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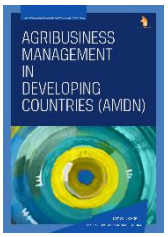

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RESEARCH ARTICLE

A MULTI-CRITERIA DECISION-MAKING APPROACH TO ROOT CROP SELECTION IN ST. ANN, JAMAICA

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ABSTRACT

This study investigates the critical factors influencing contemporary farmer decision-making processes within the Jamaican agricultural landscape with regards to roots and tubers. Recognizing the numerous challenges farmers face, this research proposes integrating Multi-Criteria Decision Making (MCDM) methodologies to move beyond heuristic-based decisions. Employing the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), the study evaluates four principal root crops cultivated in Jamaica: dasheen, cassava, yams, and sweet potato. Results of the ranking produced sweet potato emerging as the most favorable option, followed by yams, dasheen and cassava. The findings of this study have implications for agricultural development initiatives, such as Red Stripe's and underscore the necessity of MCDM techniques in facilitating informed decision-making for farmers, development agencies, and policymakers in the Caribbean agricultural sector.

KEYWORDS

Agricultural decision-making, Root crops, TOPSIS, St. Ann Jamaica;

1. INTRODUCTION

The agricultural sector in Jamaica, with particular emphasis on root crop production, is integral to national food security and economic stability. However, farmers are confronted with increasingly complex decision-making scenarios driven by dynamic market forces, climate change impacts, and resource limitations. Traditional decision-making, often reliant on intuition and experiential knowledge, may prove insufficient to navigate today's competitive business environment.

This study posits that the adoption of Multi-Criteria Decision Making (MCDM) methodologies, which provide a structured and analytical framework for evaluating alternatives based on multiple, often conflicting, criteria, is essential for optimizing agricultural production development strategies in Jamaica. Historically, root crops constituted a primary source of dietary carbohydrates in many Caribbean islands throughout the 20th century. However, a declining trend in both production and consumption of these staple crops was observed, attributed to factors such as limited culinary applications and changing consumer preferences by (Durrant, 1987).

Recent technological advancements have expanded the utilization of root crops beyond traditional food and feed applications, with increasing integration into industrial processes. A notable example is Red Stripe Jamaica's "Project Grow" initiative, launched in 2013 to promote local raw material sourcing and enhance the sustainability of its operations.

The objective of Project Grow was" To reduce reliance on imported raw materials and utilize 40% local cassava in beer production, supporting local farmers". This initiative aimed to revitalize the Jamaican cassava industry by:

- **Capacity and Knowledge Building:** Providing training and resources to cassava farmers.
- **Yield and Efficiency Gains:** Improving cultivation practices and promoting technological adoption.
- **Organized Cassava Supply Chain:** Facilitating market access and establishing efficient logistics.
- **Import Substitution:** Utilizing cassava starch in brewing processes to replace imported high maltose corn syrup.

Despite the potential economic and environmental benefits of cassava production, challenges persist within the value chain, hindering its widespread cultivation and commercial viability in Jamaica. As illustrated in Figure 1, cassava production exhibited an upward trend between 2005 and 2025, yet fell short of Red Stripe's projected targets. This underperformance, despite existing market demand and established cultivation practices, highlights a critical need to understand the factors influencing farmers' crop selection decisions in developing economies. This study aims to assess the relative ranking of cassava among four commonly cultivated root and tuber crops in Jamaica, namely cassava, dasheen, yams, and sweet potato, using a Multi-Criteria Decision-Making approach. This analysis will provide valuable insights into the complexities of agricultural decision-making and inform strategies for promoting sustainable agricultural development in Jamaica.

The complexity of agricultural decision-making has been widely acknowledged in the literature. Analysis highlighted the intricate interplay of physical, economic, and socio-personal factors in shaping farmers' decisions (Tarrant, 1974). Early studies often focused on physical and economic determinants, while neglecting the crucial role of farmers' values and individual preferences.

