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PROBLEMS AND PROSPECTIVES OF PLANT LAYOUT AND DESIGN IN SMALL-SCALE FRUITS AND VEGETABLE INDUSTRIES IN MAHARASHTRA STATE OF INDIA

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Abstract
This study investigates the challenges and opportunities in the layout and design of small-scale fruit and vegetable industries in Maharashtra, India. Using a structured questionnaire and observational methods, data was collected from five industries across the state. The research focuses on issues related to workflow efficiency, space allocation, resource utilization, storage, flexibility, safety, material handling, communication, compliance, and utility access. The findings indicate significant inefficiencies and safety concerns, with recommendations for redesigning plant layouts to improve operational performance and compliance with industry standards.

Keywords: **-** Plant layout, Design efficiency, Small-scale industries, Fruit and vegetable industry, Inventory management, Production bottlenecks, Safety hazards

INTRODUCTION

The problem of fruits and vegetable industries plant layout should be seen in relation to overall plant design which includes many other functions such as product design, sales planning, selection of the production process, plant size, plant location, building, diversification etc. layout and design of fruits and vegetable industry in most complicated compare with the other food industries due to the highly perishable nature of frits and vegetable. **Hou *et al*., (2023)** The layout problem occurs because of many developments including:

- change in product design
- introduction of new product
- obsolescence of facilities
- changes in demand
- market changes
- competitive cost reduction
- frequent accidents
- adoption of new safety standards
- decision to build a new plant

Plant layout problem is defined as follows: “plant layout is a plan of, or the act of planning, an optimum arrangement of facilities, including personnel, operating equipment storage space, materials handling equipment, and all other supporting services, along with the design of the best structure to contain these facilities”.

The plant layout problems can be classified into four types as follows:

- Planning completely new facility
- Expanding or relocating an existing facility
- Rearrangement of existing layout
- Minor modifications in present layout

The problems in layout and design of small-scale industry for the fruits and vegetable industry was studied on the basis of their space utilization and the other process and data was collected and analysed. The information and data were collected my visiting the fruits and vegetable industry, websites, articles, journals also be referred. **Vetrekar (2022)**

The layout and design of other large-scale industries were collected and analysed and the solution to the small-scale industries will be formulated. **Ali *et al*., 2016**

The layout and design of a small-scale fruits and vegetable processing plant pose several challenges. These challenges are primarily related to the infrastructure required to accommodate the necessary equipment and ensure proper hygiene and sanitation. Here are some key issues that need to be considered **Awulachew (2024)**

Infrastructure Requirements:

The infrastructure was meet the necessary requirements for a food processing plant, including physical layout, basic services or installations, and equipment. This includes ensuring that the building is designed to facilitate easy cleaning and maintenance, with features such as smooth floors, walls, and ceilings that can be easily washed and disinfected

Space and Flow Patterns:

The layout of the plant should be designed to minimize the risk of contamination by ensuring that food moves between different stages in a process without the paths crossing. This reduces the risk of contaminating finished products by incoming, often dirty, raw materials

Equipment Arrangement:

The arrangement of equipment within the plant should be designed to minimize costs and optimize production efficiency. This includes considering factors such as the proximity of equipment to raw material storage areas and the ease of movement between different stages of processing

Hygiene and Sanitation:

The design of the plant should prioritize hygiene and sanitation. This includes features such as adequate ventilation, lighting, and waste disposal systems, as well as easy access to cleaning and maintenance areas

Scalability and Expandability:

The design of the plant should be flexible enough to accommodate potential future growth and changes in the processing operations. This includes using materials that are easy to readapt and install, as well as designing the plant to be expandable

Cost and Budget:

The cost of constructing or renting the plant must be considered, especially for small-scale industries where budget constraints are often a significant challenge. The choice of building materials and design should balance the need for functionality with the need to stay within budget

Climate and Environmental Factors:

The design of the plant should also consider local climate and environmental factors, such as temperature and humidity control, to ensure optimal processing conditions

Packaging and Storage:

The plant should have adequate storage facilities for raw materials and finished products, as well as packaging facilities that meet the necessary standards for food safety and quality

Energy and Water Supply:

The plant should have a reliable energy and water supply to ensure consistent processing operations. This includes considering factors such as fuel availability and water conservation

Regulatory Compliance:

The design of the plant should ensure compliance with relevant regulations and standards for food processing, including those related to hygiene, sanitation, and product safety

By considering these factors, small-scale fruits and vegetable processing plants can be designed and laid out to ensure efficient, safe, and cost-effective operations that meet the needs of the industry and the consumers they serve **Bramsiepe *et al.*, (2012).**

MATERIALS AND METHODS

A cross-sectional study was conducted to evaluate the knowledge of fruit and vegetable industries, plant layout and design, in the Maharashtra state of India. An observational study of fruit and vegetable handlers with a structured, pre-designed questionnaire was undertaken. The study was carried out in the Maharashtra state of India after informed consent from participants. Information on socio-demographic data and knowledge and practices about fruits and vegetables was obtained. A standard questionnaire was prepared to conduct the survey and for data collection. Graphical analysis, statistical tools, and Microsoft Excel were used to satisfy the given objectives of the study.

