लिए मदद करता है। हाल में DSS का विकास फसल सिमुलेशन मॉडल के साथ मिलकर और अकेले भू-स्थानिक प्रौद्योगिकी का भी उपयोग किया गया है। इस शोध पत्र में DSS के प्रयोज्य और सीमाओं के साथ पहाड़ी क्षेत्रों के राज्यों में DSS को विकसित करने के लिए शोधकर्ताओं / शिक्षाविदों के प्रयासों पर बल दिया गया है। इस शोध पत्र में एक पूर्व चेतावनी प्रणाली और कृषि विशेषज्ञ प्रणाली के एकीकरण द्वारा पहाड़ी क्षेत्रों के राज्यों के लिए एक रूपरेखा भी तैयार की गई है।

ABSTRACT. Decision support system (DSS) in agriculture helps farming community to take appropriate decision as per the situation to maximize economic return by enhancing productivity and reducing the cost of inputs. The prime most purpose of DSS is to enhance the input use efficiency by applying the input when it is needed most. The requirement of DSS in the hilly states is being felt more as environmental conditions vary greatly in tempo-spatial domain. Climate change associated with increasing probability of extreme weather conditions has further deepened the need of DSS. There have been many attempts in the past to use / develop DSS in the hilly regions. The serious efforts in this direction were initiated by fine tuning the Decision Support System for Agrotechnology Transfer (DSSAT) in Indian conditions. DSSAT helps to take appropriate decisions on selection of cultivar, sowing time, irrigation, fertilization and harvesting of crops. Of late geospatial technology alone and in combination with crop simulation model has also been used to develop DSS. Present paper underlines the efforts of researchers / academicians to develop DSS in hilly states with their usability and limitations. Paper also conceptualizes a framework of DSS for hilly regions by integrating a forewarning system and agriculture expert system.

Key words – Decision support system (DSS), Hilly region, Agriculture expert system (AES), Geospatial technology, Remote sensing, GIS, Soil information system (SIS).

1. Introduction

Agriculture in hilly region is characterized by small and scattered land holdings, low inputs and low productivity associated with high variability. Reasons behind mentioned characteristics are high topographic and climatic variability leading to high soil variability with low fertility. Hilly regions often experiences extreme weather conditions such as high rainfall, heat wave, cold wave, droughts and floods. This results into the loss of top soils, biotic and abiotic stresses affecting the agricultural productivity. According to Agricultural Statistics at Glance (2014), approximately 80% of population of hilly states (Uttarakhand, Himachal Pradesh, Jammu & Kashmir, Assam, Arunachal Pradesh, Sikkim, Manipur, Tripura, Meghalaya and Nagaland) lives in rural area and is directly or indirectly dependent on agriculture. There are certain states like Himachal Pradesh (89.97%) and Assam (85.90%), wherein even more population depends upon agriculture. The contribution of rural population in hilly state is quite high in comparison to national average (68.9%). The share of agricultural GDP is also quite low (6 states out of 10 contribute less than 13.9% to state GDP) in comparison to national average. Productivity of almost all agricultural crops in hilly states is very low as compared to other states for example wheat productivity of Uttarakhand, Himachal Pradesh and Assam is 2.4, 1.67 and 1.30 t/ha, respectively, while productivity of plane states like Punjab, Haryana, and Uttar Pradesh is 4.72, 4.45 and 3.11 t/ha, respectively.

Irrigated land in the hilly states is also floundering far behind than the national average (58.7%), therefore agriculture is bound to depend upon the water from precipitation. On other hand the tempo-spatial distribution of the rainfall is so erratic that it virtually makes difficult to take any agricultural decision based on historical weather data. Weather forecast being issued by IMD/ NCMRWF, which showed quite promising results in the non-hilly states, exhibits limited accuracy in hilly states especially in monsoon season. Further, low spatial resolution of weather forecast (1 degree), limits it usability for agricultural operations at field scale. Frequent visits of extreme weather conditions also worsen the situation. Flash floods, landslide, soil erosion, loss of top soil are frequent phenomenon making agricultural operations very difficult. The catastrophic event at Kedarnath (June, 2013) is still fresh in the minds of people, when thousands of people died and agriculture at thousands of hectare land vanished. The tough living conditions in hilly states and lack of transportation, agricultural inputs, timely availability of inputs, electricity and implements resulted into poor state of socio-economic conditions of the people of state leading to the curse of migration. The requirement of Decision Support System, therefore, in hilly states is being felt at more intensity now than ever before.