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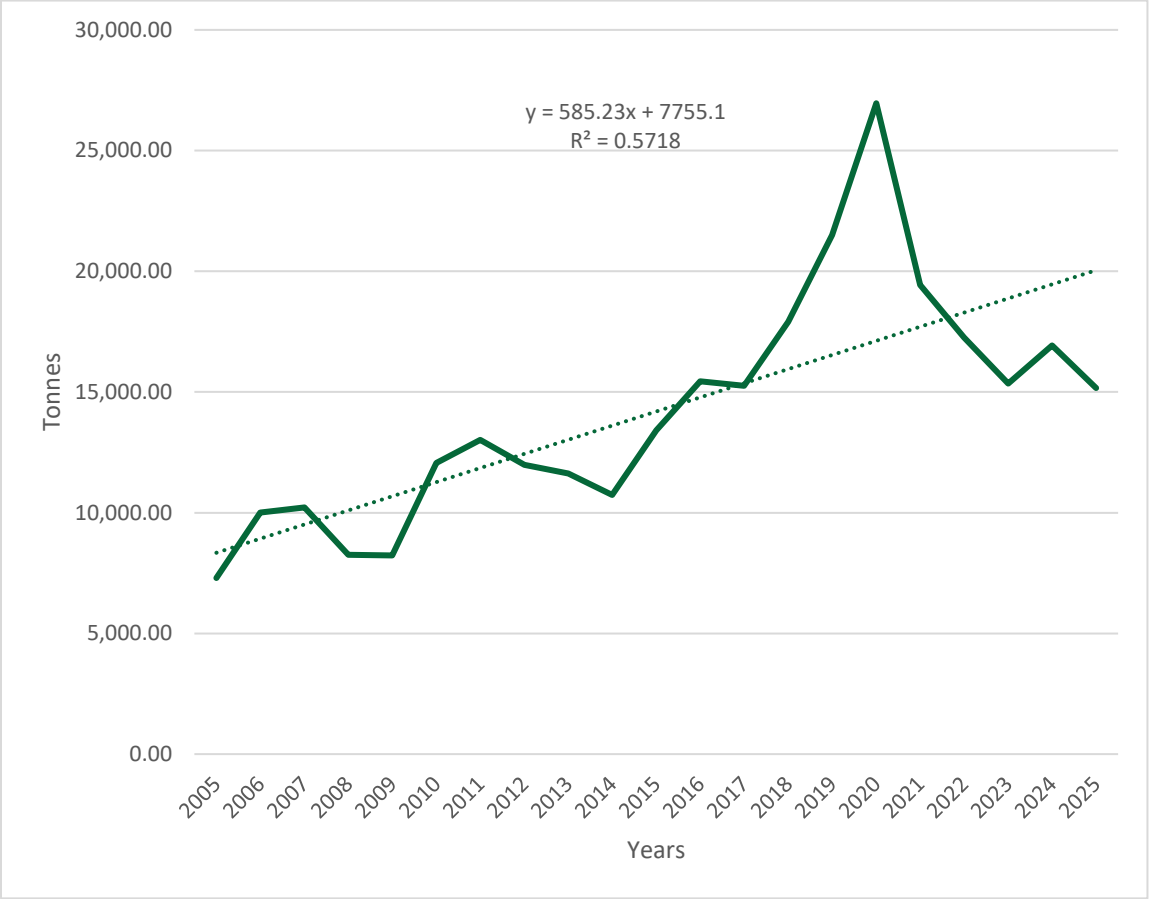

Figure 1: Cassava production in Jamaica 2005 to 2025

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As a study developed a comprehensive framework for analyzing agricultural decision-making, identifying 29 influencing factors categorized as socio-personal, economic, and physical (Ilbery, 1977). Through a survey of farmers in North-East Oxfordshire, Ilbery ranked these factors based on perceived importance, revealing the dominance of economic considerations, although socio-personal factors also played a significant role. This study emphasized the heterogeneity of farmers' decision-making processes and the need for individualized approaches.

