© 2018 IJSRSET | Volume 4 | Issue 2 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
National Conference on Advanced Research Trends in Information and
g Technologies (NCARTICT-2018), Department of IT, L. D. College of Engineering,
Ahmedabad, Gujarat, India In association with
International Journal of Scientific Research in Science, Engineering and Technology

Decision Support System for reducing Post-Harvest Loss in Supply Chain Logistics using geographical Information System in Agriculture

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ABSTRACT

Decision support system (DSS) is a broad concept which caters to the suit of ICT based applications assisting decision makers in order to take appropriate and timely decisions. DSS can help decision makers to make appropriate queries and take particular decision about a particular a particular horticulture crop in order to decide about new areas for plantation as well as supply chain logistics. This system will help in making future projections and consumptions and make scenarios for demand and supply. This system basically works on the premise of spatial network analysis, Site-suitability analysis for cold storages, shortest path analysis, image (raster) operations as geo-spatial layer provided to the system. This system is combination of vector and raster data handling in an integrated way. This DSS software site suitability module is designed for apple and it has been tested with available data for shimla district of Himachal Pradesh and network analysis module is designed potato and it has been tested with the available data for Gautambuddhnagar district of Uttar Pradesh.

Keywords : DSS, AHP, Shortest Path, Advisory, Post-harvest loss, Supply chain management

I. INTRODUCTION

Even though India is second largest country in the production of fruits and vegetables in the all over world after china we need to import fruits from the outside country. It will indirectly affect on our Indian economy. There is post-harvest loss due to lack of improper storage facilities, not using the modern technologies, improper preservation techniques and issues in market availabilities. Farmers of the rural areas do not have access to sufficient storage facilities for storing their produce during post-harvest periods. So, mainly production loss is due to lack of proper infrastructure, supply chain entities like cold storages, market outlets, mandis, transportation entities, proper road network entities especially in hilly areas. To improve production amount, it is extensively required to provide proper infrastructure facilities. Through an integrated management of their supply chains, companies react to increasingly competitive markets and trends towards globalization. Supply chain management (SCM) shown in Figure 1 can be defined as the task of integrating organizational units along the supply chain and coordinating material, information and financial flows in order to fulfill (ultimate) customer demands with the aim of improving competitiveness of a supply chain as a whole. As such, SCM should result in an internally consistent view on how a supply chain should look like in terms of production and distribution processes and their coordination.

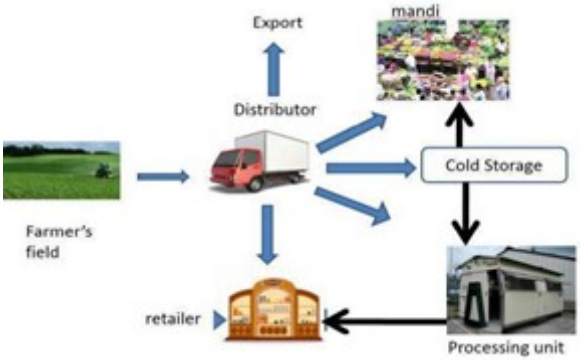

Figure 1. Supply chain entities

II. METHODS AND MATERIAL

Decision Support System Characteristics

Decision support system in general is a computer based system that is very useful in making certain important decisions based on criterions to find out solutions to the problems in hand to a decision maker. This type of system can be helpful in such an environment where problems are rapidly changed and not easily specified in advance. Decision support system (DSS) will combine all the possibilities of problem solution so that final result is more accurate than any other methods.

Decision Support System for Supply Chain Logistics will be application which will be very useful to find out the location of best cold storages nearest to the orchards. Finding out the service areas of the cold storages to identify the area to which particular cold storage can serve. Recommend the location of new cold storage so that, the areas where cold storages are not available, new cold storages can be established. Therefore, farmers of that region don't need to go faraway places to store their produce. Post harvesting losses occurring due to lack of proper supply chain entities can be minimized by having proper management plans.

1. Finding out the nearest location of cold storages from the orchard.
2. Calculate service areas for determining the areas to which cold storages can serve.
3. Recommendation of location for establishing new cold storage using site suitability analysis.