1.1. *What is DSS?*

The paramount motto of agricultural research and management is to enhance productivity and reducing the cost of inputs by increasing input use efficiency. There are visibly two options, which can be exercised: work harder or work smarter. In the short run, it is possible to make improvements by working harder, but in the long run, organizations are more likely to make sustained progress by "working smarter". The information technology revolution provides a potential source of tools that could help agricultural research institutions work smarter by increasing both the productivity of the agricultural research institutions and the agricultural systems they serve. Computer programs designed explicitly to help people work smarter by making better decisions are called Decision Support Systems (DSS). These tools are clearly no panacea, but in the right situations, they can provide significant benefits. Over time, as the cost of information technology infrastructure continues to decrease, the benefits of providing DSS technology will exceed the cost of installation, and the role of DSS in agriculture will grow. DSS are built on the experience researcher gains in the experimental field / farmer's field over the years in diverse set of environmental conditions. The relationship between environmental variables and crop response is depicted with the help of mathematical equations. The understanding of relationship helps to model even those situations which have not been experience in the past. The basic aspiration behind DSS is help the users to take better decisions at right time to enhance profitability.

1.2. *Need of DSS in hilly states*

Weather conditions in hilly states vary greatly in spatio-temporal domain due to topographical variations. Topographical variation sometimes produces triggering effects on the weather phenomenon and weather changes sharply in few hours. Changing weather conditions causes negative effect on the plants; therefore acting according to weather condition is important to achieve higher productivity. In the volatile situations prevailing in hilly states, the integration of different systems is required in order to produce a robust decision support system. A system, which informs the user about the weather conditions and their consequences like flood, drought, landslide, storms, etc and other systems which help user to take appropriate decisions in the given conditions may be integrated.

2. Review of existing / proposed DSS in hilly state

Efforts have been made in the past to prepare and implement Decision Support System for the various processes of the agricultural system. These efforts include development of statistical model for analyzing crop weather relationship / yield prediction (Tabasum *et al*., 2006; Ranjan *et al*., 2012), use of crop simulation model for decision making (Nain *et al*., 2000; Kumar *et al*., 2012; Kumar *et al*., 2014) with minimal data set (Nain *et al*., 2002; Nain *et al*., 2004), integration of CSM with remote sensing (Nain *et al*., 2012) optimizing sowing dates (Pareek, 2014), optimizing water inputs (Pareek, 2014), analyzing impact of climate change (Pal *et al*., 2012), applying GIS based Soil Test Crop Response Approach for enhancing productivity (Nain *et al*., 2014), Remote sensing based approach for analyzing soil variability and applying variable rate technology (Nain *et al*., 2014). Agro-climatic zonation / agroecological regionalization is another approach, which helps the farming community to decide on suitable cropping system (Bisht *et al*., 2012). Geospatial technology based suitability analysis of field and plantation crop also helps farmers to select appropriate crops/ traits (Dhami *et al*., 2012; Puranik *et al*., 2012). A summary of the effort is being given below state wise.

