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Modified Context Aware Middleware Architecture for Precision Agriculture

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Abstract— The opportunities for researchers are enhanced with the progression in the technology of communication and computing. The ease in life of many people like farmers, educators, administers, managers, etc., is increased with more inventions of the researchers using this new technology. The progressive technology for data management is providing more amount of information. However, is the user able to access the needed information when required? This question rises to the more questions like, how to identify whether the information is as per the requirement? Whether a user is authorized or not? The answer for all the questions is to make the support aware of the context. Therefore, the present technology needs to be modified to make the system aware about the context. The process of demonstrating the services based on the context using Wireless Sensor Networks (WSN) with the help of illustration on mango crop is emphasized in this paper. There are many serious problems like unsuitable fertilizer use, wrong selection of crops in wrong seasons, water waste, poor publicizing in the case of farming. These problems are addressed using the ubiquitous context aware middleware architecture for precision agriculture in mango crop.

Keywords- context aware, wireless sensor networks, precision agriculture, mango crop.

1. INTRODUCTION

Significant amount of research is carried out to improve the growth of the crop and therefore attain more profits in the agricultural field. Yet after extensive research, it is becoming difficult to supply relative to the demand in recent times. Any environment can be analyzed when the sensed information is available. Hence, Internet of Things attained more focus in various applications like agriculture, health care, etc., in the recent times[1]. The change in the environment is referred as change in the context. This can be observed with the help of sensor nodes in WSNs. The data that is generated by different sensors will be in different format as they are heterogeneous in their behavior. When the context of agriculture is considered, then the regular monitoring of growth, verification of any attack by insects, birds, etc. When the contexts are integrated, it is difficult to denote the information using the same format. More appropriate information is given to the users based on the location of the users with the help of the context aware services [2][3].This new computing technology helps in providing relevant information to the users and in right time. As specified before, any environment can be considered as context. For example, location, temperature, humidity, time, etc.

With the latest technology in the communications like network of heterogeneous devices, cloud computing, multitude transformations, services of Internet, etc., made the information to be available ubiquitously. Yet, there are many challenges to be considered in this context. For instance, standards inconsistency, information transferability, collection of information, broadcasting of information, increase in the communication cost among various contexts. The life of human is changed a lot either in the work place or home because of the information and communication technology. But, there is much more research to be carried out in the field of agriculture to make agriculture smarter, precision, and yield more profits. Hence, agricultural field is said to be digitally rifted when compared to most other industries.

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There is high requirement of natural resources like, power, manures, water, etc., in the case of agricultural field. This might lead to intensify many universal problems like deprivation of soil, exhaustion of underground water, global warming[4]. The intensity of these problems can be decreased with the help of technologies like Internet of Things, sensors, and other advanced technology in agricultural field.

In the upcoming decade, there are more transforms and developments in the field of "Communication". Hence more challenges as well as chances are going to be thrown on the communication among people, amid devices, among various technologies[5]. In the case of agricultural field, communication among users, bazaar, farmer, weather, soil, brokers/agents, etc., plays a very important role. It also plays a critical part in the development of the architecture which is aware of the context for precision agriculture.

2. RELATED WORK

Research in this field is carried out since long years [6-10]. The research that is recently carried out is given more focus and is presented here. The authors in [11] presented the important role of sensors in agricultural field. At the same time, challenges that need to be addressed while making an agriculture as an application of IoT[11]. The analysis of the communication procedures related to IoT and sensors being used in agriculture is made. The process of using this technology in agriculture is presented from the starting step, i.e., ploughing to the last step, i.e., marketing/sale. The authors also discussed about the process of surveillance of the crop using drones like devices. Various architectures of IoT used to enhance the crop yield are reviewed. The outcome of this review is the identification of present, forthcoming developments and research opportunities in the agricultural field with the help of IoT[12].

The authors in [13] presented the key modules involved in the smart farming using IoT. The technology related to the architecture of the network, its levels/layers, rules, procedures, etc. More trending technologies that can be used to increase the yield of crop like cloud computing, big data analysis are discussed. Also, the challenged related to security is also projected. The solutions that involve cell phones in the management of farm is also discussed.

Virtual Factory Operating System is used to develop a system for agriculture that associates the applications and the users. The system that is developed is an integration of various modules which are utilized by the users, to manage the present context and quality theory of the crop to regulate the quality of the crop throughout the process of the growth of the respective crop [14].

