Integration of internet of things to reduce various losses of jatropha seed supply chain

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Abstract. The evolution of bio fuel supply chain has revolutionized the organization by restructuring the practices of the traditional management. A flexible distribution system is becoming the need of our society. The main focus of this paper is to integrate IoT technologies into a cultivation, extraction and management of Jatropha seed. It was noticed that major setback of farmers due to poor supply chain integration. The various losses like information about the Jatropha seed availability, the location of esterification plants and distribution details are identified through this IoT. This enables the farmers to reorganize the land resources, yield estimation and distribution functions. The wastage and the scarcity of energy can be tackled by using the smart phone technologies. This paper is proposes a conceptual frame work on various losses involved in the supply chain of Jatropha seed.

1. Introduction

Jatropha in an adaptable species, its strength as a crop is its ability to grow in any part of the country with a minimum input and can be propagate easily. The uncultivable wastelands are planned to utilize for cultivating Jatropha seed which has lately emerged as major sources of bio-fuel[1] in the country. An integrated Jatropha bio-fuel project has three stages i) the first stage is production of seeds of Jatropha is the plantation[2] stage ii) extraction stages of bio-fuel iii) the final stage distribution of bio-fuel. Identifying and minimizing the losses in each stage becomes essential. The main focus of this paper is to reduce the losses of Jatropha supply chain[3]. The supply chain management success included improved relationships between warehousing and transportation within companies as a result of reduced inventory and better response time to customer requests for products and services this is done by integrating the IoT technologies in cultivation, extraction and management of Jatropha seed. Hence to assimilate the IoT technologies the foremost important factor is to forecast the various losses of Jatropha. The various losses which has been addressed in this paper are as follows, losses in the yield of the seed, barriers in Identification of factory and issues in inventory details.

The key factors that can influence the seed yield of Jatropha plant are:

- Climate
- Quality of the soil
Irrigation

- **Climate**
  
  Rainfall is an important factor when it comes to the yield. The optimum range is believed to be between 500mm to 600mm. Climate does not appear to be an important factor, considering the fact that this plant can survive in a wide range of temperatures. However, warmer climates appear to result in better yields.

- **Quality of the soil**
  
  Sandy soils[4] with ample drainage are ideal for a high jatropha yield. The condition of the groundwater[5] is an important factor as well. Irrigated soil seems to provide the best yield in terms of efficiency.

- **Irrigation**
  
  Jatropha handles dryness very well and it is possible to live almost entirely of humidity in the air. See Cape Verde where rainfall[6] is as low as 250 mm a year. Differences are expressed in what is optimum rainfall as some readings say 600 mm and some say 800 mm whilst some areas in India report good crops with rainfall of 1380 mm. Under irrigation 1 500 mm is given. 500 - 600 mm of rainfall is the limit. Below it the production depends on the local water condition in the ground.
  
  It is important to rectify yield losses which in turn increase the productivity of jatropha seed.

  In order to identify the location of the factory it is essential to estimate the production of the seed. The yield estimation is done using Seed_Estimation algorithm. The factory is identified for the esterification of plant. Inappropriate selection of factory can lead to losses in cost of transportation and Insufficient Factory capacity can route to wastage of seed. Factory losses can be controlled by applying appropriate metrics for process capacity of the factory and neighborhood Search algorithm[7] is used to find the shortest destination from the source point. Inventory management[8] is a significant component of supply chain management. Supply chain costs need to be minimized by handling inventory levels in numerous production and distribution operations related with diverse stage. The system proposed also take responsibility of handling inventory issues in supply scheduling, transactions and ordering which creates the inventory losses such as cost, time, and labor. Innovative and efficient methodology to determination of the most probable excess stock level and shortage level required for inventory optimization[9] in the supply chain such that minimal total supply chain cost is ensured. Big data technology is used to save large data such as yield estimation factory details and inventory details. The wastage of scarcity of energy can be tackled by using the smart technologies. This paper propose a conceptual frame work on reducing losses involved in Jatropha seed.

The underlying figure-1 shows the losses and issues in Jatropha supply chain.

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**Figure 1:** Losses in Jatropha Supply Chain

- Losses in Jatropha Supply Chain
  - Losses on Seed Yield Information
    - **Climate**
      - **Quality of Soil**
      - **Irrigation**
  - Factory Location Information
    - **Factory Identification**
    - **Factory Capacity**
  - Inventory Issues
    - **Scheduling**
    - **Transactions**
    - **Ordering**
2. Related Works
Ji-chun Zhao et al. (2010)[10] has shown the greenhouse monitor system based on IOT technology has certain precision of monitor and control. According to the need surrounding monitor, this system has realized the automatic control on the environmental temperature, humidity factors.