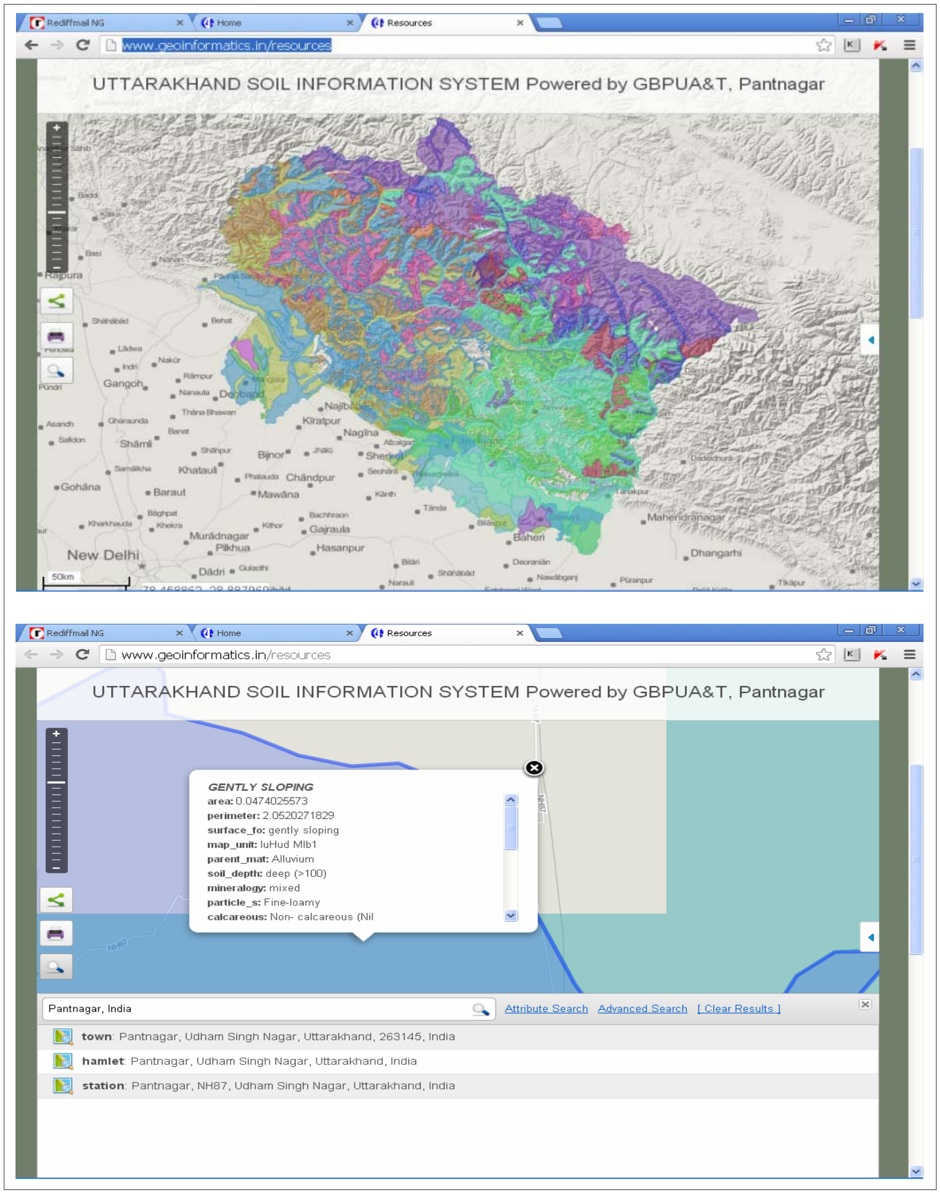


Fig. 1. The screenshot of Uttarakhand Soil Information System, (*i*) the complete system (top) and (*ii*) query and display of soil information (bottom)

2.1. *Uttarakhand*

Government of Uttarakhand had prepared a roadmap (eGRM, 2007) to implement decision support system in various governmental activities including agriculture. AGRISNET, AGMARKNET, CIS (crop information system), were few initiatives of government of Uttarakhand, which have been implemented for the farming community to help them in taking appropriate decision mostly related to market and allied sectors. Central to any decision support system is the database.

2.1.1. *Agro-climatic Planning and Information Bank (APIB)*

The scale and accuracy with which data are generated, plays an important role in the success of DSS. Considering the importance of dataset, Government of Uttarakhand has taken a serious step on developing a robust decision support system by creating Agro-climatic Planning and Information Bank (APIB) for Uttarakhand state (Rao *et al*., 2008). APIB has been designed in a way that it contains information on both spatial and nonspatial elements namely mapping, GPS survey, soil survey, GIS and Image Processing analysis, fertilizers use, plant protection, seeds/seedlings, package of practices, agricultural implements, climatological data, credit/ insurance schemes available, infrastructure for processing and marketing, demographic details, etc. The strength of APIB is a powerful state-of-the-art image analysis and GIS facilities to assess the natural resources endowments to any agro-climatic region and present them in the spatial and temporal domain. The Natural Resources databank is generated for the various themes important to develop decision support system. Entire database has been generated at 1:10,000 scale level, except in case of very steep and steep hilly areas under forest where the level of mapping was reduced to 1:50,000 scale. Maps showing spatial variation of agro-meteorological parameters were generated by GIS aided geo-statistical interpolation of ground meteorological station collected point agro-meteorological data. These maps were utilized for preparation of agro-climatic and agro-ecological zones and sub zonation at micro level suggesting agricultural management; estimation of soil erosion loss etc. Action plans for land resources development include plans for Management of agricultural land, Management of wasteland and Allied agricultural activities. The land resources data integrated with climatic variability, location specific agronomic packages of practices in vogue and management scenarios helps in optimum crop management practices and predicting productivity of the area.

2.1.2. *Web based soil information system for Uttarakhand*

The first web based interactive Soil Information System containing systematic information on Soils of Uttarakhand has been designed and developed by (Nain *et al*., 2014). The system integrates the technologies of web-server, map-server, web technology and GIS for interactive display of the soil information. The front-end of the system displays the map of Uttarakhand through map-server, which on click, put on view the soil information of any region of Uttarakhand. Soil information system is accessible through website www.geoinformatics.in and can be used either with mobile or desktop/laptop computer. The map server communicates with the local server installed at GIS lab, GBPUA&T, Pantnagar, India and retrieves the information available in database. All the times, when map is loaded or reloaded it always looks in to the database for any change, if any, and accordingly updates the information in SIS. The database in addition to the soil information also contains information on locations. An advanced search option has been provided with Soil Information System so that the location such as villages, town, city and districts may be searched. The location search option in the system allows user to locate the desired places. Once queried, the system automatically focuses on the searched area and display the soil information. The topographical map of the world has been used in the background of the system, which also enables the user to navigate through the different locations. On the display of Uttarakhand Soil Information System (USIS), the field terminal communicates with the map server and map server communicate with the data server. The map server temporarily stores the information and sends the information in packets of XML. The packets of XML are received by field terminal and information in shape of file is displayed. The XML packet information is arranged in space as per their coordinates and map appears as a vector map. Though, actually it is in raster format. On a click inside the Soil Information System, field terminal again communicate back to the map server and map server communicate with data server. Thereafter, the attribute table is sent from map server to the field terminal in XML file format and is displayed on screen in tabular form. A screenshot of the system is being given in Fig. 1.

