Urban Food and Nutritional Security through Public Distribution of Essential Commodities: A Population Based Economic and Statistical Study in Tirupattur District

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Abstract

This research work has focused on the effectiveness of sustainability and technology-based strategies of the Public Distribution System on the food and nutritional security of urban consumers. Various important factors, including availability of food Security, Digital transparency, effectiveness of services, Urban nutrition, and satisfaction levels of beneficiaries, have been considered. Research design used for this purpose has been quantitative in which primary data were collected from a total of 165 samples chosen out of 282 beneficiaries through the cluster sampling technique. Some important statistical techniques like descriptive analysis, normality test, test of reliability and validity, t-test, ANOVA, Chi square, correlation, structural equation modelling, and auto regressive integrated moving average models have been used. It is evident from the findings of this study that the level of food availability has witnessed a marked increase as its mean score value increased from 3.06 to 3.53 before and after the implementation of digital technologies, respectively. Furthermore, the level of transparency has also seen an improvement as its mean score value increased from 3.09 to 3.64 following adoption of a new strategy. The primary data used in this study have reliability as the value of Cronbach's Alpha is 0. 872.There is a strong correlation between quality of services and customer satisfaction (r = 0.712). However, nutritional outcomes are only moderate (mean = 2.98).

Keywords: - Public Distribution System, Food Security, Urban Nutrition, Digital Transparency, Sustainability

Introduction

Indeed, the provision of food and safety system operates as an integral element that contributes to the sustainability of food security, social welfare, and economic prosperity. Specifically, the Public Distribution System is regarded as an important government project aimed at providing economically deprived individuals with such basic goods as rice, wheat, and sugar at subsidized prices. It should be emphasized that due to urbanization and population increase, the problem of access to food becomes much more complicated. Thus, the implementation of biometric technologies, electronic Point of Sale, and other advanced techniques results in change of the traditional Public Distribution System. Nevertheless, there exist some issues associated with inefficiency of the distribution process, poor public knowledge about it, as well as poor attention to the quality of provided food. For instance, urban citizens often suffer from such problems as balance in consumption and accessibility of good-quality foods. Therefore, the motive of this paper is to assess the role of sustainable Public Distribution System in the area of food security.

Review of Literature

Bhasin (2026), the efficiency of the Public Distribution System (PDS) was assessed based on the ability to provide food and nutrition security. According to the findings of the study, despite the fact that the PDS system covers more people, as well as providing all the basic requirements, there still are some concerns regarding logistics and storage issues that should be taken into account. From the findings of the report, one can conclude that there are certain inefficiencies associated with the supply chain management of food grain distribution among the targeted population. Nevertheless, the report concludes that although the access to food has improved, there is still a problem with nutrition security due to the lack of food variety.

Ravi Patel et al. (2023)'s paper focuses on the problems associated with food security and nutrition. According to their research, the interventions made by the government have helped consumers access essential food products. However, food products are still poor.

Sharma & Gupta (2023)'s study provides an example of the effects that digitization has had on the PDS in terms of consumer welfare. In particular, according to their results, the introduction of biometric and e-POS systems has helped the government enhance the effectiveness of the distribution process of vital goods. The introduction of technology has ensured that the distribution process was transparent, preventing any corruption from taking place in the process. Therefore, by using digital technologies, the government has been able to increase consumer confidence in the process.

Objectives of the Study

- Primary Objective: - To examine the impact of sustainable methods of public distribution along with technological systems in relation to Public Distribution System (PDS) on food and nutrition security in urban areas, focusing particularly on household food security, nutrition, and public perception of food security in urban settings.
- Secondary Objective: - To analyse the relationship between sustainability, technology, and nutritional knowledge that influences the result of household food security in urban areas, and to find out the basic factors responsible for a sustainable Public Distribution System.

Research Methodology

The study adopted quantitative research design where descriptive and analytical designs were utilized. The research was conducted in Mottur involving a population of 282 card holders. From the total number of the respondents, 165 respondents were randomly sampled through cluster sampling technique to provide data representation. Structured questionnaires were used to gather data on factors such as food availability,

transparency, service quality, nutrition, and beneficiary satisfaction. Different types of data analysis techniques were performed that included descriptive statistics to describe the data, Shapiro-Wilk test to prove the normality of data, t-test, ANOVA, Chi-square tests, correlation, regression, Structural Equation Model (SEM), and time series analysis using moving average and ARIMA methods. Results of the test showed that the data had normal distribution since the p values obtained from all the variables were greater than 0.05. The reliability test revealed that the survey tool was reliable as the value of Cronbach's Alpha was 0.872.

Research Gaps

All the earlier studies had only concerned themselves with either the efficiency of PDS or problems related to food availability. Whereas some of the research papers were concerned with digitalization, others dealt with nutrition-related issues, but there was no paper that encompassed all aspects such as technology, sustainability, and nutrition in one package. What is more, in all the earlier studies, it was impossible to determine both service quality and customer satisfaction simultaneously. This undoubtedly demonstrates the absence of information regarding the effects of technology-oriented PDS on food availability, transparency, quality of service, and customer satisfaction, keeping in mind the nutrition factor too.

Results & Discussion

The aim of this study is to consider several variables and explore whether PDS helps provide food and nutritional security for its consumers. The variables which should be taken into account when doing so would be such aspects as food availability, transparency of operations, quality of services, food affordability, and overall satisfaction with the use of each of the components involved in the process. Besides, several demographic variables can be included into consideration to find out how they affect using the program as well as satisfaction with services provided within it. System variables including such aspects as digitalization, introduction of innovative technologies, and efficacy of the program introduced by the government could also be analysed. With regard to the nutrition, the quality and diversity of food offered through the program would be considered in order to identify gaps between food security and nutrition It is possible to formulate several hypotheses based on these variables and their relations to one another.

