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Improvement of Rice Production by the aid of Information Technology (IT)

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Abstract

Information technology (IT) use in agriculture is becoming more and more visible. As with the passage of time, the use of IT getting popularity among people on a matter relevant to rice production as well as protection. Now a day's people are carrying a computer or a device to avail the use of information technology because promulgation of information alone cannot sustain growth in agriculture; agricultural industry must have the ability to manipulate that information to make informed decisions. Modern farming practices like satellite farming has already got popularity in different corners of the world. This precision farming uses IT to make a direct contribution to maximize the rice productivity. Satellite technology, geographic information systems (GIS), remote sensing, soil science, and agronomical technologies can be used to increase the agricultural production especially in large tracts of land where this approach is cost effective and useful. Along with this, modern management in sustainable agriculture requires the fast information about the condition of cultivated plants and the quick response to undesirable phenomena such as the appearance of pests and weeds in rice. The use of drones for spraying plants will allow for rapid application of plant protection agents on the growing areas. However, the potential use of farming sector seems unexploited. Lack of awareness about the technologies is a significant constraint. Currently, the farmers are hesitating to come out of the tangles of a traditional source of inputs. Using information is not only useful but a requirement these days. Studies show that the use of modern technologies is capable of making a remarkable hike in agricultural production.

Keywords: Information technology; Modern farming; Rice; Satellite technology; GIS; Remote sensing

1. Introduction

Background Information

In agriculture development, the information is a critical driver if it is relevant, right, and received on time. For empowerment of farmers, agricultural information plays a vital role because it improves their livelihood by providing vital information such as sowing time, ways improve soils, seeking the best price of their products and methods to combat pests and diseases [1]. Farmers suffer through hardships to answer to such issues even if they are very experienced in the specific cropping system. Variation in weather patterns, deterioration in soil conditions and infrequent climatic events such as floods, droughts, pest and disease outbreaks makes difficult for farmers to decide the proper ways to tackle these issues without the proper information. Therefore, Up-to-date information allows farmers to survive and even benefit from these changes by using advance measurements.

According to RLDC [2], most of the rice farmers are lack of agricultural information in mostly in farming practices

and market trends. Hence farmers end up using their traditional and old methods of farming practices. The ultimate result is a reduction in yield and profit. In the continent, Africa, farmers are unable to access day to day updates of agricultural information, which is needed to assist farmers in making decisions regards farming practices and market price [3]. In agriculture, each step towards high production of crop needs information according to seeds, pest, and diseases, weed management, agronomy practice and market price, quantity and quality needed to the market, agricultural credit/loan and storage method to help them in decision making [4].

In the past nearly in the early 19th century, farmers used middlemen, extension officers, farmer groups, market boards, family, and relatives [5]. At the start of 20th-century television and radio and the mobile phone begins as a significant source of information to the farmers but the way of communication is one way, but through mobile phone, information is transfer in two ways manners. With the use of information technology through mobile phone, radio and television increase communication among farmers, market and traders without involving middlemen and extension officers because it provides day to day information through message, calls, and broadcasting and easily accessed [6]. The IT role in the agriculture sector is getting importance day by day. Therefore, IT importance in agriculture wouldn't be denied as it helps farmers to meet the need of information that will help them to obtained high yield, better market price, and communication among farmers and other agriculture actors [7].

Rice: an important crop

All over the world, rice is a significant food in general, and in Asia, about 90% of the world rice (*Oryza sativa* L.) is produced and consumed. More than half of the world's population is feeding on rice; however,>400 million people suffering from chronic hunger in the rice-producing areas of Asia, Africa, and South America. But as the population of the world is increasing day by day the demand for rice as a food increases within the globe which is expected to rise by the further 38% within 30 years according to United Nations [8]. The rice production in the world stands at 454.6 million tons per annum, with an average yield of 4.25 ton/ha [9]. Average yield per hectare must, therefore, be increased through careful research and through policies formulation. After the green revolution, the decrease in yield occurs abruptly, because of Imbalance use of fertilizers and pesticides, overexploitation of the natural resources especially water, spoiling of soil physicochemical properties of soil and generation of new resistant bio-type pests and diseases.