Methodology

The design chosen for the study was observational and based on the responses of fruit and vegetable industry employees. The study was conducted in the Maharashtra state of India.

Selection of Area

Maharashtra is a state in the western region of India occupying a substantial portion of the Deccan Plateau. It is bordered by the Arabian Sea to the west, the Indian states of Karnataka and Goa to the south, Telangana to the southeast and Chhattisgarh to the east, Gujarat and Madhya Pradesh to the north, and the Indian union territory of Dadra and Nagar Haveli and Daman and Diu to the northwest. Maharashtra is the second-most populous state in India and the fourth-most populous country subdivision globally.

Maharashtra contributes 6% of production of vegetables in the country. The area under vegetable crops is about 4.04 lakh ha. The total production is 50.96 lakh M.T. per year and the productivity is 12.00 M.T. per ha. Maharashtra is the largest producer of onion in the country covering an area about 1,18,262 ha., Moreover, the second-largest producer of fruits in the country, Maharashtra houses large-scale production units for fruits like mango, banana, and orange in districts including Jalgaon, Jalna, Kolhapur, Latur, Nagpur, Satara, and Ratnagiri.

Table no.1 Socio Demographic Scenario of Maharashtra State of India

Area	**307,713 km^2 (118,809 sq. mi)**
Population	**13.16 Crores**
Divisions	**6**
Districts	**36**
Language	**Marathi, Hindi and English**

Data Collection

Data collection was done by visiting industries and face-to-face interviews of the fruits and vegetables industries and the employees are co-operates for the collection of research data by asking problem and prospectives.

Selection of fruit and vegetable industry employees for interview (questionnaire)

The survey was done in five fruit and vegetable industries operating in the Maharashtra state of India, and employees were selected for the interview (questionnaire) to elicit information on the layout and design, inventory management, production efficiency as affected by processes, and waste management. The survey was done by questionnaire concerning the current status of the layout and design, therefore, not all the information was obtained from the questionnaire; some aspects pertaining to fruit and vegetable industry employees required observation and the questionnaire was done.

Selection of area for study

The Maharashtra State, India, was selected for the further study for the collection of the data. After the selection of the area, the fruits and vegetable industries were selected, and employees were surveyed. The main parameters that were observed of fruit and vegetable industry layout and design, inventory management, production efficiency as affected by processes, and waste management.

Observational study

The overall results were not observed by questionaries, then the observations of the further study were done by observing daily routine of the employees, thus, observing the complete and detailed idea of the workings of fruit and vegetable industry employees. The study was carried out to keep track of the layout and design, inventory management, production efficiency as affected by processes, and waste management.

Questionnaire and data collection

A questionnaire was prepared for the employees of the fruit and vegetable industry to get their general information. After all the data was collected, it was tabulated accordingly. The collected data was used for the study.

Mathematical tools used

The present study questionnaire was used to obtain data. The respondent had to fill out the questionnaire, which could interpret the question with the employees. The percentage analysis tool was used for analysis. A pie chart or percentage analysis was used to specify the number of respondents agreeing or disagreeing with specific statement or question. It is also used as a standard for comparison purposes.

Pie-chart representation

The pie chart was used for the present investigation. The graph was representing the proportion of the whole through sectors in the divided circle. It is a powerful visual tool to represent and compare percentages and proportions.

RESULTS AND DISCUSSION

The present investigation on "problems and prospectives of small-scale fruits and vegetable industries in Maharashtra State of India" was conducted in Maharashtra State of India. Five industries were surveyed in different cities in the Maharashtra State region. The information was collected through face-to-face interviews and questionnaires comprising different sections, demographic characteristics, the layout and design. Graphical analysis was used to analyse the obtained data. The results obtained with relevant discussion are presented under suitable headings.