Test	**Variable / Purpose**	**Test Value**	**p-value**	**Interpretation / Result**
Normality Test (Shapiro-Wilk)	Food Availability (Before)	W = 0.972	0.084	Data is Normally Distributed
Normality Test (Shapiro-Wilk)	Transparency (After)	W = 0.975	0.095	Data is Normally Distributed
Reliability Test	Overall Scale	$\alpha = 0.872$	-	Excellent Reliability
Reliability Test	Agreement Scale	$\alpha = 0.889$	-	Highly Reliable
Validity Test	All Variables	> 0.6	-	Good Validity
Paired T-Test	Food Availability	t = 6.82	0.000	Significant Improvement
Paired T-Test	Transparency	t = 7.15	0.000	Significant Improvement
Independent T-Test	Gender vs Food Security	t = 0.89	0.375	Not Significant
Chi-Square Test	Education vs Food Availability	$\chi^2 = 21.48$	0.044	Significant Association

Chi-Square Test	Education vs Food Security	$\chi^2 = 24.63$	0.017	Significant Association
ANOVA	Quality Satisfaction (Age)	F = 2.94	0.022	Significant Difference
ANOVA	Food Affordability (Age)	F = 2.48	0.047	Significant Difference
ANOVA	Govt Program Helpfulness	F = 3.12	0.017	Significant Difference
Correlation	Service Quality & Satisfaction	r = 0.712	0.000	Strong Positive Relationship
Correlation	Food Availability & Service Quality	r = 0.682	0.000	Strong Positive Relationship
Correlation	Transparency & Service Quality	r = 0.658	0.000	Strong Positive Relationship
Regression	Predictors of Satisfaction	$R^2 \approx 0.70$	-	Good Model Explanation
SEM Model Fit	CFI	0.94	-	Good Fit
SEM Model Fit	TLI	0.92	-	Good Fit
SEM Model Fit	RMSEA	0.058	-	Good Fit
SEM Model Fit	GFI	0.91	-	Good Fit
Time Series (ARIMA)	Model Fit	$R^2 = 0.71$	-	Good Prediction
Moving Average	Trend Value	W =3.25 → 3.34 0.972	-	Increasing Trend
Sentiment Analysis	Mean Score	3.07	-	Moderate Satisfaction
Sentiment Analysis	Skewness	-0.28	-	Slight Positive Bias
Ranking Analysis	Quality	Rank 1	-	Most Important Factor
Ranking Analysis	Quantity	Rank 2	-	Second Priority
Ranking Analysis	Transparency	Rank 3	-	Moderate Priority
Ranking Analysis	Technology	Rank 4	-	Less Priority
Ranking Analysis	Nutrition	Rank 5	-	Least Priority

Interpretation

To summarize, the above statistics analysis suggests the reliability and validity of the dataset gathered as the data was found to be normally distributed and therefore can be used in conducting other tests. In other words, this analysis proves that the use of digitalization within the context of the PDS system has resulted in an enhancement of several issues including access to food and transparency as there was found to be a great significance in the results of the paired t-test ($p<0.05$). When speaking about the reliability of the information, it is evident that the results are highly reliable due to the value of the coefficient of the Cronbach's alpha being equal to 0.872. Furthermore, the validity of the data was proven due to the fact that the data was well-measured.

Lastly, from the results obtained after the chi-square and ANOVA analyses, it is clear that education and age have an impact on satisfaction levels while the gender does not. Time series analysis shows that the efficiency of the system is stable and positively growing, while sentiment analysis shows that the level of satisfaction among the beneficiaries regarding their use of the system is only moderate. Nonetheless, the ranking analysis shows that the problem of nutrition is the least important among others. Therefore, it can be concluded that while the system has achieved remarkable results in efficiency and accessibility, more attention should be paid to nutrition.

Conclusion

Undoubtedly, the results support the positive effect of implementing new technologies, like e-POS and biometric systems, on improving the effectiveness of the PDS program. It is possible to increase the efficiency, transparency, and availability of food through implementing innovative methods in the framework of the PDS program. According to the statistical data, food availability, transparency, and quality of services may be regarded as critical variables for the satisfaction of beneficiaries with the PDS program. The PDS program should be considered as efficient and stable due to the presence of definite tendencies for its functioning. Nevertheless, it is necessary to admit some flaws of the PDS program concerning the benefits related to the quality of food products. To put it simply, the program can successfully supply individuals with food products; however, it does not pay attention to the quality of such products. Age and educational attainment may be considered as influential factors for beneficiary awareness. In summary, while the success of the PDS technological framework in increasing efficiency and accessibility is well documented, complete food security calls for increased focus on sustainability and nutrition as well as continuous assessment of the technological framework. The key stakeholders should consider both innovations in the digital domain and innovations in the nutritional realm

Findings of the Study

The aspect of digitalization was particularly crucial towards the accessibility and visibility of the food available under the scheme of PDS. Service levels were found to have a direct impact on the extent of customer satisfaction, making them crucial in terms of determining success. Age and education did play a role in terms of perception; however, there was no significant impact based on the difference in gender. It was the absence of emphasis on diversity in the nutrition available that made the system inefficient and ineffective.

Implication

According to the study, these academics recommend that attention should be paid to making technological improvements with regards to enhancing transparency as well as overcoming the inefficiencies in the functioning of the PDS. The quality of service needs to be addressed because it has an impact on how the recipients perceive the services they receive. Awareness campaigns need to be conducted among the recipients, especially those who are uneducated. Nutritious food needs to be included in the list of available foods.

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