8-9-2022

Bayesian network development for depots location selection with biomass supply system excellence

Alaa Ashraf Abulhamail
aa2798@msstate.edu

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By

Alaa Ashraf Abulhamail

Approved by:

Raed Jaradat (Major Professor)
Junfeng Ma
Mohammad Marufuzzaman (Committee Member/Graduate Coordinator)
Jason M. Keith (Dean, Bagley College of Engineering)

A Thesis
Submitted to the Faculty of
Mississippi State University
in Partial Fulfillment of the Requirements
for the Degree of Master of Science
in Industrial & System Engineering with a Management concentration
in the Department of Industrial & System Engineering

Mississippi State, Mississippi

August 2022

Name: Alaa Ashraf Abulhamail

Date of Degree: August 9, 2022

Institution: Mississippi State University

Major Field: Industrial & System Engineering with a Management concentration

Major Professor: Raed Jaradat

Title of Study: Bayesian network development for depots location selection with biomass supply system excellence

Pages in Study 23

Candidate for Degree of Master of Science

The renewable energy of the wood pellet market has taken great attention over the last few periods. However, the returns from the pellet business depend largely on how well the quality of biomass. The objective is to economically harvest pellets matching pellet standards set forward by the U.S. and European markets. The purpose of this study is to develop a Bayesian network model to ensure a high-quality flow through the supply chain of the pallet industry in the top ten counties in Mississippi state. Multiple critical decisions (harvesting, storage, transportation, and quality control) of a biomass-to-pellet supply system could potentially affect the supply chain. The biomass-to pellet supply chain is an extremely challenging problem. It is a Multi-criteria Decision Making (MCDM), therefore, criteria and sub-criteria were developed associated with biomass-to pellet supply chain pellet. Experimental results indicate that the biomass-to-pellet supply system is sensitive to the biomass quality parameters especially ash and moisture contents. Fifty were studied and ten locations were recommended and ranked based on affordability and resiliency of the availability of both corn stover and forest residues in the depot facilities. There are several anticipated and unpredicted energy turbulence in the Depots property. Pellets have been recognized as an alternative power approach to managing risk throughout power generation. These prospective users from using alternative power. This research proposes a solid foundation for in-depth future research to acquire detailed insights into how the Pellets depots location works in practice in Mississippi state to give a more substantial basis for strategic, tactical, and operational levels of possible risk profiles in Mississippi state.

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BAYESIAN NETWORK DEVELOPMENT FOR DPOTS LOCATION SELECTION

Introduction

Vital energy is an alternative source of energy that is essential to help improve the dependence on petroleum energy. For years, U.S. Vital energy has relied on conservative biomass supply systems. However, the instability in the crude oil market increases the demand for the development of sustainable feedstock for future bio-economy growth. Feedstock can be defined as renewable biological material including forest residue (wood), and agricultural residue (corn-stover) (Quddus el.,2017).

The pellet market is projected to increase to 54 million tonnes by 2025, which is approximately the total market demand is expected to be consumed in Europe alone. The Pellet market is also expected to increase in North America and Asia. Wood pellets consumption has increased internationally (Sikkema, 2011). These opportunities made investors towards increasing the new/existing biomass-to-pellet supply chain request, which can economically produce and transport pellets in Mississippi. Several reasons make the biomass to pellets transformation is complicated, but not limited to biomass quality variability, seasonality, season market-specific pellet production requirements.

There are many complexities in the pellet industry standards for the U.S. and the European markets (Sjoding, 2013). The two markets have different pellet production standards which must be met to ensure customer satisfaction and long-term sustainability of the pellet business. A pellet industry in Mississippi require to produce particular grades of the pellets for the local markets (e.g., PFI premium, PFI standard, PFI utility). In addition to these market-specific pellet manufacture necessities, challenges depend on procurement the quality and quantity of the feedstocks from ranchers, which essentially increases the complexity in the pellet industry. The US markets customize a range of moisture and ash content.

Our study is to develop a potential depots location around Mississippi state that achieves the market need. A set of candidate depot locations will be studied to obtain the pellet market in Mississippis State. Uncertainty exists in finding high-quality biomass from ranches. Also, biomass availability is uncertain throughout the year. This randomness makes high challenges for the pellet industry to produce and get the market the correct grade of pellet. Robust decision tools are desired, to manage the uncertainty linked with biomass yield and quality and consider all the critical steps (e.g., harvesting, storage, transportation, quality inspection, and production decisions) that significantly impact the biomass-to-pellet supply chain.

Methodology

This segment presents the methodology for depot location selection in Mississippi state. We classify this selection process into *three* different classifications:

- Evolvement phase
- Modeling phase
- Evaluation phase

The *evolvement* phase involves identifying many criteria and sub-criteria to discover a depot facility in Mississippi state systematically. Expert knowledge and available literature are followed to construct the criteria and sub-criteria. Next, a proper connection between the criteria and sub-criteria is made, and the relevant data are collected to construct the BN model. With the knowledge gathered during the development phase, a BN model is constructed for each potential site during the *modeling* phase. The BN score for all potential sites will be evaluated through many sensitivity analyses throughout the *evaluation phase*. If validated, the analyst will select the best depots site(s); otherwise, the *development* phase will be visited again to reevaluate the criteria/sub-criteria selection and data collection processes. The practice will remain until each site is sufficiently validated through demonstrated sensitivity analysis.