On one hand is to increase the production of rice is through the application of new technologies such as system of rice intensification (SRI), laser land levelling, direct seeded rice (DSR), precision farming, use of leaf colour chart (LCC), brown manuring, crop residue management, crop diversification, water conservation technologies, integrated crop management (ICM) and site-specific nutrient management (SSNM) along with application of resource-conserving techniques (RCTs). On the other hand, the use of information technology also playing its role in the improvement of the production of rice. Information technology (IT) is a strategic tool for agricultural development and the welfare of rural areas. Therefore, the main aim to agrarians and researches is to innovate the appropriate the technologies to produce more food from diminished soil resources to full fill the food requirements of growing and mushrooming population of the world population and to improve and conserve the natural resources of the small and marginal farmers.

2. Issues Involved in Rice Sustainability and Production

Rice feeds almost half of the world population because it is the staple food for most people. Its cultivation caused the start of agriculture, most ten thousand years ago farmers have made tremendous efforts to increase the yield under tropical and subtropical areas. But there are still many factors involved in the reduction of growth and production of rice.

Residues management and organic matter reduction in soil

In the field of rice, the main issue is maintained by rice straw. Among rice and wheat residues, the significant portion of wheat residues are used by the animal husbandry sector, but rice straw has high silica contents in rice, which make it inappropriate for animal diet. It also has comprehensive C:N ratio, which immobilizes the nitrogen and therefore farmer prefers to burn the residues in the field to make sure the sowing of wheat. The plant friendly insects are killed during the burning of rice causing global warming, imbalance of nutrients and degradation of soil and also the reduction of soil organic matter which ultimately affect the both biological and physicochemical health of the soil [10].

Labour storage

As rice cultivation and transplanting is an energy, water, and labor-intensive system because harvesting and spraying of rice need labor. Reduction in labor is a growing issue in rice cultivation system due to a shortage of labor; the availability of labor is responsible for the increase in wages. To resolve the labor problem, transplanting, mechanical transplanting, and direct rice are the reliable because manual transplanting is lengthy and needs more time and need more or less 300 persons per hectors. While the delay of one month in transplanting will leads to a 25% reduction in yield while the delay of two months causes a delay of 70% in the yield [11]. Under zero tillage the germination of weeds increased and to uproot these weeds labor is required for water productivity and lower land, weed seeds stayed near the upper soil surface get more water, light, and nutrients [12]. Labour shortage is considered as the problem towards reliable agriculture [13,14].

Nutrient deficiencies and toxicity in a rice field

Early in the sixties, the use of macronutrients is supposed to be essential for the rice plant but with the passage of time when the health of soil start deterioration, and micronutrients started in wheat and rice cropping system. This deficiencies of micronutrients overcome with the addition of different micronutrient fertilizers like borax, sulfur application helped in yield production and yield enhancement [15,16]. But other than deficiencies rice plant also facing the problem of toxicity. The selenium toxicity in wheat after rice harvesting is the major issue in the coping rice system; it is worth noting where the cultivation of kharif rice is carried out from 8 to 10 years, however, under wheat and maize crop system, the toxicity of Se was not witnessed. The appearance of toxicity in all living organisms is not an exceptional case. The other problem is the deficiencies of micronutrients such as Fe and Zn in the rice field which is playing its own role in the sustainability of rice because farmers can neither identify them precisely nor improve them by putting on their balance dose by broadcasting, spraying, and fortification.

Reduction in groundwater table level

The use of groundwater is more than a quarter of the total global water use earth [17]. Although agriculture is the major consumer of water, still the water usage in agriculture is decreasing day by day [18]. Availability of per capita water is reducing day by day in the main rice cultivating countries of Asia (Table-1)[19]. Water is the elementary for the agriculture, but due to its unequal and un-judicious distribution, other sources of water are required for the agriculture [20]. Keeping in view of over mention situation of water depletion in this rice grown major area in the region it was suggested that there is terrible requirement to talk about the issues relating workable production of crop and average water use. In some countries, the provision of free electricity to the agriculture sector also creating complication and centrifugal pumps are failed to full fill the water requirements, so the installation of submersible pumps is needed because of deeper underground water. The reduction in groundwater table has multiple reasons, but 3 major causes are following 1) water pumping cost increase; 2) growing tube well arrangement costs (3) bad quality of water below ground. Due to the pumping of a large amount of water, the salts start upwelling from the deeper native groundwater and also due to the mixing of saline water into fresh water, the groundwater becomes un-useable.