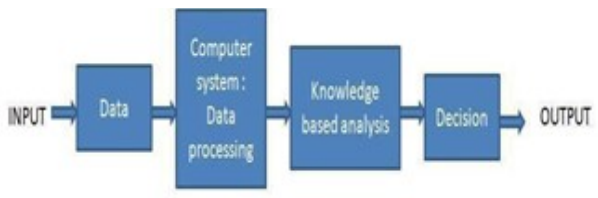

Figure 2. Simple model of Decision Support System

2.1 Site-Suitability Analysis:

To determine site suitability in any region for establishing a location of new cold storage AHP technique is used. Analytical hierarchy process (AHP) is a decision-making technique which can be used to analyze and support decisions which have multiple and even competing objectives. To do this, a complex problem is divided into a number of simpler problems in the form of a decision hierarchy. Once the hierarchy has been established, a pair wise comparison matrix of each element within each level is constructed. Participants can weight each element against each other within each level, which is related to the levels above and below it, and mathematically tie the entire scheme together. AHP is often used to compare the relative suitability of a small number of alternatives concerning the overall goal.

2.2 Network Analysis:

Networks are necessary for the movement of people, transportation of goods, communicate information and control of the flow of matter and energy. Network application is quite vast. Phenomena that are represented and analyzed as networks are roads, railways, cables, and pipelines. A graph is a mathematical abstraction that is useful for solving different networking problems. Finding the shortest paths plays an important role in solving network based systems. In graph theory, a number of algorithms can be applied for finding the shortest path in a graph based network system. This reduces the complexity of the network path, the cost, and the time to build and maintain the network based systems.

2.3 Advisory:

Agriculture sector requires innumerable types of data analytics in various sectors such as crop productivity prediction models, economic models, pest and crop disease prediction models, and so on. Big data analytics in agriculture can be used to analyze huge volumes of structured as well as unstructured data to generate faster and more accurate results that will aid in faster and accurate decision making.

III. RESULTS AND DISCUSSION

3.1 Site-Suitability Analysis:

We proposed the use of GIS based on analytical hierarchy process (AHP) to select sites suitable for building new cold storages. It not only includes environmental factors but also economic factors. We graded every criterion from 1 to 10; 1 being the least suitable and 10 being the most suitable. Thus, our

method combines qualitative and quantitative criteria for establishing location of new cold storage.

3.1.1 Calculating criteria weights by AHP:
Matrix is created according to the size of the parameter.

For example, for seven parameters 7x7 matrix is used.
Step 1. Complete the Matrix.
Sum of all columns.

Table 1. Fill matrix operation

B1	C1	C2	C3	C4	C5	C6	C7
C1	1	1	3	4	5	9	7
C2	1	1	2	3	5	8	6
C3	1/3	1/2	1	1	2	7	3
C4	1/4	1/3	1	1	1	7	9
C5	1/5	1/5	1/2	1	1	1	8
C6	1/9	1/8	1/7	1/7	1	1	1
C7	1/7	1/6	1/3	1/9	1/8	1	1
SUM	**3.03**	**3.28**	**7.75**	**10.25**	**15.125**	**34**	**35**

CR=0.089, B1= Parameters, C1 =Crop, C2 =Wetland, C3 =Road, C4 =DMSP, C5 =Elevation, C6 =Slope, C7 =LULC, W is the weight of C1–C7 to B1.

Step 2. Normalization and weight determination Each cell value is divided by sum of that column value. Average of all the rows is calculated and store in column sum. Average of sum column is 1.

Table 2. Normalization and weight determination

B1	C1	C2	C3	C4	C5	C6	C7	SUM
C1	0.32924	0.32924	0.10974	0.08231	0.06584	0.03658	0.04703	**0.31307**
C2	0.300752	0.30075	0.15037	0.10025	0.06015	0.03759	0.05012	**0.27294**
C3	0.376119	0.25074	0.12537	0.12537	0.06268	0.01791	0.04179	**0.12955**
C4	0.390093	0.29257	0.09752	0.09752	0.09752	0.01393	0.01083	**0.13351**
C5	0.330579	0.33057	0.13223	0.06611	0.06611	0.06611	0.00826	**0.08187**
C6	0.264706	0.23529	0.20588	0.20588	0.02941	0.02941	0.02941	**0.03287**
C7	0.2	0.17142	0.8571	0.25714	0.22857	0.02857	0.02857	**0.03086**

Step 3. Calculation of consistency ration (CR)
Value of consistency ratio must be <= 0.1.