The proposed methodology is to develop certain criteria and sub-criteria that are acquired after identifying the problem statement of pallet requirement in Mississippi state. A ten potential depots location will be studied in 10 counties and use previous historical data to develop a certain distribution for each location. A study will rank all locations from 1 to 10 according to their preferences.

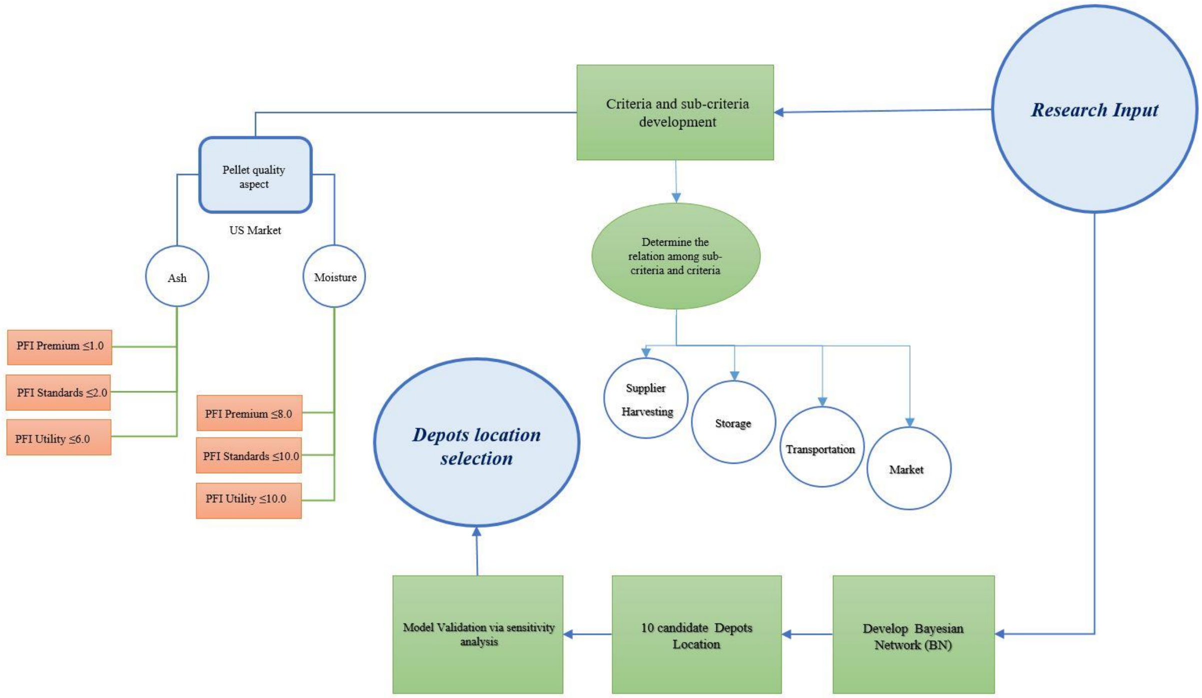

Figure 1 Methodology and criteria and sub-criteria development for selecting depots locations

Bayesian Network (BN)

The Bayesian concept has been in existence for some time now. Judea Pearl introduced the Bayesian network concept in 1985, whereby he used it to test the probability of events occurring due to the influence (Pearl 2022). BNs used to detect errors. Detecting errors and an alternative method to detect blood lab errors are better than the existing automated methods. Other people that find the network models useful are cybersecurity people. They tend to dig into different cases, and as such, they tend to find the probability of one event to the other. A BN is a beneficial approach for calculating the previous probability distribution of unknown variables that depend on prior observed variables. A BN model is constructed of double parts. The first part is called *nodes*, and they describe the uncertain variables. Nodes in BN can be categorized into three classes, namely, *major* nodes, that do not depend on prior nodes, minor nodes, that depend on past nodes which are the major nods, and *middle* nodes, that have both major and minor nodes. It is the probability distribution of the variable given prior major nodes. The second part of the construction of BN is the *arrows*. Arrows in BNs illustrate the relationships and associations among the variables. **Figure 2** is a sketch of the BN model with six nodes Y_1, Y_2 Y_3, Y_4, Y_5, and Y_6. Y_1, Y_2, and Y_3 are major nodes, so they do not depend on the previous nodes, while Y_4 and Y_5 are middle nodes. Y_4 depends on Y_1 and Y_5 depends on Y_2 and Y_3. Y_6 is a minor or leave node, and it depends on both Y_4 and Y_5. It can be obviously seen that the arrow coming out Y_1 to Y_4; thus, it indicates that Y_1 is an independent node, while Y_4 depends on Y_1 (Fenton & Neil, 2018).