Contamination of groundwater

Due to the excess use of fertilizers, insecticides, and pesticides in the rice field, the underground quality of water become polluted. Application of this polluted water causes numerous agricultural issues led toward the rise of many infections and reduced the quality of the grain, which at the end affect the living organisms health. Nitrate leaching is because of more use of nitrogen fertilizers leads to the groundwater contamination causes serious alarm [21]. In short, the contamination of groundwater is an evolving issue which must be attended by creating social awareness.

Weed diversity in the rice field

Unnecessary and different weed flora is an essential issue towards agricultural sustainability as these weeds compete with the rice plant, light, water, and nutrients and reduced the overall production of the land. In Asia, the major biotic constraint in agriculture sustainability is weed as it is causing grain yield losses ultimately. In direct-seeded rice, the

water use efficiency is higher as compared to in puddled soil rice because early weeds growth is uncontrollable by flooding in dry direct-seeded rice [22,23]. Therefore alterations in technology, sowing methods, and weed management methods in dry direct-seeded rice result in various weed composition. Therefore, these are the primary source for the yield reduction in any ecology [24,25].

The occurrence of insect-pest and diseases

Rice crop is grown in the extreme environment; the green crop with a high dose of N-fertilizers and wet conditions because of repeated irrigation act as a heaven for the outbreak of insects-pests and diseases. It is generally accountable for lowering of land and water production and considered as a severe problem because it somehow decreased the productivity of the crop. New breeds of insect-pest causing a number of diseases appeared from previous months, the breeders have to developed around more resistant crop varieties to tackle this issue. Some significant diseases in rice are; blast and stem borer, sheath blight disease, false smut, and bacterial leaf blight in rice. From the above mention discussion, it is concluded that evolving disease and insects are a liable source of lowering productivity of land.

Degrading soil structure and health

To reduce percolation losses, easiness in tillage and suppress weeds, rice is generally grown under wet conditions through tillage. Rapid puddling of rice become major source sub-surface compaction apart from labor requirements, which have been unfavorable wheat [26]. Again and again, puddling of soil also affects the soil health to an alarming rate due to deficiencies of micro and macronutrients. Intensive tillage leads to a breakdown of large aggregates along with poor contact with seed and soil contact, which reduce the crop productivity [27]. Conventional practices like burning of crop residues also common in a rice field for management of residu, which is causing serious problems such as loss of nutrients, emission of greenhouse gases.

3. Use of Advanced Techniques and the Role of IT for Sustainable Production of Rice

Resource-conserving technologies (RCTs) are those practices that conserve resources and ensure their optimum utilization and boost up resource or input use-efficiency. It has also following aims

- Mountainous of soil cover, particularly through the retention of crop residues on the soil surface
- Profitable and sensible crop rotation

Direct seeded rice

There is two types of rice cultivation wet and dry-seeded rice. In the dry type of rice cultivation, the seeds of rice can be directly seeded by using a drill, the seeds of rice are seeded into fine seedbed at a depth of 2-3 cm. while in wet seeding the field for rice is leveled and after flooding field was left for 12-24hrs of puddling. The drum seeder is used for sowing of germinated seeds. In both seeded field, seeds can be broadcast, but weeding of the rice field is difficult in both cases. Therefore the timely application of herbicides or one or two hands provides effective control of weeds in a rice field.

Management of crop residue

Crop residues are the major source of organic matter into the soil. It is remaining parts of crops and plant left after harvesting and thrashing. It is not a field waste but an important part of the organic source, which plays an essential role in agriculture stability. Many researchers suggested that cultivation of rice on raised bed areas is good in areas where the groundwater table is dropping its level, and herbicide-resistant weeds are causing a problem for rice crop. Soil tillage and establishment of crop helps in crop modification.