Knowledge of employees in the fruit and vegetable industry

The knowledge level of employees working in five different fruit and vegetable industry was collected. The knowledge level and understanding level of the managers and employees are involved in the processing of fruit and vegetables were assessed. It is important to understand the knowledge of employees in the fruit and vegetable industry because it helps reduce contamination, process, period, frequency and market demand.

General information about the fruit and vegetable industry employees

The general information collected about the employees includes age, gender, and educational level. The general information collected.

Gender is the most significant variable that is influenced by social or economic phenomena. Most of the employees working in the fruit and vegetable industry were male. The male staff is mostly involved in the preparation and maintenance in the fruit and vegetable industry because it is difficult for the females to do the do the preparation and maintenance. Similar findings were found in males, as seen in the findings of **Devi *et al.*, (2016).** The age indicates the maturity level of the industry employees. Employees age is one of the most important features, and the age suggests the maturity level of the employees working in the industry. The most common age group was between 20 and 24 years, that is, (30%), (30%) were between the ages of 24 and 28 years, and (40%) were between the ages of 28 and 32 years. A similar study has been done by **Ellis *et al.*, (2010).**

The educational level is also an important characteristic; it affects the behaviour of the person and helps in the earning of the person. (70%) of the employees had obtained education till graduation, (0%) had obtained education till high school, and (30%) had obtained education till post-graduation. Those employees who are educated are more aware of their income. (70%) of the employees graduated. The findings were the same as those seen in **Garayoa *et al.*, (2011)**, who reported that the level of education affects the growth and the handling of fruits and vegetables industries.

Problems of fruits and vegetable plant layout and design of small-scale industry

The table under examination provides a detailed analysis of the problems associated with the layout and design of a small-scale fruit and vegetable plant. The responses are categorized into five levels, ranging from "Never" to "Always/Strongly agree," reflecting the extent to which the respondents agree with the statements about the layout issues.

The first statement indicates that the current layout poses challenges for efficient workflow, with the majority of respondents (50%) sometimes agreeing, and a smaller segment (30%) neither agreeing nor disagreeing. This suggests that while there is recognition of workflow inefficiencies, opinions on their severity vary. Inadequate space allocation, leading to congestion and bottlenecks, is another significant issue, as indicated by 40% of respondents sometimes agreeing and 30% always agreeing. This reflects a widespread recognition of space-related inefficiencies.

The optimization of available resources is a critical concern, with a notable 50% of respondents being neutral and another 20% rarely agreeing. This indicates that many respondents feel the layout does not effectively utilize space and machinery. Poorly designed storage areas are also a problem, leading to inefficiencies in inventory management, as indicated by 40% of respondents sometimes agreeing. This points to a clear need for better storage solutions.

Flexibility in the layout is another area of concern. The lack of adaptability to changing production demands is seen by 40% of respondents who sometimes agree, indicating that the layout may be rigid and unable to accommodate varying production needs. Safety hazards for workers due to the layout are acknowledged by 30% of respondents sometimes agreeing, suggesting that safety is compromised due to design flaws.

Material handling inefficiencies, which result in increased operational costs, are a significant issue, with 50% of respondents always agreeing. This highlights a critical area for improvement to reduce costs and improve efficiency. Communication and collaboration among workers are hindered by the plant's design, with 40% sometimes agreeing and 30% always agreeing, indicating that the layout may obstruct effective teamwork.

Compliance with industry standards and regulations is another critical issue, with 40% of respondents being neutral and 30% always agreeing that the current layout does not meet these standards. This points to potential regulatory risks and the need for redesign to ensure compliance. Lastly, limited access to utilities impacts production efficiency, with 40% of respondents always agreeing, highlighting a significant operational bottleneck.

(Never-1, Rarely-2, Neither agree or disagree-3, Sometimes/agree-4, Always/ Strongly agree -5)

Table no.2 Questionary

Sr.no	Statement	Responses (%)				
		1	2	3	4	5
1.	The current layout of our fruit and vegetable plant poses challenges for efficient workflow	0	10	30	50	10
2.	Inadequate space allocation leads to congestion and bottlenecks in production	0	10	20	40	30
3.	The layout does not optimize utilization of available resources (e.g., space, machinery)	0	20	50	10	20
4.	Poorly designed storage areas lead to inefficiencies in inventory management	10	0	40	40	10
5.	Lack of flexibility in the layout hampers adaptability to changing production demands	10	20	10	40	20
6.	The layout contributes to safety hazards for workers	0	30	30	30	10
7.	Inefficient material handling processes result in increased operational costs	0	10	10	30	50
8.	The design of our plant hinders effective communication and collaboration among workers	0	10	20	40	30
9.	Our current layout does not comply with industry standards and regulations	0	20	40	10	30
10.	Limited access to utilities (e.g., water, electricity) impacts production efficiency	20	0	10	30	40