CR = Consistency index(CI) / Random Consistency Index(RI)

Consistency Index (CI) = λ – n/ n-1

λ= Principal Eigen value, n= number of factors
0.31307*1+0.2729*1+0.1295*3+0.133*4+0.081*5+0.0328*9+0.030*7 =2.4166 2.4166/0.31307 = 7.719

Like this all the values of rows calculated and average of **these seven values are considered as a λ.**
CI = 7.707133 – 7/ 7-1
CI = 0.11785
CR = 0.1178/ 1.32 = 0.089 < 0.1

If value of CR is less than 0.1 then the weights are correct for all parameters.

Now, C1 to C7 all parameter's Raster Layer is given as an input according to it's weights generated by AHP. After all this process final output Raster file will generated which is shown in figure 3.

This case study illustrates the process of identifying a single or a few optimal sites. In the end, the best landfill areas were given, and they can be taken as the optimal suitable sites for establishing new cold storages. The better suitable sites for establishing new cold storages areas can be taken as back-up sites.

10 = Most Suitable Sites
1 = Least Suitable Site

Output:

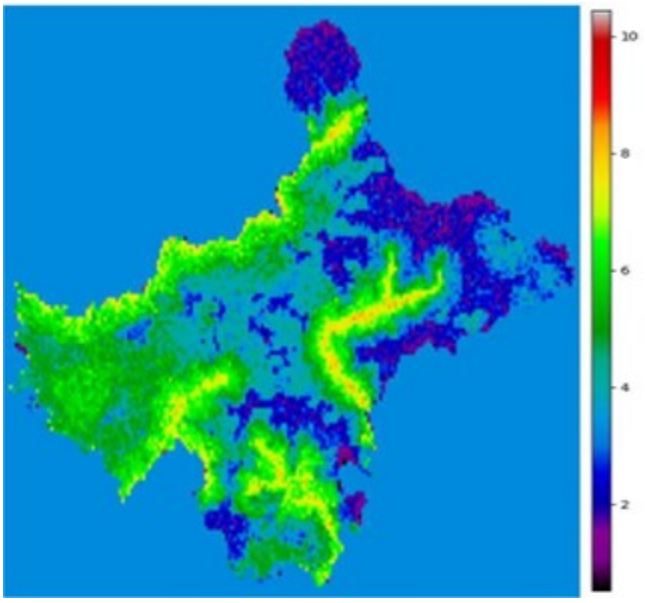

Figure 3. Suitable Sites for establishing new coldstorages in Shimla district

3.2 Network Analysis:
The network analysis is used to find transportation facility from production field to the mandis, processing units, cold chain entities. Network analysis also used for finding out the cost effective path, shortest path in terms of time or distance. Network analysis is needed to find out shortest path from orchard to the nearest cold storage location. Decision support system is a facility management system for supply chain in order to easily help in showing the shortest path. But that shortest path to the cold storage should be based on available capacity of the cold storage. Because sometimes nearest cold storage does not have that much capacity to store the produce of farmers, thereby increasing the cost of transportation unnecessarily. So, it is one kind of facility management system for farmers helping them to get the nearest location of cold storage based on produce capacity and availability of space.

Output:

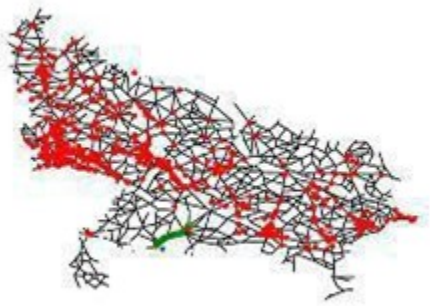

Figure 4. Shortest path from selected source to nearest coldstorages for U.P. State

3.3 Advisory:
An advisory module can be developed using various analytical services like rainfall prediction, crop recommendation, procure agro inputs recommendations, supply chain management, crop disease alert, fertilizer recommendations, etc. based on agricultural and weather data. The role of domain expert/ agricultural scientist is to generate recommendations and constitute decision policies based on analytical results.

IV. CONCLUSION

Decision Support System will help decision makers to make a decision about a particular horticulture crop in order to decide about new areas for the plantation as well as supply chain logistics. This system will help in

making future projections on consumption of scenarios for demand and supply. Mainly post-harvest loss is due to weak supply chain entities like road network, cold chain entities and markets. By improving this type of entities post-harvest loss can be reduced. For that network analysis, proximity analysis, buffer analysis performed.

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