2.1.3. *Disease Monitoring and Management System (DiMMS)*

Various technologies have been tested for monitoring / surveillance and forewarning of the incidence of different diseases and pests ranging from field survey, weather based statistical model, remote sensing and GIS based systems. However, these approaches are either site specific or deal with a specific disease or pest. The availability of the input data (weather or disease related survey) has been always a constraint in the model. The delivery of the information till recent past has been very challenging as most of information was being transmitted through published bulletins, news papers and radios. In case of disease management the time has been very crucial as crops are sometime completely destroyed in few days.

Another major constraint in the application of remote sensing and GIS based system has been proprietary image processing and GIS software and limited availability of the remote sensing images that too are received at a time lag of 5-10 days. However, due to recent advancement in information technology and remote sensing, now data of various resolutions, various sensors are available at very reasonable cost (some time free like LANDSAT data). High speed internet connections have facilitated delivery of the remote sensing data in a very time efficient manner. Free and open source software have further accelerated the use of remote sensing and GIS technology for mapping and monitoring of various objects/events/ phenomenon.

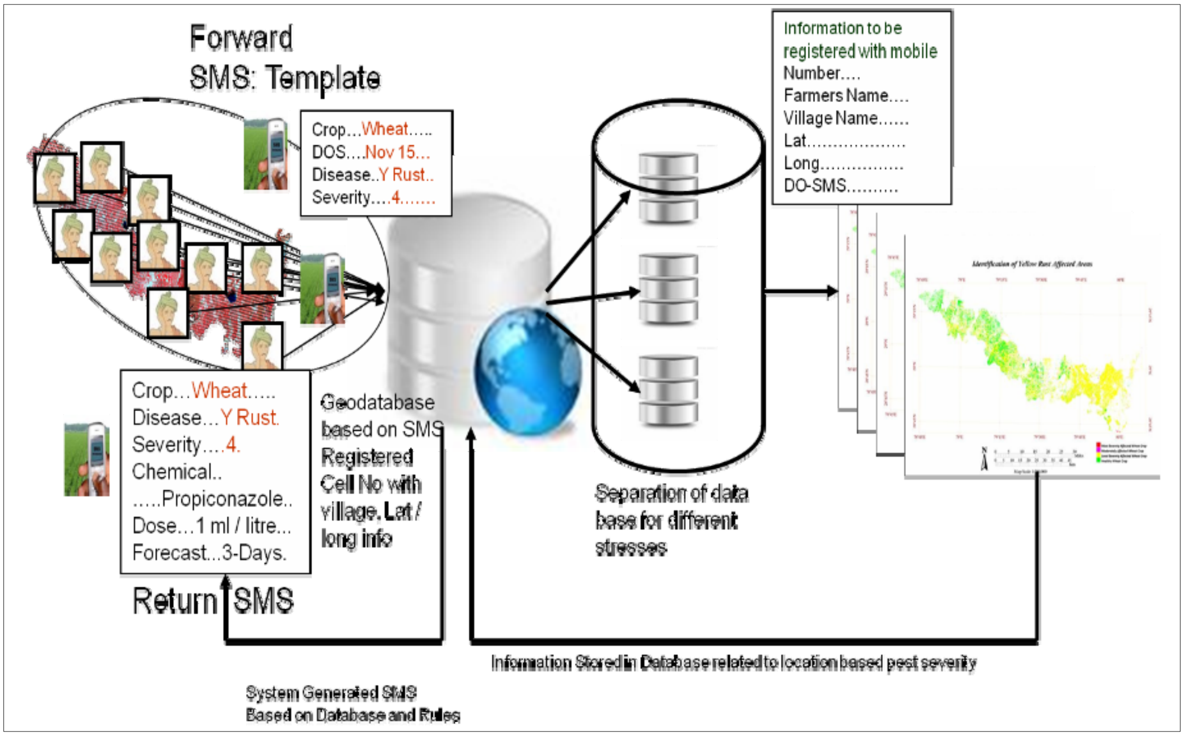


Fig. 2. Schematic representation of the integrated system for disease surveillance and management system

Therefore an attempt has been made to develop an innovative and advanced system, which integrates the different technologies of data generation (remote sensing, mobile phones), data analysis (GIS and statistical packages), data base creation (geo-database management system), and information delivery (SMS and web technology) (Nain *et al.*, 2014). These technologies together may offer a great potential to generate and analyze the data very quickly and also to deliver data / information in most time efficient manner. A complete schematic representation of the system has been shown in the Fig. 2.

DiMMS relies upon regular flow of information from stakeholders through an Innovative approach Data Collection and Transmission Node (DCTN). A SMS template for the purpose has been developed and installed at individual's mobile set. A template of SMS is being given below:

Crop...Wheat.....
DOS....Nov 15...
Disease..Y Rust..
Severity....4.......