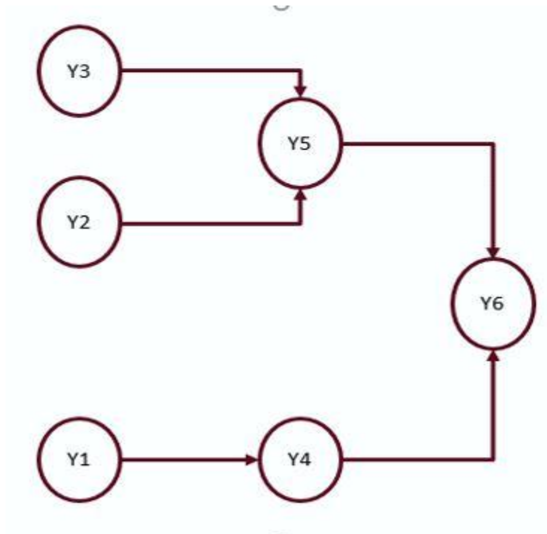

Figure 2 A description of Bayesian Network concept

It is required first to calculate the unconditional probability of $P(Y_1),\ P(Y_2),\ and\ P(Y_3)$ and the conditional probability of $P(Y_4|Y_1),\ P(Y_5|Y_2, Y_3),\ and\ P(Y_6|Y_5, Y_4)$ to calculate the joint probability distribution. An important quality of BN is the ability to update propagation after witnessing other nodes. The detected nodes are named evidence(Hosseini & Barker., 2016).

Literature review

This section will discuss the state of the art of biomass to pellet industry and depots location selection. Biomass past studies show biomass supply chain literature detection on reducing the supply chain costs (e.g., feedstock collection, inventory, production, and facility location decisions). A recent study of biomass supply chain prove that biomass is so random in nature, a number of past studies assumed a random approach to observe the impact of feedstock supply (e.g., Huang, 2014; Poudel, 2016; Poudel, 2019) and cost (e.g., Tong, 2014; Gong, 2016; Uster, 2018), emission policy (e.g., Alizadeh, 2019), and biofuel demand (e.g., Chen, 2012; Gong, 2016) and management of a biofuel supply chain network. Scholars have studied ways to enhance the biomass supply chain verdicts under a different scenario, such as financial uncertainty (e.g., Gebreslassie, 2012), environmental conditions (e.g., Marufuzzaman, 2014; Marufuzzaman, 2014;

Alizadeh, 2019), and even in handling risks underneath thrilling weather conditions, such as hurricanes and tornados (e.g., Marufuzzaman, 2014; Marufuzzaman, 2017; Poudel, 2016).

Biomass-to-biofuel supply chain got significant attention in the past researches. However, the biomass-to-pellet supply chain is uncharted. Recently, several researches performed a an economic investigation to find the economical path to make pellets from different agricultural sources (e.g., unmerchantable forest residues, pole mill residues, straw, and switchgrass) (Mani, 2006; Agar, 2017; 2014; Sultana, 2010). For example, Mani (2006) estimates the total operating costs for different volumes of the biomass pellet production plants. The location and feedstock supply calculation, the authors estimated the optimal pellet plant size (55 to 315 Gg/year).

Studies consider depots is one of the treatment process of biomass within a four-layer supply chain network. The biomass obtained at the feedstock supply sites, transported to depots for transforming into pellets then its taken into biorefineries via intermodal facilities (i.e., rail or barge) for producing biofuels. These researches were successfully studied the managerial insights for the bioenergy market. However, it couldn’t pay enough attention to the main criteria that mostly affect the quality of this trasnfomation which are biomass seasonality, quality, and US/Europe market requirements. Without considering criteria in the models the economic feasibility of the pellet production can not be achieved.

Recent revisions, Mobini (2013, 2014) initiate a simulation-based models to minimize both financial and carbon emissions for wood pellet-based supply chain. However, no previous studies modeled the influence of biomass quality changeability in identifying the economics behind market demands pecific pellet production.

Criteria and sub-criteria development

This study aims to provide decision makers with a tool to facilitate an approach toward selecting the best depots alternatives. These decisions can be made based on the provided five criteria and eleven sub-criteria to identify the top ten locations in the Mississippi state. Criteria evaluation plays a substantial role in the location selection of depots. Harvesting supplier, storage region, transportation, and quality control. Therefore, these aspects are considered to ensure the suitability and resiliency of the selected depot's locations. Figure 3 demonstrates the criteria and sub-criteria considered for the location selection of the depots.

Figure 3 Summary of the research supply chain thinking process involved in locating ultimate location

The first criterion in this study is the harvesting supplier, which includes both the period of the contract and the pellet cost per ton. Previous studies have shown that the duration of the contract ranges between 10, 15, or 20 years and that the cost can be 15, 20, or 30 per ton. Storage availability captures the availability pellet in each region of Mississippi state of each region (e.g Northeast, Delta, Coastal, and Central region. The third criterion is transportation which includes the distance the from supplier to the fifty recommended locations around Mississippi state. It also includes the transportation cost per mile. Finally, the quality control node is n important node that ensures the needed quality for the Us market which includes both inorganic ash control and moisture control. Thirty-three location were identified that has an average production of more than 31,000 ton per year and are produced as per the US standard. For the storage perspective, a study was conducted in 2021 with fifty possible depots location in MS was studied and utilized to locates the top ten ultimate alternative (Aghalari et al., 2021).