An agricultural framework based on IoT is presented in [15] which is pioneering and conserves energy. LoRaWAN is the basis of this framework. This network helps in transmitting the data to the cloud server which is very far from the sensor nodes with less energy. Grape farm is considered to illustrate the efficiency of the proposed framework.

In [16], the challenges and advantages of Internet of Things are presented. At the same time, the authors discussed how the agriculture can be made smart by integrated IoT with data analytics. Then, the areas like technical, application oriented, etc., where the research can be carried out is presented.

An architecture which is scalable is proposed in [17] to monitor and control the crop and farm in countryside locations. The latency in the network is minimized to a particular level by the proposed framework. The process of sensing and actuation is made by incorporating routing and access to the channel using cross layer technique. The parameters used to evaluate the performance of the proposed structure are latency, throughput, and range of cover [18].
The analysis of the research carried out in the field of agriculture is carried out in [19]. At the same time, the challenges to be faced and the probability of more research in this field is also presented by the authors.

3. MODIFIED CONTEXT AWARE MIDDLEWARE ARCHITECTURE FOR PRECISION AGRICULTURE

Doing agriculture is not an easy task as it requires more knowledge related to the crops, environments, type of soil, fertilizers, etc. The farmer should be able to know which crop to be cultivated when, which type of soil is required, how much water is needed, what fertilizers to be used, when to use, how much to use, etc. Most of these are interrelated to make good yield of the crop. As there are many things involved in the doing the agriculture or cultivating the crop, not one solution is available to solve all the problems related to agriculture. Even though single solution cannot be provided, a single system which can deal with almost all the problems related to the agriculture is very essential. Hence, a modified version of Context Aware Middleware (M-CAM) is proposed in this paper. CAM is proposed by Krishna et al. in [11].

The steps to be followed during the cultivation are shown in the Fig.1: choice of crop; identify the best time to plant the chosen crop; soil preparation; selection of good quality of seeds; sowing of seeds; choice and usage of fertilizers; effective irrigation; weed protection; crop growth; harvesting; storage and selling. Here, each and every step during cultivation is considered.

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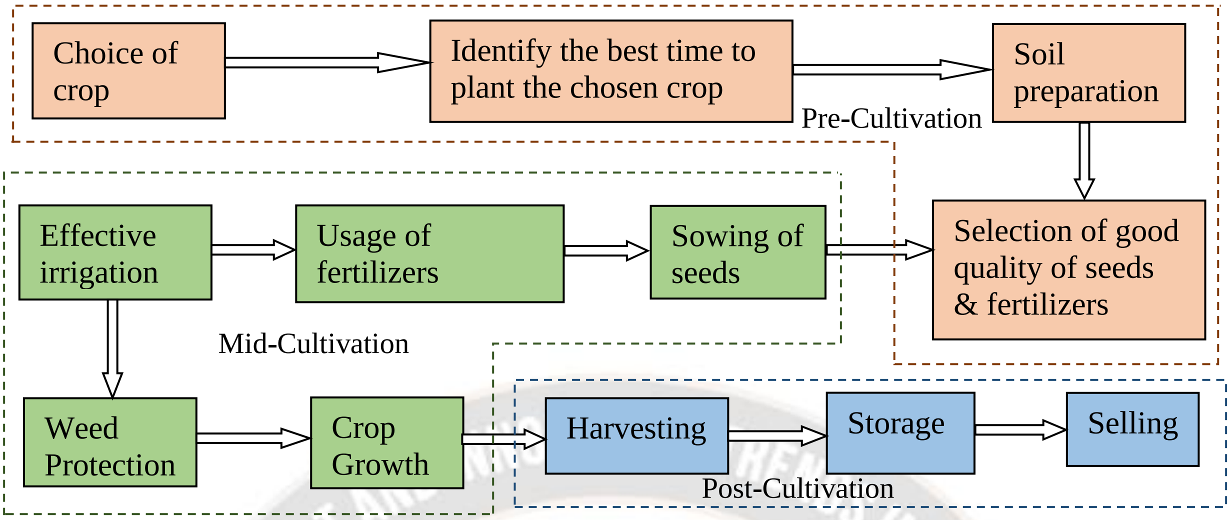

Fig. 1 Steps in the Cultivation

Some of these steps are dependent on the farmer whereas some can be automated such that the yield of crop increases. Farmer can choose the crop to be cultivated. Best time to plant the chosen crop can be determined based on the experience of the farmer or using technology. Sowing of seeds also need to be done carefully as the depth of the land for sowing the selected seeds need to be known. Good fertilizers should be chosen appropriately. Effective irrigation is made better in smart farming. Weed protection can be made effective using latest technology. Harvesting need to be done in right time, store properly in right place and right temperature and finally need to be sold through proper channel or directly to the customers such both farmers and customers both benefits.