Some information such as date of data collection, mobile number of DCTN is retrieved from SMS, while other information such as name of village, farmer's name, latitude and longitude of the location will be drawn from the database available at server. This information is collected from individual DCTN during training and is stored at local server. The information to be automatically retrieved / updated is being given below:

Information to be registered with mobile
Number....
Farmers Name....
Village Name......
Lat..................
Long................
DO-SMS..........

Additionally an Android (mobile) based data collection system has also been developed for real-time location specific data collection and transmission (Fig. 3). The GPS enabled Smartphone, which allows internet connection and displaying of Google map is used for real-time data collection. System once opened will automatically read the latitude and longitude information through GPS and displays the location at Google map. Thereafter a template automatically prompted at the bottom of screen, which allows entry of information on

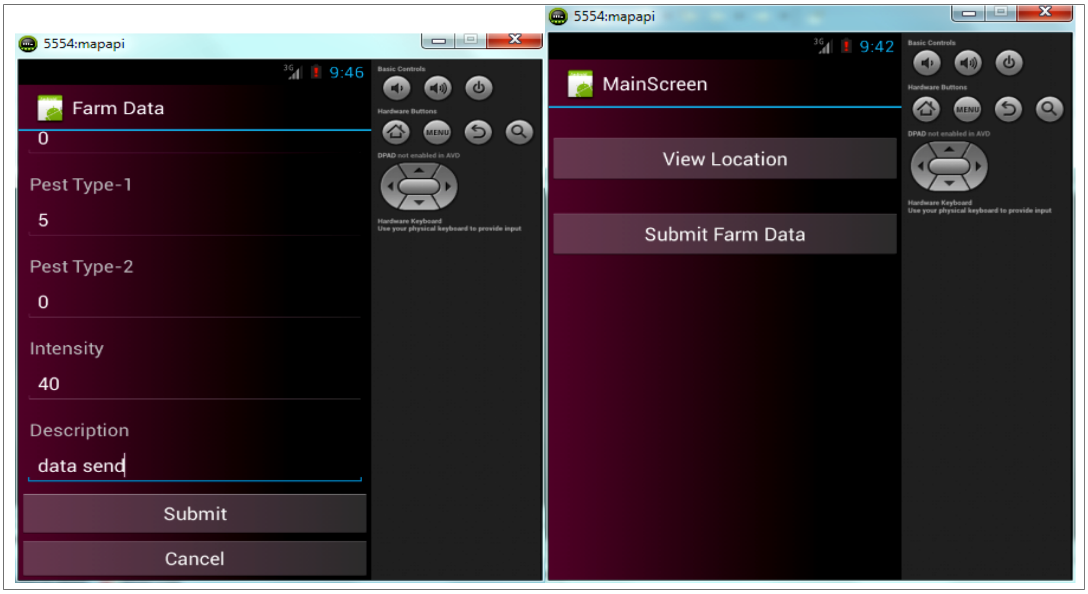
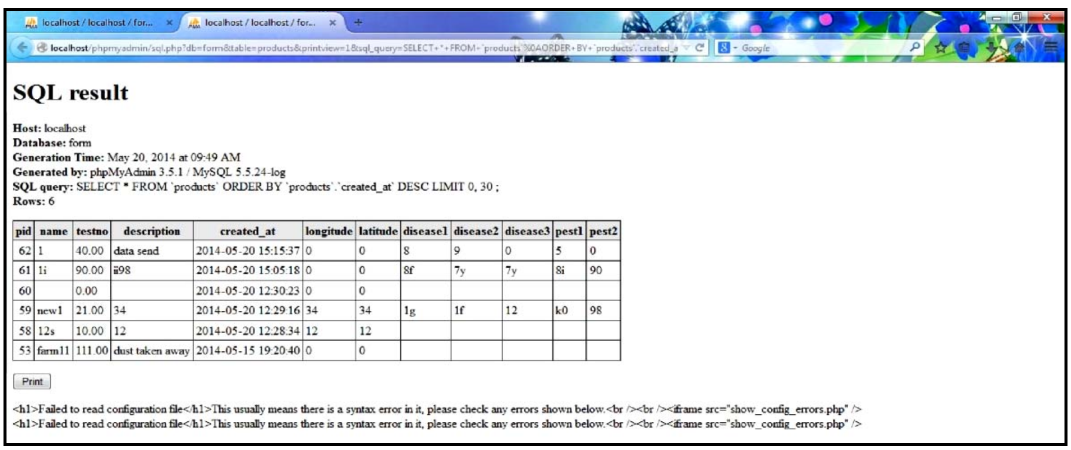


Fig. 3. Screenshot of android based applications for submitting data related to disease and its intensity



SQL result

Host: localhost
Database: form
Generation Time: May 20, 2014 at 09:49 AM
Generated by: phpMyAdmin 3.5.1 / MySQL 5.5.24-log
SQL query: SELECT * FROM `products` ORDER BY `products`.`created_at` DESC LIMIT 0, 30 ;
Rows: 6

pid	name	testno	description	created_at	longitude	latitude	disease1	disease2	disease3	pest1	pest2
62	1	40.00	data send	2014-05-20 15:15:37	0	0	8	9	0	5	0
61	1i	90.00	ii98	2014-05-20 15:05:18	0	0	8f	7y	7y	8i	90
60		0.00		2014-05-20 12:30:23	0	0					
59	new1	21.00	34	2014-05-20 12:29:16	34	34	1g	1f	12	k0	98
58	12s	10.00	12	2014-05-20 12:28:34	12	12					
53	farm11	111.00	dust taken away	2014-05-15 19:20:40	0	0					

Print

<h1>Failed to read configuration file</h1>This usually means there is a syntax error in it, please check any errors shown below.