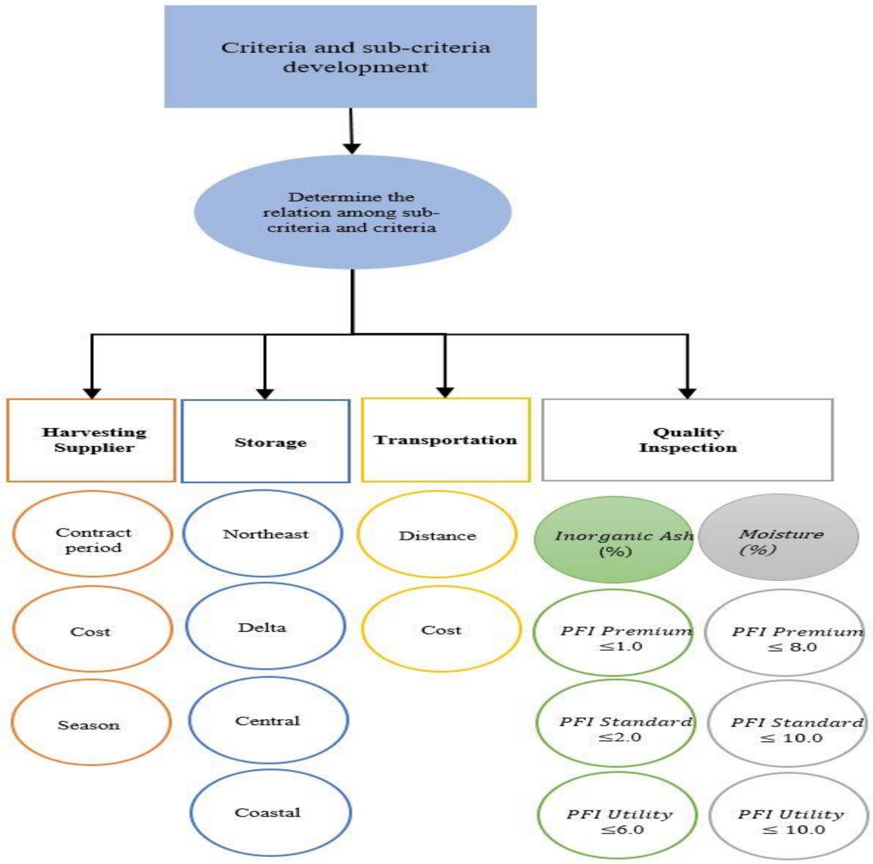

Figure 4 Depots Locations Selection Criteria and sub-criteria

Major contributions

The major contributions of this research as follows:

• This paper is provide a calculated model using agena risk that custodies the impact of biomass quality like ash/moisture contents on a biomass-to-pellet transformation industry. The proposed model captured U.S standard of the pellets, preprocessing requirements based on different ranges of ash/moisture contents that efficiently optimized in an attempt to minimize the overall pellet production cost under biomass yield and quality uncertainty.

• The model works efficiently on the evaluation of all MS suppliers and other fifty locations developed by (Aghalari et al., 2021). Our specific contribution is the develop a model that identifies top sites that produce high quantity and quality pellets to have high resiliency and identify top depots location based on supplier, storage location, transportation, and Pellet quality control

• The final contribution of this paper is to develop a representative scenario by using Mississippi as trial. Mississippi holds several satisfactory factors like abundant biomass, that are likely to attract investors to capitalize on the pellet industry in the future. The result of this research would provide several visions for the decision-makers, such as the best ten location that can invest on them immediately.

BN Modeling of Depots criteria

Twenty-three locations were studied and included in the Agenarisk software to locate the top ten locations with at least two depots in each location. These twenty-three locations comprise both the high-quality ash and moisture content. Another aspect included the top supplier location in terms of pellets availability. The pellet's availability data were divided into the region and study each region efficiently to be able to find the top location in each region. This research has assumed the depot's facility size is fixed across all MS. It also assumes operation and maintenance costs are excluded since the different counties would have different wages. Finally, taxes are considered fixed since our study is in MS and they have a fixed tax across MS. The fifty recommended locations around Mississippi were provided from a previous study in 2021 with no specific ranking mentioned. The developed criteria and sub-criteria will help the decision maker to utilize the tools used to decide the best location for depots in MS and they can use the same approach for other counties around the United States.

Modeling of pellet supplier

Modeling of pellet supplier includes three variables contract period, cost, and season variability. Table 1 demonstrates the different nodes are modeled under the pellet supplier. A clarification behind modeling the variables is further given in Table 2. Range are provided to estimate the pallets cost. Table 1 displays how the different node are constructed under the pellet supplier.

Table 1 Modeling of Pellet supplier

Variable	Modeling Procedure	Explanation
Contract period	Range (10, 15, or 20)	For modeling the contract period, the range will be between 10, 15, or 20 years.
Pellet cost	Range (15, 35, or 60)	According to the historical data, the average pellets cost ranges from $15 to $60
Pellet season	Production capacity range (Low, Medium, High)	Pellet production capacity varies in cold weather which eventually will drop production capacity

Modeling of Storage

Storage variables capture the availability of biomass/ pellets in each region in Mississippi state. Table 2 displays how the different nodes are demonstrated under the storage criteria.