Leaser land leveling (LLL)

Leaser land leveling is the very first conservation technology of land resources. It is the predecessor of all techniques and process of leveling land surface more or less 2 cm from its present average elevation using laser furnished dragging machines. For equal and uniform distribution of water and other resources, it is a very beneficial technique to increase the resource use efficiency. It is used to level the land having slop of 0 to 0.2%. It has the following advantages over non leveled land like: it saves water (10-15%) due to uniform distribution of water and land leveling of field, it increases the fertilizer and water use efficiency, 4% increase in cultivated area due to elimination of bunds and channels, and reduce the cost of production and increase crop productivity.

Brown over green manuring

As water resources are reduced nowadays as compared to past, green manuring is not picking up by the farmers. To resolve this issue, brown manuring is being recommended instead of green manuring. In brown manuring, sesbania is intercropped with direct seed rice. After 30 to 35 days the plants of Sabina is killed by spraying 2,4D (without affecting the rice plants). The plants of sesbania turn brown and fall down on the surface and act as mulch. It has following advantages: it helps to reduce the germination of the weed (40-50%), keep the soil moisture conserve, improved soil fertility, and there is no need of water for the growth of sesbania crop in summer before rice when evaporation demand is close to 10-13 mm/days.

Use of advance technologies for rice

Precision farming system (PFS)

In developing countries for the promotion of agriculture, they should allow entry of IT which will move agriculture from its traditional pathway towards mechanized agriculture. In this way, they will improve the labor efficiency and productivity before getting high level in PFS. Site-specific or precision farming (PFS) is a manner of crop management by which areas of land within a field may be managed with different levels of input depending upon the yield potential of the crop in that particular area of land. There are following advantages of precision farming:

1) Production cost in the area can be reduced

2) Control of environmental pollution due to lower level use of agrochemicals

It is an integrated agriculture management system along with several other intercropping techniques. These technological tools mostly are the global positioning system (GPS), geographical information system (GIS), remote sensing, yield monitor, and variable rate technology.

Rice integrated crop management

All the innovations and technologies described in this chapter described works for the PFS. In most of the developing countries research wing of agriculture is familiar with PFS. In industrial countries, the tools and the technologies used in PFS are beyond the access of poor farmers. Both the continent Asia and Africa are making slow progress in mechanizing agriculture because they are less advanced in IT and it's everyday usage in PFS. Due to this reason, scientist and field workers in developing countries use integrated crop management to improve crop yield across the fields. The basic unit of PFS is spatial, and temporal variability is the basic unit of PFS. To determine the yield of rice production, the correct use of fertilizers is essential due to its effects on grain yield, crop establishment, and pest and weed occurrence. In Asia, for the correct use of N-fertilizers chlorophyll and leaf color charts are used by farmers to check the field-specific N management [28]. For farmers having small landholding in the continent, it's not an easy job to convince them for crop management.

There are several factors that determine the crop management practices like varieties of crop, factors of environment, market trends. PFS improves the skills of farmers by using the data collected and information because it is the major feature and due to its joining into the improvement and dissemination of rice integrated crop management (RICM) in a number of

developing countries.

The rice growing farmers perfume number of traditional operations during rice sowing season, all these operations directly or indirectly affect the crop growth and development and automatically yield. RICM systems identify the problems of rice growing area by following framework [29,30]:

1) Identification of the area needs more management.

2) Computing the good management practices (GMP) of progressive grower and analysis of production technology and practices adopted by farmers. It is done to identify the problems and differences in management from area to area.

3) Study of previous literature: The study of outcomes of researchers, field workers, and farmers is important to improve current knowledge.

4) Development of temporary organize step by step GMPs with the collaboration of with researchers, extension workers, and farmers.

5) After the formation of evaluation of GMPs with the help of experienced farmers and trained extension worker in group discussions.

Therefore in developed areas of the world agricultural and research scientist use the IT, e.g. GPS, GIS and yield maps to articulate recommendations for site-specific management and implementation of pest, drought, floods, and diseases management plans.