<iframe src="show_config_errors.php" />
<h1>Failed to read configuration file</h1>This usually means there is a syntax error in it, please check any errors shown below.

<iframe src="show_config_errors.php" />

Fig. 4. The design of database used for inserting data and for sending SMS to registered users

crop, disease and intensity. Thereafter push button converts the data into XML format and transmits the same data to the server.

A framework has been designed and developed in programming language (C++ / Java) for preparing the severity maps of different diseases (Fig. 4). This framework connects the geo-database with open source GIS software QGIS and the data collected through DCTN/ Smartphone is used to prepare disease severity maps. The disease severity maps are automatically classified into four categories very severe, moderately severe, marginal severe and no-disease. The system has also been configured to collect information on disease forecast and on the basis of the type of disease and severity of disease, system will draw the information from database related to appropriate pesticide and its dosages/quantity, will prepare the SMS and thereafter SMS will be broadcasted to the different registered users.

2.2. *Himachal Pradesh*

CSK Himachal Pradesh Agriculture University has attempted to develop Agriculture Spatial Info and Decision Support Software (AgDSS), under Department of Science and Technology (DST), New Delhi initiative

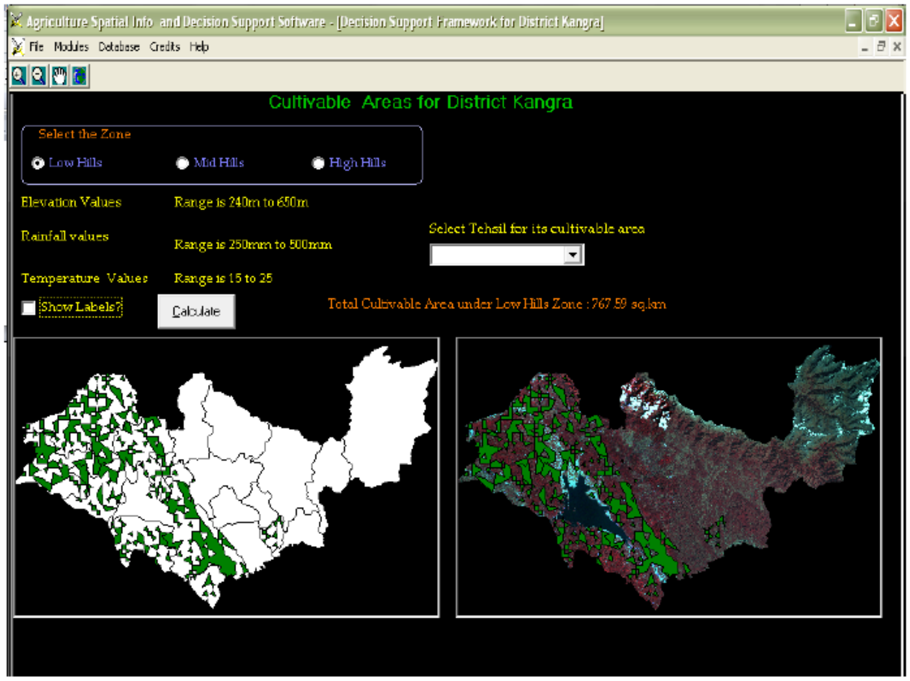


Fig. 5. Agriculture Spatial Info and Decision Support Software (AgDSS) developed by CSK Himachal Pradesh Agriculture University, Palampur

on Decision support system framework for agricultural land use management and livelihood options for sustainable development of mountain district of Himachal Pradesh (Singh *et al*., 2009). AgDSS was developed for the district of Kangra, Himachal Pradesh (Fig. 5). AgDSS is a standalone application which is deployable on any workstation. The software provides most of the functionalities of GIS analysis without the user having the need to deploy other GIS software. Agriculture Spatial Information and Decision support software includes four modules: (*i*) Agro socio economic information module, (*ii*) Bio Physical module, (*iii*) Crop Information and Management and (*iv*) Agriculture Decision support System. AgDSS chiefly provides information on Crop Requirement, Available Resources, Diversification Index, Income Generation, and Suitable Agriculture areas on the basis of data collected from various sources. Most of data incorporated in the system were collected during 1991-2003. The changes, whatsoever take place over study regions are not incorporated / updated. In absence of regular update / link to central data server, system provides predictable information all the times. Considering the highly dynamic nature of agriculture system, the link of AgDSS with central server through internet will help farming community in better way. The coverage area of AgDSS needs to be broadened to cover entire state of Himachal Pradesh for helping the farmers of other regions. Inclusion of module to help the farming community to take day-to-decision on irrigation, fertilization, pests & disease management, harvesting etc and regular update of base data will further increase the applicability of the system.