Table 2 Modeling of Storage variable in terms of Pellets availability

Variable	Modeling Procedure	Explanation
Northeast	IF (Pellet availability ≥ $average$=25,000)	For modelling the availability of Pellet in the Northeast region. An if conditioned is used to ensure the availability of pellet supplies is more than or equal the average which is 25,000
Delta	IF (Pellet availability ≥ $average = 33{,}000$)	For modelling the availability of Pellet in the Delta region. An if conditioned is used to ensure the availability of pellet supplies is more than or equal to the average which is 33,000
Central	IF (Pellet availability ≥ $average = 27{,}000$)	For modeling the availability of Pellet in the Central region. An if conditioned is used to ensure the availability of pellet supplies is more than or equal the average which is 27,000
Coastal	IF (Pellet availability ≥ $average = 42{,}000$)	For modeling the availability of Pellet in the Coastal region. An if conditioned is used to ensure the availability of pellet supplies is more than or equal to the average which is 42,000.

Table 3 Show the top depots supplier in Mississippi state, US.

County	Total Produced	long supply	Lat supply	Region	County	Total Produced	Long supply	lat supply	Region
Yazoo	89760	-90.38	32.83	Delta	Sharkey	43966	-90.85	32.92	Delta
Sunflower	82841	-90.6	33.57	Delta	Monroe	42395	-88.5	33.92	Northeast
Lauderdale	76933	-88.69	32.4	coastal	Washington	41774	-91.01	33.37	Delta
Leflore	69366	-90.22	33.52	Delta	Neshoba	41692	-89.11	32.76	Coastal
Itawamba	68443	-88.4	34.29	Northeast	Panola	39044	-89.96	34.36	Delta
Pearl River	62656	-89.64	30.64	coastal	Pontotoc	38886	-89.02	34.24	Northeast
Clarke	60597	-88.72	32.06	coastal	Tippah	37406	-88.93	34.78	Northeast
Wayne	59027	-88.66	31.66	coastal	Jackson	36970	-88.63	30.42	coastal
Lincoln	58483	-90.45	31.55	Central	Newton	36354	-89.13	32.41	coastal
Jones	57071	-89.16	31.67	coastal	Harrison	35964	-89.04	30.41	coastal
Jasper	54985	-89.13	31.97	coastal	Tishomingo	35931	-88.23	34.73	Northeast
Greene	54960	-88.66	31.2	coastal	Holmes	35885	-90.05	33.1	Delta
Copiah	47534	-90.38	31.89	Central	Marion	35029	-89.84	31.24	coastal
Winston	46907	-89.05	33.09	Northeast	Amite	34231	-90.84	31.18	Central
Warren	46600	-90.86	32.32	Central	Hinds	33727	-90.24	32.31	Central
Kemper	44982	-88.67	32.75	coastal	Tallahatchie	32975	-90.19	33.96	Delta

Modelling of Pallet transportation

The transportation criterion consists of two nodes: distance per mile and transportation cost. Table 4 demonstrate how the nodes are constructed under the transportation criteria to locate a the lowest distance to the depots facility in Mississippi State with the lowest possible cost.

Table 4 Modeling of Pellet transportation

Variable	Modeling Procedure	Explanation
Distance	IF (distance ≤ 100 miles,” True”,” False”)	For modeling the distance. and if conditioned is used to ensure the distance is less or equal to 100 miles.
Cost	TNORM (μ = 10, σ2 = 8, LB = 4 UB = 90)	According to the historical data, bank steepness follows a truncated normal distribution with a mean of $10 per mile.

Modeling of pellet Quality Inspection

The quality control node adheres to the US standard that covers two important aspects, the Inorganic ash, and the moisture level to get the most benefit during the transformation.

Table 5 Modeling of Quality inspection node

Variable	Modeling Procedure	Explanation
Inorganic ash	IF (PFI premium ≤ 1.0 or PFI standard ≤ 2.0 or PFI Utility ≤ 6.0)	For modeling the inorganic ash. and if conditioned is used to ensure ash standards are followed
Moisture	IF (PFI premium ≤ 8.0 or PFI standard ≤ 10.0 or PFI Utility ≤ 10.0)	For modeling the Moisture. the if conditioned is used to ensure Moisture standards are followed.

Probability of Depots Selection

As shown in Figure 6, we were able to identify ten successful locations in MS around four regions. Since our main contribution was to locate the best ten alternatives following the developed four criteria and eleven sub-criteria. We found that three locations were selected in the Delta region and Coastal region. Two depots location were selected in the northeast and central regions. Based on our initial investigation we know that the select twenty-three locations were higher percentage in Delta and coastal region. Also, the initial study shows the production capacity in these two regions are more by 15% compared to the northeast and central region. The model outcomes show Washington county was the top selected county with 95%. Kember county was ranked 2nd. Where Copaih and Wilkinson were third. Table 6 listed all the selected locations that have a higher success probability.