The steps shown in Fig.1 helps in developing precision farming with the use of M-CAM. The steps in the cultivation shown in Fig. 1 can be divided into 3 categories. They are pre-cultivation, mid-cultivation and post-cultivation. Steps 1-4 can be classified as pre-cultivation steps. Steps 5-9 can be classified as mid-cultivation and steps 10-12 can be classified as post cultivation. Furthermost, the feasible solution for the farmers is the precision farming which challenges the farmer in practice.

Modules in M-CAM:

- Environment Observing Module (EOM): The environment is learnt using various sensors in this module. Temperature, speed with which wind is blowing, probability of rainfall, organic matter, clay, chemical information, nutrient levels, compaction, permeability and moisture level of the soil, leaf wetness, chlorophyll, solar radiation are measured to learn about the environment using various sensors. This module also analyses the demand crop in the particular location.
- Crop Selection Module (CSM): Based on the EOM, the crops that can be cultivated in the corresponding environment based on EOM information are identified. Then based on the demand in the particular location, crop is selected.
- Context Repository Module (CRM): The details collected related to various contexts in EOM is stored in database that can be utilized in different applications. Sequence of actions to be taken against each context also is maintained.
- Context Integrating Module (CIM): Various contexts are integrated in this module to test whether the integrated context is suitable for the selected crop or not.
- Context Model Development Module (CMDM): This module develops the model to depict the sequence in which various contexts need to be considered and addressed. The sequence is based on the priority of each context.
- Action Taken Module (ATM): Based on the content of CMDM and CRM, the context to be addressed and the sequence of actions to be taken is known. This information is used by the farmer to taken the required actions in right time.
- Global Context Module (GCM): How many ever measures a human take, there might be a failure. Hence, an alternate is given in this paper. If failure occurs in one place, the similar context in other locations is identified using CRM and cultivation can be done in the respective locations to meet the required demands.

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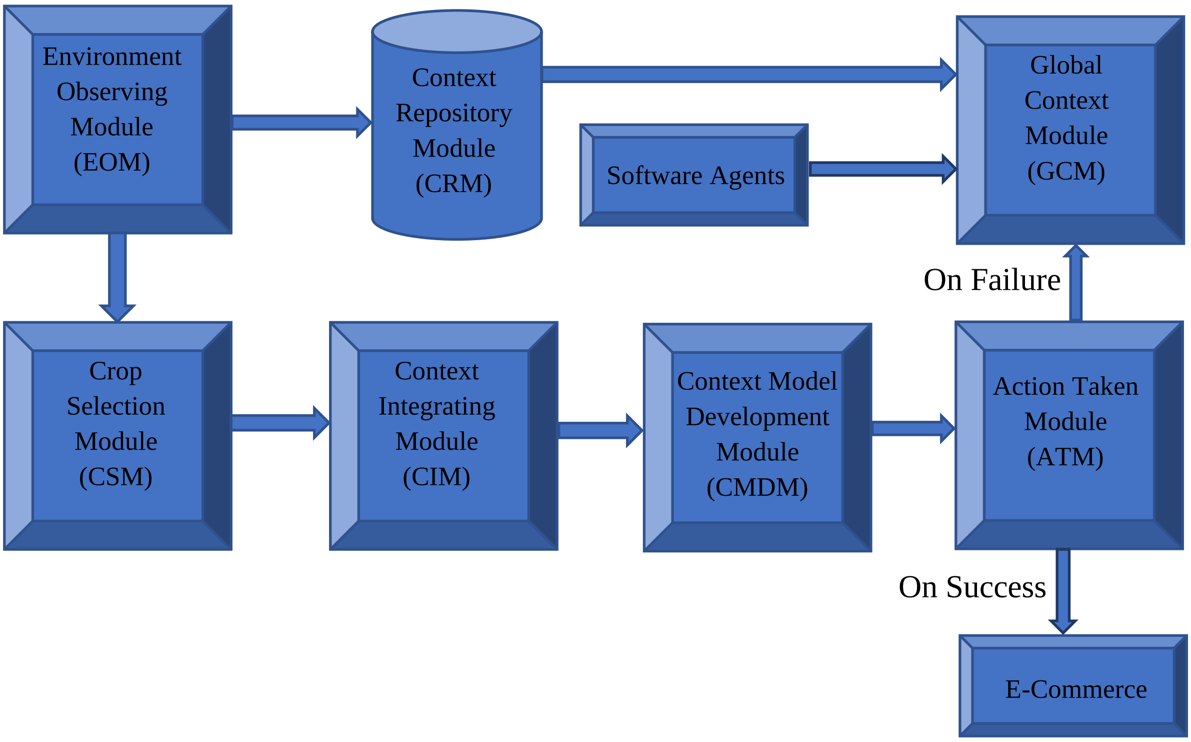