Global positioning system (GPS)

GPS is a manged system of satellites that save and record the information about longitudes, latitudes, and elevation with almost 100 and 0.01 m accuracies [31]. It tells about the accurate location of field features like pests, weeds, water holes, soil, hurdles, and field boundaries; therefore, according to this information, farmers are able to use agrochemicals effectively. It also helps them to check the performance criteria and history of previous input usage [32]. There are following functions performed by using GPS: farms machines are guided along long tracks by making small scale deviations, able to avoid repeating the same row of crops when applying different chemicals on the crop rows,

Tools and apparatus can be operated in the same way from year to year, It makes conceivable to work at night or in the mud with precision because it is not affected by weather changes and a supplementary recorder can store field information to be used in making a map [33].

Geographic information system (GIS)

Its use starts from 1960, comprises software, hardware, and procedures designed to help the assembling, storage, recovery, and analysis of characteristics and data of a certain location to create maps. The linkage of information in one place so that it can be extrapolated when needed, is the main function of GIS. The GIS database of a farm provides information on topography, drainage from surface and subsurface, soils type and testing, irrigation, amount of chemical applied, and crop yield. After analysis of data, one can be able to understand the relationship among numerous components affecting the crop on a specific spot [34].

GPS and GIS is an important tool for PFS

As the rice field is more vulnerable for insects, pests, and diseases as the field conditions are more suitable for the growth of these insects and pests. To tackle these insects and pests at their specific location field portable GPS and GIS receivers are available for rapidly making insects invasions and data collected from this can be accurately communicated to the field manager who may apply some specific spry and chose some relevant specific chemicals for the specific site of infection. It's not only for time the application of these chemicals but also the spray operator can provide history or record

to the field manager with GPS data where and when the treatment took place [35]. Identification and mapping of crops are needed nowadays to get more precise information of the field to conserve the resources. Crop mapping is done both at national and international levels agencies, and local agricultural boards to prepare a record about what was grown in certain areas and to identify the age of the crop. The most important activities include the identification of crop types and depict their extent (often measured in acres). The efficiency and accuracy of data are enhanced when remote sensing data products and GIS are used as shown in **Figure-1**.

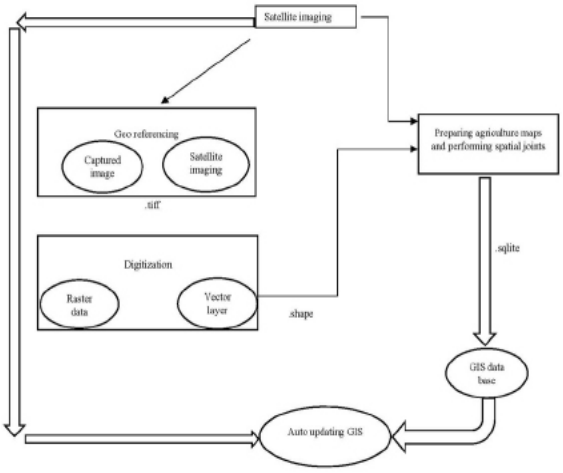

Figure 1: Flow of system in GIS and satellite imaging

Table 1: Per capita water availability in major rice-growing countries of Asia (2000–2050).

Country	2000 m^3	2005	2010	2015	2020	2050
China	2210	2134	2068	2006	1956	1927
India	2000	1844	1717	1611	1525	1292
Japan	4314	4292	4307	4348	4423	5381
Indonesia	12,325	11,541	10,881	10361	9952	8781
Nepal	6958	6245	5695	5230	4820	3467
Pakistan	3159	2822	2533	2277	2069	1396
Philippines	4158	3778	3450	3175	2945	2210
Sri Lanka	2302	2212	2117	2041	1990	1990
South Korea	1424	1390	1363	1345	1336	1500
Thailand	2871	2714	2627	2559	2505	2440

Along with this rice productivity is the major concern of farmers and also the sustainability of rice production. For this purpose the yield monitors will be connected to GPS receivers to map yield. The resultant yield maps will help identify areas of the field requiring different treatments [36].