Table 6 Top ten depots located in Mississippi State

Site	County	Region	Location name	Depots Location		Probability of Depots
				Latitude	Latitude	"True"
1	Washington	Delta	Leo William Road	33.15	-91.01	95%
2	Kemper	Coastal	Townsend-Porterville Rd	32.74	-88.54	94.6%
3	Copiah	Central	Old Port Gibson Rd	31.88	-90.57	93.3%
4	Wilkinson	Central	Milbrook Road	31.13	-91.5	93.1%
5	Pearl River	Coastal	Backbone Road	31	-89.63	84.2%
6	Sunflower	Delta	Trotter Road	33.64	-90.58	83%
7	Yazoo	Delta	Mryleville Road	32.75	-90.3	82%
8	Jasper	Coastal	Bethesda Road	31.9	-89.29	80%
9	Lafayette	Northeast	Holly Springs National Forest	34.49	-89.34	79.5%
10	Choctaw	Northeast	Bethlehem Road	33.34	-89.14	79%

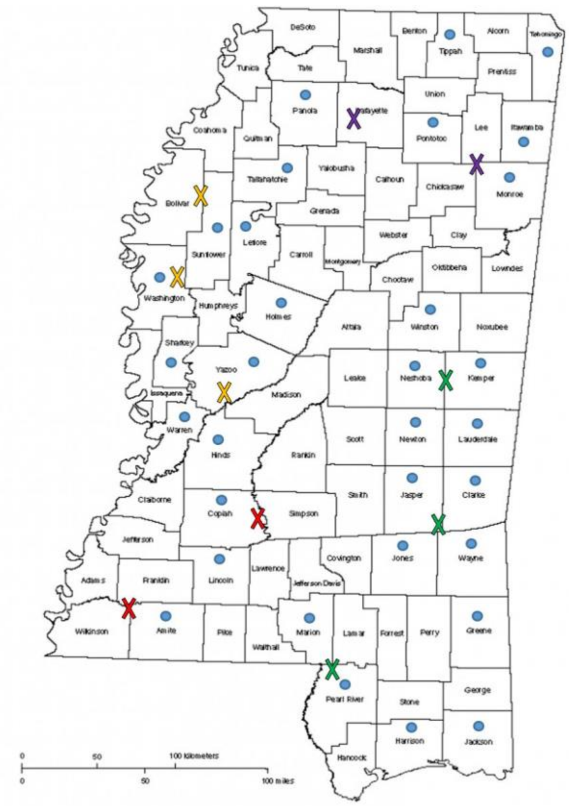

Figure 5 Shows the Top location selected by the BN model using agenarisk software