The analysis conducted a point score analysis of agricultural decision-making in the Dominican Republic, surveying 80 farmers to assess the relative importance of 18 factors (Ryder, 1993). Family tradition, market demand, and area tradition emerged as the top-ranking factors, underscoring the influence of socio-cultural and economic considerations.

Researchers in their seminal study commonly referred to as, "The Edinburgh Study on Farm Decision-making", outlined a range of variables they considered critical when evaluating farmers' decision making including: antecedent variables, mediating variables and outcome variables (Willock et al., 1999). They also documented various attitudes, goals and behaviors of farmers which they considered affected farmer decision-making, as is illustrated in table 1.

By combining qualitative and quantitative methods, the study provides valuable insights into the decision-making processes on farms and though the research was focused on the UK it provides guidance for agricultural decision making generally. The conceptual framework of the Edinburgh model is illustrated in figure 2 and shows the interplay between not only by economic considerations but also by social values, personal experience, environmental concerns, and policy frameworks.

Table 1: (Willock et al., 1999) Attitudes, Goals and Behaviors impacting farm decision making

Attitudes	Goals	Behaviors
Risk aversion	Job satisfaction	Profit maximizing
Innovation	Status	Information gathering
Diversification	Quality of life	Diversification
Off-farm work	Management goals	Off-farm employment
Environment	Other specific objectives	
Production		
Management		
Legislation		
Stress		
Pessimism		
Satisfaction		

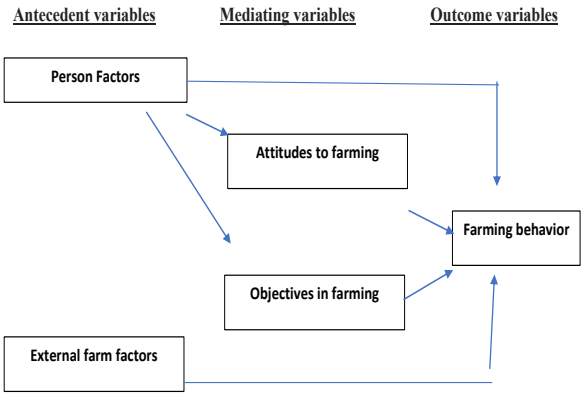

Figure 2: The Edinburgh Study on Decision Making on Farms Conceptual Framework

The analysis outlined a number of factors that impacted the decision making and innovation of small-scale yam farmers in central Jamaica (Beckford, 2002). Table 2 illustrates the results of this study and as is observed economic factors took the top 4 positions.

Table 2: Decision-making and innovation among small-scale yam farmers in central Jamaica

Factors (category in parentheses)	**Score (possible 220)**	**% of maximum**	**Rank**
Economic security (economic)	220	100	1
Low demand (economic)	200	91	2
Small tuber (economic)	200	91	2
High risk (economic)	180	82	4
Cultural ecology (socio-cultural)	175	80	5
Family tradition (socio-cultural)	175	80	5
High production cost (economic)	170	77	7
Lack of information (institutional)	165	75	8
Lack of understanding (personal)	150	68	9
Dissemination strategy (institutional)	97	44	10
Soil drainage constraints (environmental)	40	18	11
Aspect (environmental)	30	14	12
Terrain constraints (environmental)	27	12	13
Personal preference (personal)	23	10	14
Resistance to change (personal)	19	9	15

This research in "Domestic Food Production and Food Security in the Caribbean" Chapter 4 provides an exhaustive overview of decision making in the (Tropics Beckford et al., 2013). In the summary they state "Small-scale farmers' safety-first mantra is the product of their lived experiences and the lack of institutional support and relief". Study offered as similar sentiment for Kenya "An enduring puzzle about small-scale farming is that smallholders regularly devote larger shares of land and other resources to low yielding food crops than they do to cash crops that have higher market returns (Omamo, 1998). How farmers decide what crop to produce has puzzled economists and other researchers from time in memorial.Multi-Criteria Decision-Making method is defined as a scientific decision-making approach designed to help decision-makers choose between alternatives by evaluating multiple, often conflicting criteria simultaneously. Multiple Criteria Decision Making (MCDM) methods, as a formal academic and operational research discipline, were largely developed in the 1960s. By the 1980s Satty's Analytic Hierarchy Process (AHP) and Hwang and Yoon's Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), were established and today there are over 200 MCDM methods (Cinelli et al., 2022).