Sensor technologies

There are various sensor technologies used in agriculture to measure used to measure temperature, vegetation, humidity in air and vapor etc. These include electromagnetic, conductivity, photo-electricity, ultrasound, etc. The important and commonly known as remote-sensing it is used to find out stress conditions, pests and weeds, differentiate crop species, soil, and plant conditions. Sensors enable the collection of a large amount of data without analysis in the laboratory. The use of sensor technology at farm operations are; to check physicochemical conditions of soil [37], sense colors to understand plant conditions relating, e.g. plant population, water scarcity, and plant nutrients, Monitor crop yield and humidity, Variable-rate system to monitor the movement of fertilizers and check weed attack.

Use of remote sensing in agriculture

In agriculture, most of the farming in a broad acre is carried out by using human-driven machines nowadays.

Intensive farming methods in mechanized agriculture, farmers lack applied experience for sensing the condition of the field. Remote sensing method has been suggested, which helped in precision farming to collect data and the analysis of data to check out the growth throughout the season. Satellite imaging data availability is increasing day by day during the season. Drusch et al., 2012 coated the examples such as satellite images from Sentinel-2 satellites are available and provided by the European Space Agency (ESA). Drones, or Unmanned Aerial Vehicles (UAV), or Remotely Piloted Aircraft System (RPAS) are another source for remote sensing. With drones, imaging is possible in cloudy conditions, whereas satellite-based imaging is limited in these situations [38].

Use of Unmanned aerial system (UAS) for monitoring rice field

UAS required because of its monitoring technologies of crop diagnostic information due to their advantage in manoeuvering tasks at high-spatial resolutions and low costs in a user-friendly manner. Jeong et al., [39] reported that UAS-based remote sensing techniques could represent an innovative way of projecting reliable spatiotemporal crop productivities for precision agriculture in the rice field. In drought assessment of rice field area, application of UAV (Unmanned Aerial Vehicle) remote sensing and geo-information system (GIS) based images in detection and measuring of rice field drought area in South Korea was carried out by research, and they concluded that Drought-damaged paddy rice reached is 47.1 %. For paddy rice by UAV investigation, the drought monitoring and crop productivity were effective in improving drought assessment method [40].

UAS also plays its important role in quick and accurate detection of plant disease at the field scale and improve the management of diseases effectively by on time and site-specific application of fungicides and pesticides. Most important rice disease in the world was detected accurately and quickly with the combined use of a UAV with high-spatial resolution camera is an innovation that has the high potential for quick and accurate detection of ShB, one of the most important diseases in rice in the world. This technology can aid in the scouting and monitoring process of this disease and reduce the costs in time and effort associated with this process. This UAV system in the current form can also assist crop breeders in breeding for rice cultivars with resistance to ShB [41].

Variable-rate technologies (VRT)

It is a reflexive technology used in the numeral operation of farm operations. According to map and set rate, the inputs are applied on the soil as its type is already noted. GIS Information can control processes, i.e., seeding, fertilizer, pesticide, herbicide selection, and application, at a moveable but appropriate rate, time and place [32,42].

Grain yield monitors for mapping

To measure the grain yield of wheat, rice, barley and oat crops a video display unit attached on the combine harvester which constantly measures and records the grains flow in the grain elevator. After linking of it with GPS, yield monitors can offered data for a yield based map that helps farmers to regulate the complete controlling of inputs such as fertilizer, pesticides, tillage, lime, seed, and water [43].

4. Conclusion

Rice is an important crop in many countries of the world on this blue planet. There are a number of issues in the sustainability of rice production to full fill the dietary requirements of the growing population. To solve this issue their number of adoptable technologies along with the use of modern IT technologies which helps to sort out the rice issues like insect pests, nutrient management, weed control, improvement of soil health and control of environmental pollution. From last few decades, latest technologies are included in the precision agriculture to improve the productivity of the crop. These technologies are useful where human interventions are not possible for spraying of chemicals on crops and scarcity of the labor. This could also be reduced the wasting of water and chemicals.

Future aspects

IT in precision agriculture and rice cultivation is still in its early stage and maybe scope for further development in both the technology and the agriculture applications. Conveniently, it is used that with the development of IT, improved image processing techniques, lower costs, new camera designs, low volume sprayers, and nozzle types. A significant number of experimental studies of IT-based remote sensing, use of GPA, GIS, and drones for agriculture application. It will be a more noticeable benefit of these systems in precision agriculture and environmental monitoring.

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