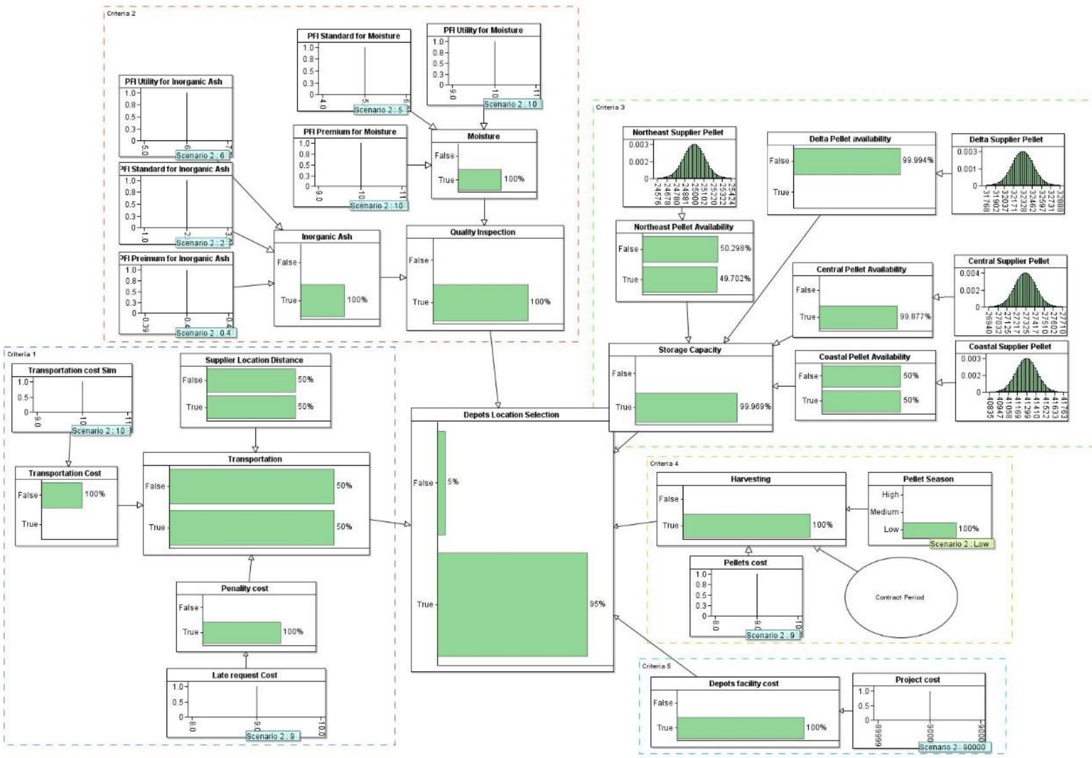

Figure 6 The developed BN model for the first Depots alternative in Delta region

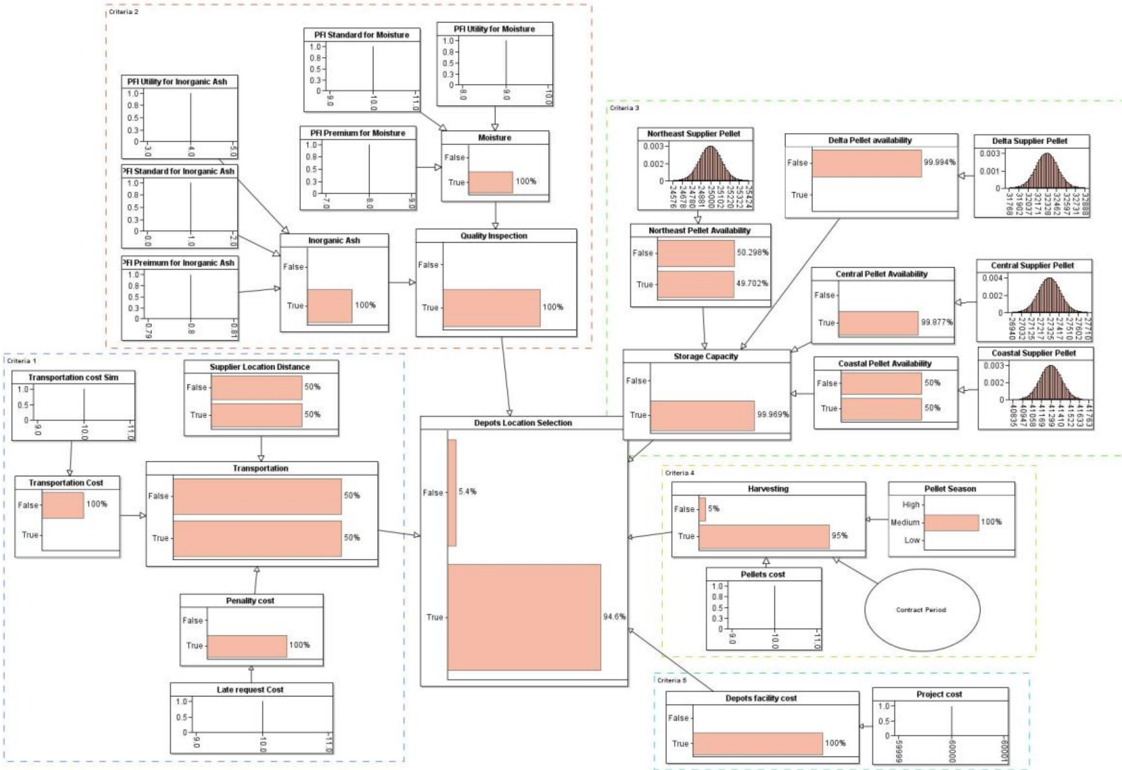

Figure 7 The developed BN model for the second Depots alternative in Coastal region

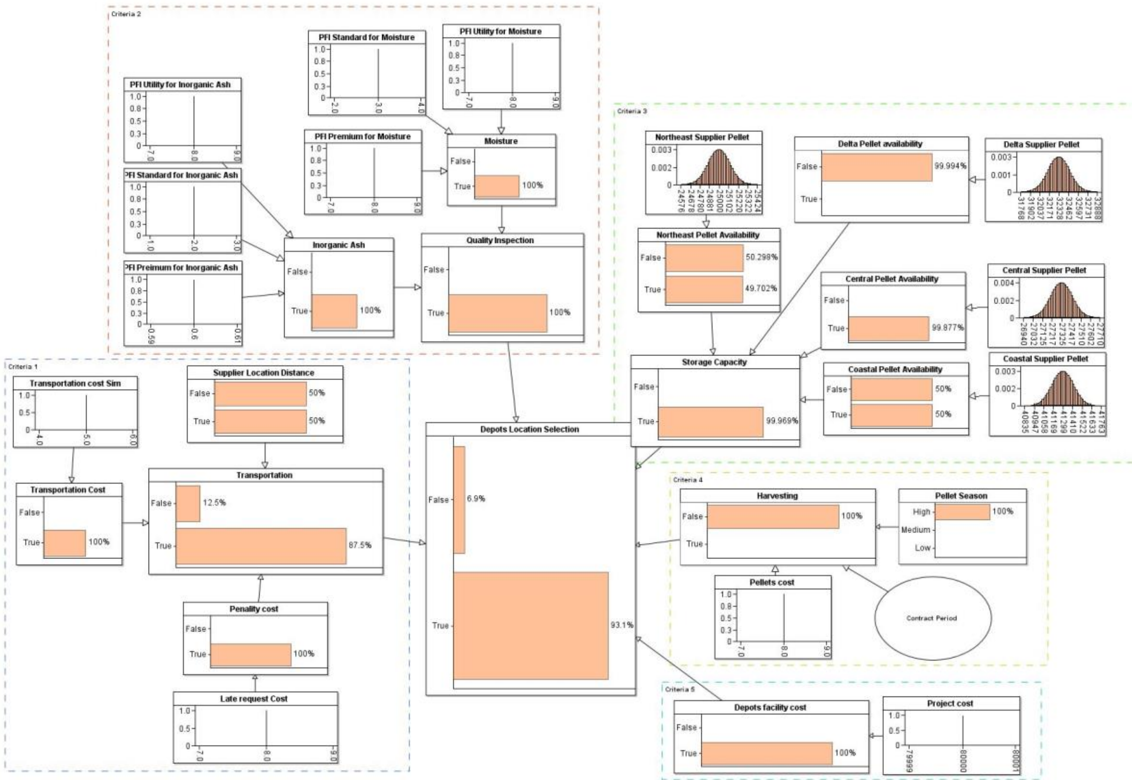

Figure 8 The developed BN model for the third depots alternatives in central region