Multi-criteria decision-making (MCDM) techniques have gained prominence in addressing complex decision-making problems across diverse fields, including agriculture, natural resource management, and engineering (Behzadian et al., 2012). This study utilizes the TOPSIS method. Table 3 summarizes some of the advantages and disadvantages of the TOPSIS technique.

TOPSIS TECHNIQUE	
Advantages	**Disadvantages**
1. Simplicity and Clarity	1. Dependence on Normalization
2. Logical and Intuitive	2. Linear Assumption
3. Efficiency	3. Computational Complexity
4. Flexibility	4. Sensitivity to Weights
5. Objective Weighting	5. Assumption of Independence
6. Comparison Capability	6. No Explicit Trade-Off Analysis
7. The number of steps remain the same regardless of the number of attributes	

2. Materials and Methodology

The remaining four criteria were ease of marketing the crops, access to planting material, access to extension services and access to technical knowhow about the crops. Respondents were asked to rank the eight criteria using a five-point Likert Scale, with 1 being the lowest rank (of least importance) and 5 the highest. The individual scores were then averaged. Respondents were also asked to weight the importance of the eight criteria to total 100.

The individual weights were then average and divided by 100 so they sum to 1. The questionnaire was administered in the first half of 2025. The four principal root crops identified for the study were: dasheen (*Colocasia esculenta*), cassava (*Manihot esculenta*), sweet potato (*Ipomoea batatas*), and yams (*Dioscorea spp.*).

The selection of these crops was based on their prevalence in the Jamaican agricultural landscape and their significance to national food security. The decision matrix, presented in Table 4, includes the calculated weight for each criterion. The TOPSIS method was employed to rank the four selected root crops based on the identified criteria. The following steps were undertaken in the TOPSIS analysis as is illustrated in figure 3. Equation 1 illustrates the vector normalization method utilized.

Based on the factors identified in the literature review a questionnaire was designed and eight criteria were presented to small farmers in St Ann Jamaica in the form of a decision-making matrix for completion. Four of the criteria were obtained from secondary data which was obtained from the Ministry of Agriculture. These criteria were:

- Cost of Production (JA$): This encompasses all expenses incurred in the cultivation process, including land preparation, planting material, fertilizer, labor, and pest control.
- Time to Harvest (Months): This represents the duration of the crop growth cycle from planting to harvest, influencing the frequency of

income generation and the farmer's ability to respond to market fluctuations.

- Yield per Acre (kg): This denotes the quantity of marketable produce obtained per unit area, directly impacting farm profitability and resource utilization efficiency.
- Farmgate Price per Pound (JA$): This refers to the price received by farmers for their produce at the point of sale, reflecting market demand and the economic value of the crop.

Table 4: Decision Matrix for Root Crop Selection - Selected crops, criteria and weights

Root crop	Cost of production (JA$)	Time to harvest (months)	Yield/acre (kg)	Farmgate price/lb (JA$)	Ease of marketing	Access to technical knowhow	Access to extension services	Access to planting material
Dasheen	562425	9	7895	290	3	4	3	4
Yams	571725	9	6579	460	3	3	3	3
Sweet potato	380863	5	5972	341	4	3	3	3
Cassava	210575	9	8097	86	3	3	3	3
Weights	*0.17*	*0.1*	*0.14*	*0.2*	*0.1*	*0.1*	*0.09*	*0.1*