2.3. *Jammu & Kashmir*

Singh and Mansotra (2010) have proposed to establish an ICT based decision support system for the development of agriculture in the state of Jammu & Kashmir. Farm Management Information System (FMIS) will be a localized web based decision support system in agriculture and will be made available on Agriculture portal of the state. A properly designed FMIS is an interactive software-based system intended to help decision makers compile useful information from raw data, documents, personal knowledge, and/or business models to identify and solve problems and make decisions. FMIS will contain information about agro ecological zone, climate, soil, weather, temperature, humidity, moisture, drought, seed varieties, fertilizers, crop disease and their management, pest management, crop pattern, irrigation and water management, agricultural equipment, food processing, food preservation, food quality, agricultural marketing, regulation of markets, grading and supply of agriculture produce, transportation, government polices about agriculture, Bank loan information. The farmers, agricultural technician, extension agents, field advisors, researchers and Kiosk operators will operate the FMIS

TABLE 1

Types of decision support system in use with their limitations and advantages

S. No.	Type of system	Limitations	Advantages
1.	Statistical DSS	Static in Nature, crop and site specific, temporal and spatial variation is not accounted for, limited applications, need to update regularly.	Easy to develop and use, fast in response.
2.	System Simulation Based DSS	Difficult to develop, require more time and integrated efforts, require specialized person to use, data requirement is high.	Dynamic in nature, generic in behavior, can account spatial and temporal variation, can be used for many crops, common platform for data input, consider plant and soil processes, can be linked with weather forecast to take decision in advance.
3.	GIS based DSS	Do not provide dynamic environment, mainly based on logical models, cannot provide futuristic scenario.	Can be used for many crops and traits, can be linked with latest dataset through internet, can offer web based applications.
4.	Remote Sensing based DSS	Require specialized person, tools, and techniques, variation in soil is difficult to be accounted for, can be used for limited applications, cannot provide futuristic scenario.	Can provide dynamic environment and handle spatial and temporal variation in crop, can be linked with website.
5.	Integrated DSS	Require specialized person, tools, and techniques.	Provide dynamic environment and efficiently handle spatial and temporal variation in crop and soil, operationalized through web, can be used to take decision in advance.

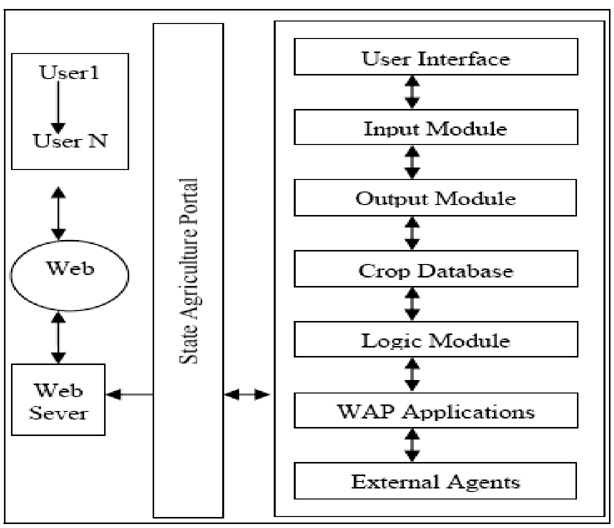


Fig. 6. Proposed framework of Farm Management Information System in J&K

effectively and get information related to agriculture and improving the productivity through precision farming (PF). The knowledge of domain and expertise of the users can be embedded into the system. The user can provide data for processing by putting various parameters as per the prevailing conditions and FMIS will passes the information back through appropriate interface. Framework of the proposed system has been given in Fig. 6.

3. Conceptual framework of ideal decision support system

A variety of DSS have been developed by various institutions / organizations to help farming community to take better decisions. These include simple statistical DSS to complicated DSS like DSSAT and advance technology like remote sensing based DSS. System simulation based DSS provides dynamic environment and can be used at any temporal and spatial scale. On other hand simple statistical DSSs are highly site and crop specific and answer only few queries. Geospatial technology base DSS are very efficient in handing problems related to spatial and temporal variation in soil and plant, however they do not account for soil and plant processes. A summary of various DSS in use has been given in Table 1.