Fig. 2 Architecture for Modified – Context Aware Middleware

The global context module of M-CAM is depicted in Fig. 3 using a simple example. Initially, when one software agent receives information that flood occurred in Tamil Nadu and another software agent receives information about cyclone in Karnataka. The information received by the software agents is transmitted to M-CAM. Then GCM of M-CAM identifies the areas similar to Tamil Nadu to grow mangoes and Karnataka to grow grapes. In the example that is depicted in Fig. 3, M-CAM identified Andhra Pradesh to grow mangoes and Maharashtra to grow grapes. The farmers who are associated with M-CAM will receive this information.

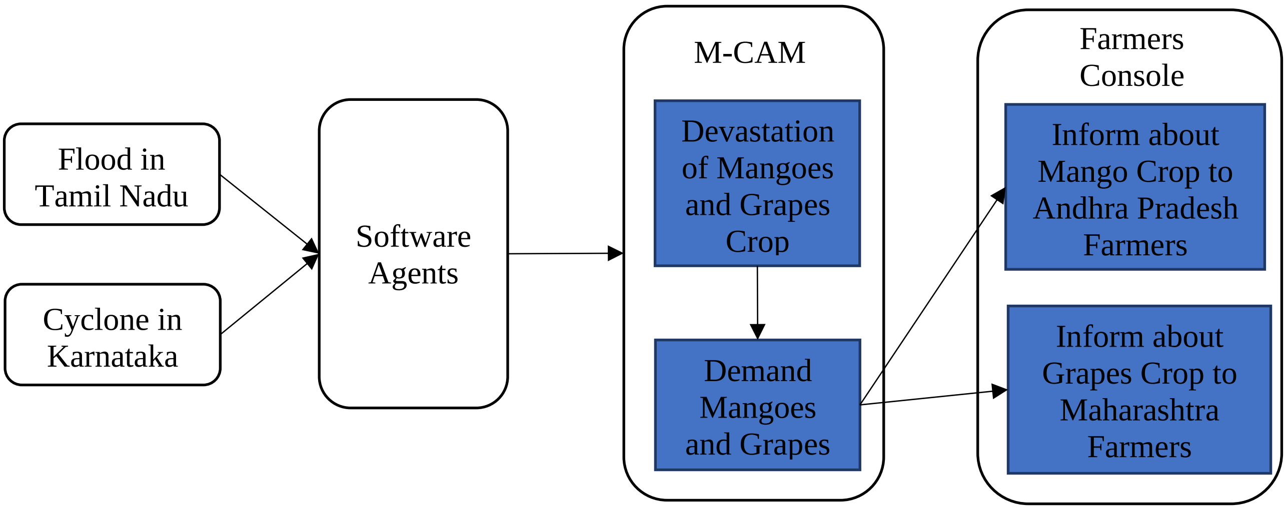

Fig. 3 Illustration of GCM of M-CAM

Table.1 provides better understanding about how contextual information is classified for a crop. This table captures few important contextual information for the farming lifecycle of crop like Mango and Grapes. Also, the Table. 1 provides information related to soil, seasons, weather and markets required for cultivation.