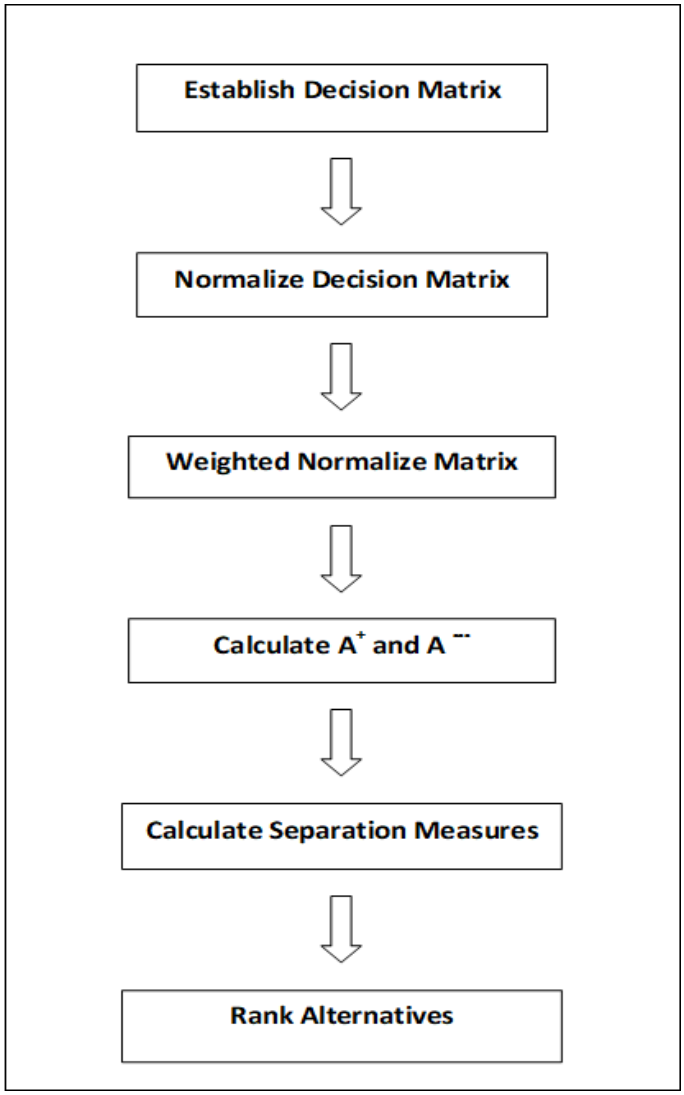

Figure 3: TOPSIS Method Steps

$$n_{ij} = \frac{rij}{\sqrt{\sum_{i=1}^{m} r_{ij}^2}} \quad \text{Equation 1}$$

3. Results

The TOPSIS analysis yielded a preferential ranking of the four root crops based on their performance scores, as summarized in Table 5 and visualized in Figure 4. Sweet potato emerged as the most preferred crop, achieving the highest performance score (0.8812), followed by yams (0.8468), dasheen (0.8200), and cassava (0.7767).

Table 5: Rank of crops based on TOPSIS analysis

Root crop	Performance score	Rank
Dasheen	0.8200	3
Cassava	0.7767	4
Sweet potato	0.8812	1
Yams	0.8468	2