3.1. *Ideal DSS*

High variability (temporal and spatial as case may be) in weather, soil and topography and risk of extreme conditions like floods, cloud burst, drought, landslide etc makes agriculture in hilly state highly vulnerable. Therefore, a robust DSS, which handles and analyzes inputs on above cited factors will be useful in hilly region. Hence, an integrated system which monitor environmental conditions, incorporates weather forecasts analyzes impact of these phenomenon on agriculture, accounts for plant and soil processes, provides dynamic environment and is available right at the door of farming community (web based applications) is ideal in hilly states like

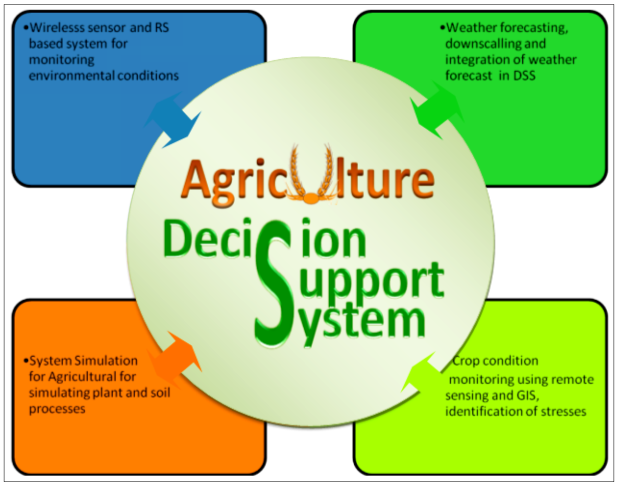


Fig. 7. Prototype of Ideal Decision Support System (DSS) for hilly region

Uttarakhand, Himachal Pradesh, Jammu & Kashmir and other states of North-eastern India. A framework of such system has been given in Fig. 7.

3.2. *Data acquisition and processing*

DSSs in Agriculture are usually targeted to help farmers on taking decisions on (*i*) selection of crops / traits, and time of sowing / harvesting, (*ii*) nutrient and moisture management, (*iii*) pests and diseases monitoring and management and (*iv*) to save crops from extreme weather conditions. The data requirement for making these decisions includes historical weather and soil data (for type "*i*" decisions), real time field nutrient and moisture status (for type "*ii*" decisions), real time and forecasted weather data (for type "*iii*" and "*iv*" decisions). There will be following processes to achieve ideal DSS.

(a) Proposed DSS calls for the need of acquisition of regional historical weather and soil data; conversion of the data into the suitable grids of 1 arc or so; suitability analysis of different crops / cropping systems considering optimum requirements. Grid level analysis of climatic information for finding suitable growth window for targeted crops, *i.e.*, dates of sowing /harvest may be achieved by scripting codes.

(b) Nutrient and moisture monitoring system may be used for real time status of nutrient and moisture deficiency. It can be achieved by developing and placing sensor based systems at various location of study region. Crop simulation model validated on sensors location may be integrated with satellite data to generate regional information at grid basis (at 1 arc or so).

(c) Historical weather data may be related to observed diseases and pests dynamics (the data of this aspect is usually available in agricultural universities) in order to develop statistical/dynamic models. These statistical /dynamic models can be used to predict dynamism of pests and diseases and accordingly protective measures can be taken.

(d) Real time weather data (usually acquired from AWS) along with forecasted weather variables may be used to analyze extreme weather events like high rains/ floods, dry / drought conditions, storms etc. Satellite data may also be used to derive critical information on rains and storms at regional scale. The information generated so may be downscaled at pre-decided grid level.

(e) All these layers may be generated at a time interval equaling the satellite pass (for example if LANDSAT data has to be used a time step of 16 days may be opted). These layers may be made available to users through web based data retrieval and visualization system.

3.3. *Transformation of outputs in actionable information*

In order to provide information generated through DSS to stakeholders in the most meaningful way, it is important that information should be transformed in a format so that it is readily understood and used by stakeholders. An additional layer may be generated consisting of information on suitable crops/cropping system. In addition to this a user friendly search option to find out the regions having specific set of climatic and soil conditions will further be helpful for the stakeholders to analyze the suitability of crops / traits not previously covered in the analysis. Further, real-time nutrients and moisture information may be used to suggest the additional requirement of crop for these inputs. The requirement of nutrient and moisture computed through crop simulation model may be used to find out the additional requirement of inputs. User may be given the dropdown option to select the region and crops those may suit to the local conditions, once selected, crop simulation model will be initialized and compute the crop requirement. Same time model developed for pests and diseases will be automatically activated and analyze their dynamism and will pickup appropriate measures from look-up table. The values of forecasted weather parameters may be corroborated with satellite data to confirm extreme weather conditions. The information of extreme events may be flashed through DSS to warn stakeholders and to suggest appropriate measures. All the data related to DSS may be kept at central server specially designed for the purpose and may be made available to users through internet.

4. Conclusion

The risks confronting with agriculture production are very high in hilly region due to highly variable weather conditions and varying soil and topography. Decision support system (DSS), which helps taking smarter decisions for enhancing agricultural productivity and reducing risk is important for hill agriculture. To reduce the risk of sudden changes in weather / environmental conditions, a system for monitoring weather conditions and incorporating weather forecast into DSS is necessary. Hence, a DSS by integrating advanced technologies of crop simulation modelling, remote sensing, GIS, wireless sensors, satellite linkages, server and web technology, is required to reduce risk of agriculture failure during adverse environmental conditions in hilly states.

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