Arindam Giri et al., (2016)[11] has proposed a framework that consists of smart devices, WSN, and Internet by which agricultural processes will be automated. Using smart mobile phones the farmer can control the agricultural tools such as an automated water sprayer to be used in the field of agriculture.

S.Geetha et al., (2016)[12] have used wireless sensor network (WSNs) GSM and Android phone supporting android application and System for plant disease monitoring. With the information in the web server the farmer can automatically control irrigation using android application.

3. METHODOLOGY
The system Architecture consists of three layers. They are Application layer, Resource layer and service layer.

**Application layer**: This layer functionality is to retrieving and receiving the demand from external data source such as customer, retailer and factory and trigger the service layer to process the information.

![System Architecture Diagram](image)

**Figure 2**: System Architecture Diagram

**Service layer**: This is the core part of the framework which has been proposed to control the losses of Jatropha seed supply chain. It is classified into four components to handle the predicted losses. Follows are the details of the four components.

**Inventory System** can forecast the demand and can handle the issues of scheduling, ordering and transaction

**Neighborhood search algorithm** is used to optimize the search of factory details.

**Soil information system** to predict the estimation of water content and they are categories as medium, low and high. The predicted outcome is captured by seed estimation algorithm.

**Seed estimation algorithm** calculate the yield estimation of jatropha seed and the extracted seed is dispatched for esterification of biofuel by identifying the optimal Factory.

**Resource layer**: It consist of two components as follows

\[ M_w \] - Mass of Water
\[ M_m \] - Mass of Mineral
\[ V_t \] – Total Volume

**\( \rho_w \)** - density of water

**Land resource** component consist of sensor which is used to sense the moisture content of the soil and the information is given to soil information system to predict the estimation of water content.
**Big data** This component provides the functionality of storage and retrieving various data such as land resource details, inventory detail, factory details, supply chain network member data and production information.

The Figure 3 shows the step by step procedure for measuring the Volumetric Water Content (ϴ). The predicted ϴ value is used to categories the soil into three types as High (H), Medium (m) and Low (L).

The Seed Estimation algorithm is proposed for total Jatropha seed yield estimation.

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**Seed Estimation Algorithm:**

This algorithm is used to calculate the total seed estimation, for which soil type, collar diameter, age and height of the tree is given as input. The sensor senses the soil information and categories the type of the soil (H, M, L). Based upon the type of soil the production value (P) has been set and total Jatropha seed has been estimated.
Seed_Estimation(Soil_Type, Col_Dia[n], Age[n], HeighT[n]):
//Estimating Total number of Jatropha Seed
//Input:Collider diameter, Height, Age of tree, Soil Type, a,b,c
//Output: Total estimation of Jatropha Seed
If Soil_Type = H
Then P = 1.0
Else If Soil_Type = M
Then P = 0.75
Else
P = 0.5
For i ← 1 to n
YS_i = P * ( Col_Dia_i + c*Age_i/In(HeighT_i) )
Total_Estimation = \sum_{i=1}^{n} YS_i

Neighborhood Search Algorithm:
This algorithm is proposed to locate optimal factory for extraction of biofuel. The input parameters are total seeds (S_n), capacity of factory (C_n) and Locations of factories (L_n). The step by step procedure to find the shortest distance from the source of the seed has been given.

Step 0:
Total Seed S ← {S_1, S_2, … , S_n}
Factory_Details ← {(C_1, L_1),(C_2, L_2),(C_3, L_3), … ,(C_m,L_m)}

Step 1:
For i ← 1 to n
For j ← 1 to m
Find the distance by using Euclidian Distance. (i.e., one point from current location point, another point from Factory Location)
Sort distance of factories in non-decreasing order.
Step 1.1:
Select the min distance factory
Step 1.2:
If S_i <= C_j
Move S_i to C_j
Reduce S_i from C_j
Else
Select next min distance factory
Goto step 1.2

4. Conclusion
Supply chain management is focused by all the researchers in the world today, Bio fuel supply chain management is one of the important research direction. The biggest challenge faced by farmers and manufactures of bio fuel has been addressed in this proposal by applying various technologies in each stage of the supply chain process. This paper addresses the problem of supply chain losses and proposes a step-by-step procedure for predicting yield of seed estimation and conceptual frame work of IoT to reduce the losses in Jatropha supply chain. The proposed framework helps to make more optimal decision including how to control costs, improve demand forecast and enhance yield of Jatropha seed the future work will focus on constraint-based optimization, advanced forecasting and modeling of system.
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