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Table 1: Sample contextual information of farming lifecycle [11]

Crops		Soil		Seasons		Weather		Markets	
Grapes	**Mango**	**Clay**	**Sandy**	**Winter**	**Summer**	**Rain**	**Snow**	**Direct**	**Indirect**
Bud Break	Seeds	Less Alkaline	Alkaline	Cold Waves	Heat Waves	NIL	NIL	NIL	NIL
Flowering	Sprouting	PH: 6.5 to 8.0	PH: 4.5 to 7.0	Short day Long night	Long day short night	Low	Low	Interactive	Non-interactive
Fruit Set	Tree	Low permeability	High permeability	Snow or Cold rain	Forest fire	Medium	Medium	Low overhead	High overhead
Veraison	Flowering	Less fertile	Moderately fertile	Very cold	Draught	Heavy	Heavy	Cheaper	Costlier
Harvesting	Fruit	Good water holding capacity	Less water logging	Moderate Windy	Less windy	Flooding	Flooding	Single channel	Multi-channel

A part of context information related to some of the stakeholders in M-CAM is projected in Table 1. For an instance, if seasons is considered as a key context, then cold waves, short day long night, snow or cold rain, very cold and moderate windy shall permit to cultivate better. Similarly, large context can be considered as "Field with sandy soil, high permeability, long day short night, medium weather helps in attaining more mango crop". Therefore, precision agriculture can be achieved with the help of M-CAM which provides solutions that are aware of contexts.

3.1 MANGO AGRICULTURE BASED ON CONTEXT ORIENTED MIDDLEWARE

There are few context-oriented sensor networks for farming that have been recommend to solve issues such as application of pesticides, water management, supervision of land and crop [10]. This paper proposes a malleable and importantly effective solution based on context awareness.
Environment:

In India, Mango is a commercially enticing fruit crop. Mango trees prefer low relative humidity, low rainfall at flowering, harvest and fruit set with warm to hot temperatures during fruits.

Mango trees grow finest in well-drained soil that is slightly acidic and drop. If the temperature drops below 40 degrees, both flowers and small fruits gets killed or spoiled.

Sensors need to be deployed on each server network. Sensor collects the environment information and help mango growers to take necessary steps for good profit in the mango crop.

Mango is grown in India in tropical and subtropical regions from sea to an attitude of 1500 meters. It is grown almost in all states of India. Mainly cultivated in Andhra Pradesh, Bihar, Gujarat, Karnataka, Kerala, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal. Tamil Nadu is followed by Andhra Pradesh.

During the months of March to May, supply exceeds demand in market which leads to decrease in prices. Kerala is the nearest market, compromised to Maharashtra. Natural calamities like wind with high velocity lead to drop in supply of mangoes during June to September.

Growers do not store the produce for long, when it is unripe hardly they held it for one day or two days. Farmer cannot negotiate the best rate for his produce since he is not willing to carry the risk of holding the inventory of perishable items.

Environment Observing Module comprises of various sensor nodes to handle various physical phenomena like temperature, humidity, pH level of water, snowfall, rainfall with speed.

Software agents acts as an adapter and convert the information in common format for processing.

The virtual mall and online trading agencies like eBay and Amazon are represented as E-Commerce industries. The government agencies like national information centers, meteorological centers and other private ambience monitoring status are represented in datacenters.

The mango pre-farming comprises of off-field activities such as collection of inputs like seasonal facts, market demands. It can also include on field activities like nursery productions and initiation of data acquisition.

The mango mid-farming consists of on-field activities like irrigator, disease control and pest control. The mango post-farming involves tasks such as harvesting, grade processing, packaging, identification of demand and supply.

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The context-oriented middleware frames [20] the context, classifies and finally stores at. The M-CAM updates stakeholders farming and public with alerts regarding the information. If the fruit has completed its development and growth that can be called as stage of maturity. Farmers have a very good idea about maturity indices of mango fruit. One or two naturally ripened fruits fall off from the tree. It often happens before they attain optimum maturity for benefit of high prices in the beginning of the season. Before optimum maturity, harvesting of fruits may lead to white patches on the fruits. Fruits should be harvested at proper store such that post-harvest losses can be reduced and quality and market value can be enhanced.

4. State wise Area, Production and Productivity of Mango during 2015-16, 2016-17, 2017-18 [20].

Table 1. State wise Area, Production and Productivity of Mango during 2015-16, 2016-17, 2017-18 [20].