Conclusion

Previous studies showed fifty locations could be qualified to be a depots location in the Mississippi State. Our study shows the best twenty three sites that combine good ash and good moisture. In this study, the top ten depots locations were selected depending on a developed four criteria and eleven sub-criteria. Harvesting supplier, Storage loations, transportation, and quality control Criteria were used to develop a robotics decision tool for stakeholder to select the best depots alternative in all region in Mississippi state. This tools can be dublicated in any state or country once the historical date are collected. Figure 4 summarize the developed model outcomes and it rank the region based on their pellet affordability and depots sustainability and resiliency as well. This tool will eventually help future investor to place the ultimate decision when it comes to depots location selection in the United state given the standard requirement of pellet industry in the US.

REFERENCES

Pearl, J. (2022). Causal Diagrams for Empirical Research (With Discussions). In Probabilisticand Causal Inference: The Works of Judea Pearl (pp. 255-316).

Quddus, M. A., Hossain, N. U. I., Mohammad, M., Jaradat, R. M., & Roni, M. S. (2017). Sustainable network design for multi-purpose pellet processing depots under biomass supply uncertainty. Computers & Industrial Engineering, 110, 462-483.

Sikkema, R., Steiner, M., Junginger, M., Hiegl, W., Hansen, M. T., & Faaij, A. (2011). The European wood pellet markets: current status and prospects for 2020. Biofuels, Bioproducts and Biorefining, 5(3), 250-278.

Fenton, N., & Neil, M. (2018). Risk assessment and decision analysis with Bayesian networks. Crc Press.

Hosseini, S., & Barker, K. (2016). A Bayesian network model for resilience-based supplier selection. International Journal of Production Economics, 180, 68-87.

Alizadeh, M., Ma, J., Marufuzzaman, M., & Yu, F. (2019). Sustainable olefin supply chain network design under seasonal feedstock supplies and uncertain carbon tax rate. *Journal of Cleaner Production*, *222*, 280-299.

Xie, F., Huang, Y., & Eksioglu, S. (2014). Integrating multimodal transport into cellulosic biofuel supply chain design under feedstock seasonality with a case study based on California. *Bioresource technology*, *152*, 15-23.

Poudel, S. R., Marufuzzaman, M., & Bian, L. (2016). Designing a reliable bio-fuel supply chain network considering link failure probabilities. *Computers & Industrial Engineering*, *91*, 85-99.

Tong, K., Gong, J., Yue, D., & You, F. (2014). Stochastic programming approach to optimal design and operations of integrated hydrocarbon biofuel and petroleum supply chains. *ACS Sustainable Chemistry & Engineering*, *2*(1), 49-61.

Gong, J., Garcia, D. J., & You, F. (2016). Unraveling optimal biomass processing routes from bioconversion product and process networks under uncertainty: an adaptive robust optimization approach. *ACS Sustainable Chemistry & Engineering*, *4*(6), 3160-3173.

Üster, H., & Memişoğlu, G. (2018). Biomass logistics network design under price-based supply and yield uncertainty. *Transportation Science*, *52*(2), 474-492.

Chen, C. W., & Fan, Y. (2012). Bioethanol supply chain system planning under supply and demand uncertainties. *Transportation Research Part E: Logistics and Transportation Review*, *48*(1), 150-164.

Gebreslassie, B. H., Yao, Y., & You, F. (2012). Design under uncertainty of hydrocarbon biorefinery supply chains: multiobjective stochastic programming models, decomposition algorithm, and a comparison between CVaR and downside risk. *AIChE Journal*, *58*(7), 2155-2179.

Marufuzzaman, M., Eksioglu, S. D., Li, X., & Wang, J. (2014). Analyzing the impact of intermodal-related risk to the design and management of biofuel supply chain. *Transportation Research Part E: Logistics and Transportation Review*, *69*, 122-145.

Marufuzzaman, M., Eksioglu, S. D., & Huang, Y. E. (2014). Two-stage stochastic programming supply chain model for biodiesel production via wastewater treatment. *Computers & Operations Research*, *49*, 1-17.

Mani, S., Sokhansanj, S., Bi, X., & Turhollow, A. (2006). Economics of producing fuel pellets from biomass. *Applied Engineering in agriculture*, *22*(3), 421-426.

Agar, D. A. (2017). A comparative economic analysis of torrefied pellet production based on state-of-the-art pellets. *Biomass and bioenergy*, *97*, 155-161.

Mobini, M., Meyer, J. C., Trippe, F., Sowlati, T., Fröhling, M., & Schultmann, F. (2014). Assessing the integration of torrefaction into wood pellet production. *Journal of Cleaner Production*, *78*, 216-225.

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Aghalari, A., Aladwan, B. S., Marufuzzaman, M., Tanger, S., Da Silva, B. K., & Gude, V. G. (2021). Optimizing a pellet supply system: Market-specific pellet production with biomass quality considerations. *Computers & Chemical Engineering*, *153*, 107417.