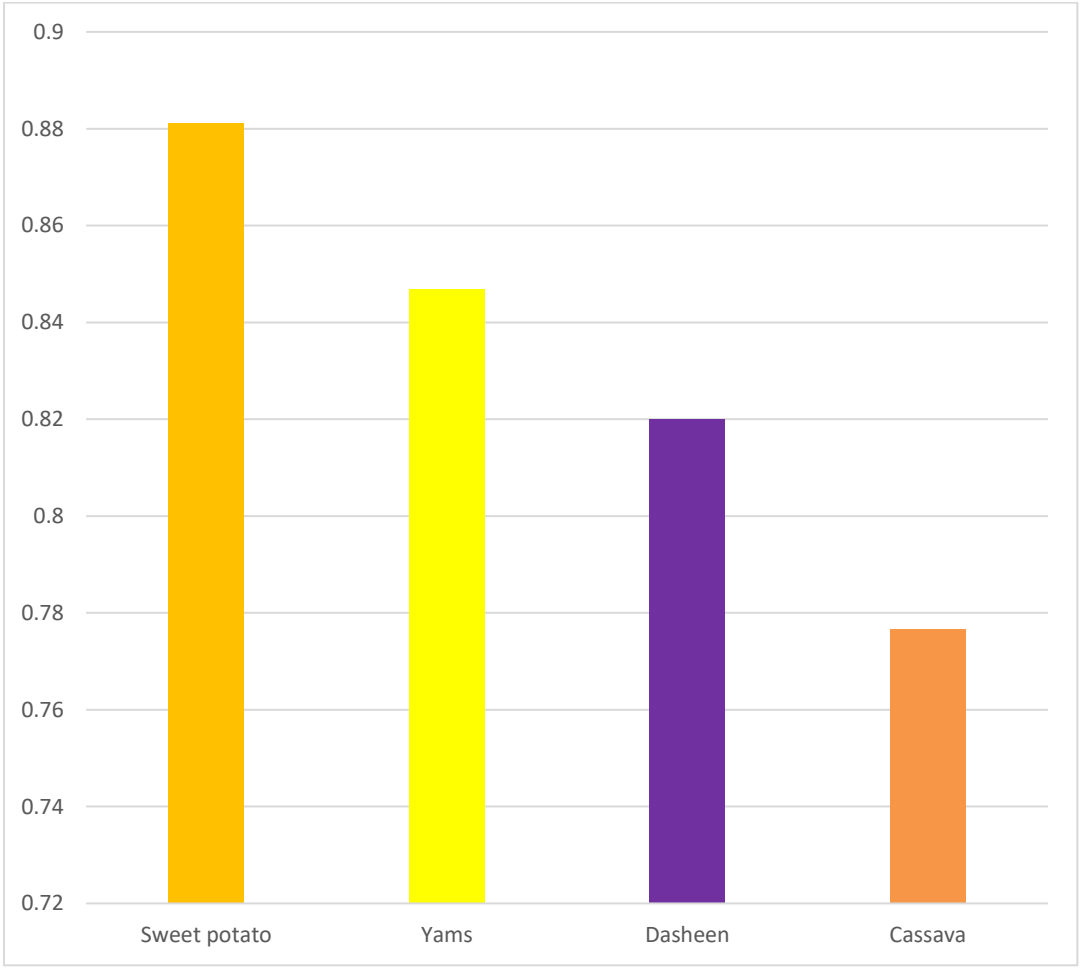

Figure 4: Graphical Representation of Root Crop Ranking

This ranking aligns with the observed challenges faced by Red Stripe in their Project Grow initiative, which aimed to increase cassava production for industrial use. The relatively low ranking of cassava in this analysis suggests that, from the farmers' perspective, the other root crops may offer more favorable economic returns or family security, potentially explaining the shortfall in cassava production despite existing market demand.

4. CONCLUSION

Successful crop selection can impact numerous areas, such as agricultural production output, farmers' financial security, food security, and environmental sustainability, to mention a few of the critical areas in the Jamaican economy. The results of this study have significant implications for agricultural development initiatives in Jamaica, particularly those aimed at promoting specific crops or increasing production for specific purposes, such as Red Stripe's Project Grow initiative.

Understanding the factors driving farmers' crop selection decisions is essential for designing effective policies and interventions that align with farmers' economic motivations and core beliefs. In this regard it is important to note that farmgate price was thought to be most important in the farmers' crop selection to produce and received the highest weight, 0.2 from the participants.

The MCDM approach can facilitate informed decision-making that accounts for the complex trade-offs inherent in agricultural production systems and promotes sustainable agricultural development. In closing, it should be pointed out that using another MCDM method, the Simple Additive Weighted Method (SAW), which is the oldest and most widely used MCDM method, cassava was again ranked 4th.

Given Red Stripe's difficulty in getting the desired volume of cassava starch for brewing, it would be informative to see what results a similar study will provide when undertaken in the other 13 parishes in Jamaica.

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