		2015-16		
S. No	**STATE**	**AREA**	**PRODUCTION**	**PRODUCTIVITY**
1	ANDHRA PRADESH	327.31	2803.66	8.57
2	ARUNACHAL PRADESH	0.05	0.03	0.5
3	ASSAM	4.62	46.15	9.99
4	BIHAR	149.14	1464.93	9.82
5	CHHATISGARH	71.52	420.61	5.88
6	GUJARAT	153.18	1241.59	8.11
7	HARYANA	9.26	89.97	9.72
8	HIMACHAL PRADESH	41.52	37.63	0.91
9	JAMMU & KASHMIR	12.67	23.74	1.87
10	JHARKHAND	50.41	393.67	7.81
11	KARNATAKA	181.7	1725.67	9.5
12	KERALA	70.12	382.52	5.46
13	MADHYA PRADESH	27.89	371.48	13.32
14	MAHARASHTRA	162.08	463.17	2.86
15	MIZORAM	0.87	4.18	4.8
16	NAGALAND	0.57	3.74	6.61
17	ODISHA	199.29	778.72	3.91
18	PUNJAB	6.74	113.5	16.83
19	RAJASTHAN	5	82.27	16.45
20	TAMIL NADU	125.98	975.11	7.74
21	TELANGANA	194.05	1778.32	9.16
22	TRIPURA	11.75	59.06	5.02
23	UTTAR PRADESH	263.28	4512.71	17.14
24	UTTARAKHAND	35.91	149.73	4.17
25	WEST BENGAL	96.74	693.39	7.17
	OTHERS	6.91	27	3.91
	TOTAL	2208.56	18642.53	8.44

		2016-17		
S. No	**STATE**	**AREA**	**PRODUCTION**	**PRODUCTIVITY**
1	ANDHRA PRADESH	336.96	4043.47	12
2	ASSAM	4.66	47.15	10.12
3	BIHAR	149.96	1472.38	9.82
4	CHHATISGARH	74.17	434.32	5.86
5	GUJARAT	161.27	1424.87	8.84
6	HARYANA	9.34	96.79	10.37
7	HIMACHAL PRADESH	41.77	48.24	1.16
8	JAMMU & KASHMIR	12.74	24.15	1.9
9	JHARKHAND	50.56	438.54	8.67
10	KARNATAKA	180.6	1719.73	9.52
11	KERALA	70.41	388.14	5.51
12	MADHYA PRADESH	43.42	586.24	13.5
13	MAHARASHTRA	156.84	603.83	3.85
14	MIZORAM	0.89	4.18	4.7
15	NAGALAND	0.64	4.23	6.6

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16	ODISHA	199.42	817.91	4.1
17	PUNJAB	6.75	113.69	16.85
18	RAJASTHAN	5.16	154.79	29.97
19	TAMIL NADU	176.42	1282.44	7.27
20	TELANGANA	111.65	482.46	4.32
21	TRIPURA	10.64	57.03	5.36
22	UTTAR PRADESH	264.94	4341	16.38
23	UTTARAKHAND	36.42	150.14	4.12
24	WEST BENGAL	99.22	736.9	7.43
	OTHERS	7.4	33.58	4.54
	TOTAL	2212.24	19506.2	8.82

16	ODISHA	199.08	805.77	4.05
17	PUNJAB	6.9	116.52	16.9
18	RAJASTHAN	4.97	87.37	17.58
19	TAMIL NADU	152.57	1234	8.09
20	TELANGANA	115.99	1080.14	9.31
21	TRIPURA	10.33	54.93	5.32
22	UTTAR PRADESH	265.62	4551.83	17.14
23	UTTARAKHAND	36.48	152.71	4.19
24	WEST BENGAL	103.25	918.35	8.89
	OTHERS	7.17	35.14	4.9
	TOTAL	2258.13	21822.32	9.66

		2017-18		
S. No	**STATE**	**AREA**	**PRODUCTION**	**PRODUCTIVITY**
1	ANDHRA PRADESH	363	4373.61	12.05
2	ASSAM	4.68	48.44	10.34
3	BIHAR	149.28	2443.47	16.37
4	CHHATISGARH	77.03	461.73	5.99
5	GUJARAT	162.77	1207.78	7.42
6	HARYANA	9.35	98.6	10.54
7	HIMACHAL PRADESH	41.99	31.35	0.75
8	JAMMU & KASHMIR	12.96	30.35	2.34
9	JHARKHAND	54.53	435.86	7.99
10	KARNATAKA	183.23	1760.6	9.61
11	KERALA	83.12	439.2	5.28
12	MADHYA PRADESH	45.52	654.79	14.38
13	MAHARASHTRA	166.76	791.36	4.75
14	MIZORAM	0.91	4.19	4.6
15	NAGALAND	0.64	4.24	6.61

Andhra Pradesh is the lofty plough area (363 HA) of mangoes when contrast to the other states in India and the minimum plough area is Nagaland (0.64 HA). Maximum production is in Uttar Pradesh (4551.83 MT).

In Uttar Pradesh, the area, production and productivity show a practical shift for all three years and it also stands first in case of productivity with (17.14) even though the usage of land (265.62 HA) is 100HA less when compared to Andhra Pradesh where the production is (4551.83 MT) in 2017-18.

5. ILLUSTRATION OF WORKFLOW FOR MANGO CROP

Initially, the software agent picks upon important event from known third party resource. An agent has received parts of mango growing in north India. The captured event by both software agents and smart data acquisition system is sent to context-oriented middleware. The cart analyses the event and frames a context that explained the pests of mango fruits and leaves in north India. The M-CAM[21] creates new context that can identify demand for growing of mango through advanced context modeler modules in M-CAM.

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Table 2: Sample Contextual Information of Farming Lifecycle

Crop	Soil	Season		Markets	
Mango	**pH**	**Winter**	**Summer**	**March -May**	**June-Sep**
Germination and leaf Development	High Porosity	Cold Waves	Heat Waves	Decline	Witnessed
Flower blossoms	High Permeability	Snow Or Cold rain	Forest Fire	Low Overhead	High Overhead
Ripening	Small Surface area	Very Cold	Draught	loss	profit

Table 2. gives information regarding how the contextual information is classified for mango crop. For farming of mango crop, this table captures few important contextual information. If soil pH is considered as the main text, then sub contexts can be highly permutable, highly porosing small surface area. It will enable to farm better contextual mapping with other stakeholders. The pests of mango are found in all the mango growing countries such as India, Pakistan, Burma, Philippines. In India, this pest is more prevalent in the North India. During the flowering season, the nymphs and adult damage the plant by sucking the sap. The pests suck the sap from leaves and shoots. The infected flowers shrivel, and turn brown, finally fall off from the tree.

The matured nymphs and adults suck the sap from ventral surface of leaves by moving onto the leaves and the shoots. The insects secreting "honeydew" encourage the development of fungi. Meliola mangiferae and copnodium mangiferum by moving in swarm on the branches of the tree. In order to protect the flower blossoms and leaves of the mango tree, we need to spray the medicines like Sulphur and malathene to the
leaves as well as flower blossoms. Hence, M-CAM makes feasible and flexible saturates to mango agriculture by furnishing context aware solutions.

5.1 Problems Faced by the Farmer

Farmers in India turn on steadily on middlemen particularly in marketing the fruits and low coherence in the marketing channels escort with poor marketing infrastructure would not only lead to lofty and swinging consumer prices. It may also lead to decline in quality, persistent mismatch between demand and supply both contiguous and over time resulting to highly swinging prices, lack of knowledge, cost of marketing, long marketing channels, inadequate natural resources, less participation of farmers in selling, lack of proper warehouse and preservation during transportation time, imbalance between demand and supply, policies of importing countries, price increase, other most problems faced are diseases and pest on input side which reflect in quality of product.

6. CONCLUSION

India ranks first position in world for mangoes production. In case of productivity and quality it doesn't sounds high. It may be due to espouse of low-cost technology and lack of knowledge among the distributors and producers. Enlightening the mango growers in pest control, necessary of water drip irrigation, diseases, marketing knowledge and followed by updates of government policies, financial remedies and subsides may enhance the production. Mango growers should be edified in knotty mango cultivation which includes plot density, fertigation etc. Another serious problem is bearing of fruits in mango trees. The large-scale demonstrations of the techniques have to be shell out in different parts of country. Growers should be edified with proper methods of harvesting. Government agencies should take capability to enlarge the adequate number of cold storages in the country to store the mango fruit and sell the fruits in the off-season to get the lofty price.

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