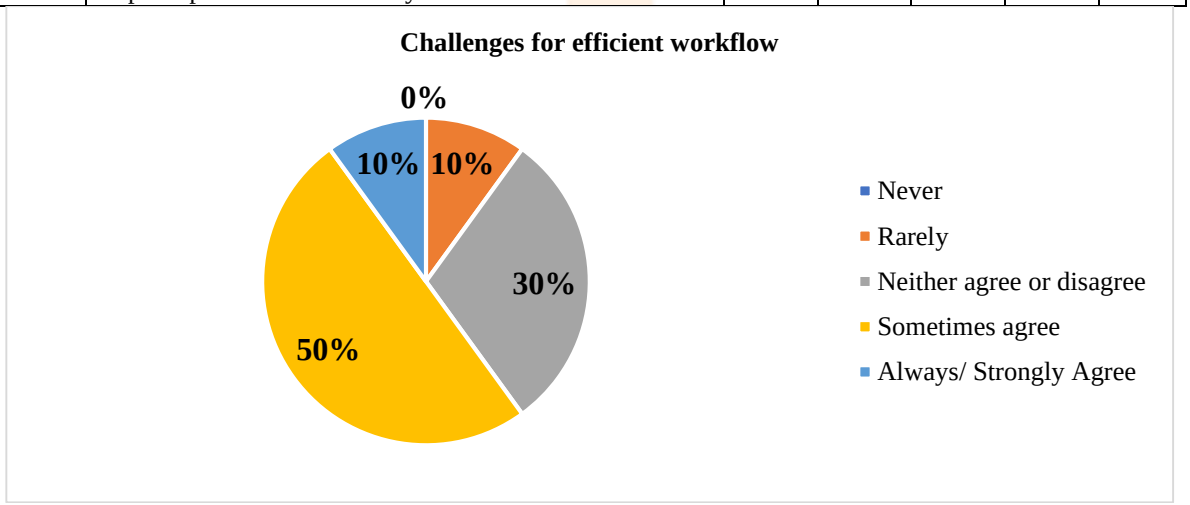

Fig.1 The current layout of our fruit and vegetable plant poses challenges for efficient workflow

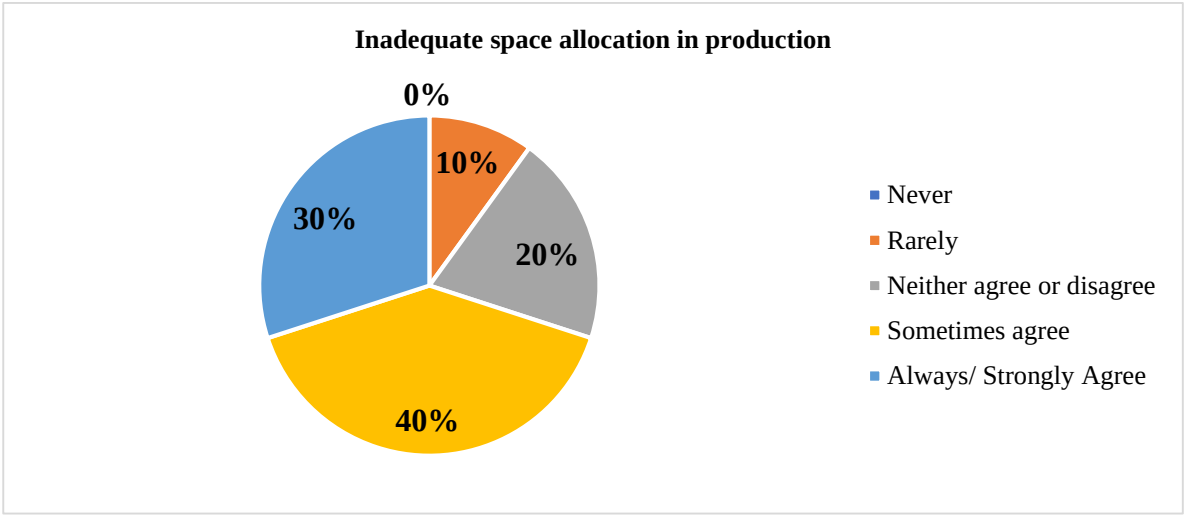

Fig.2 Inadequate space allocation leads to congestion and bottlenecks in production

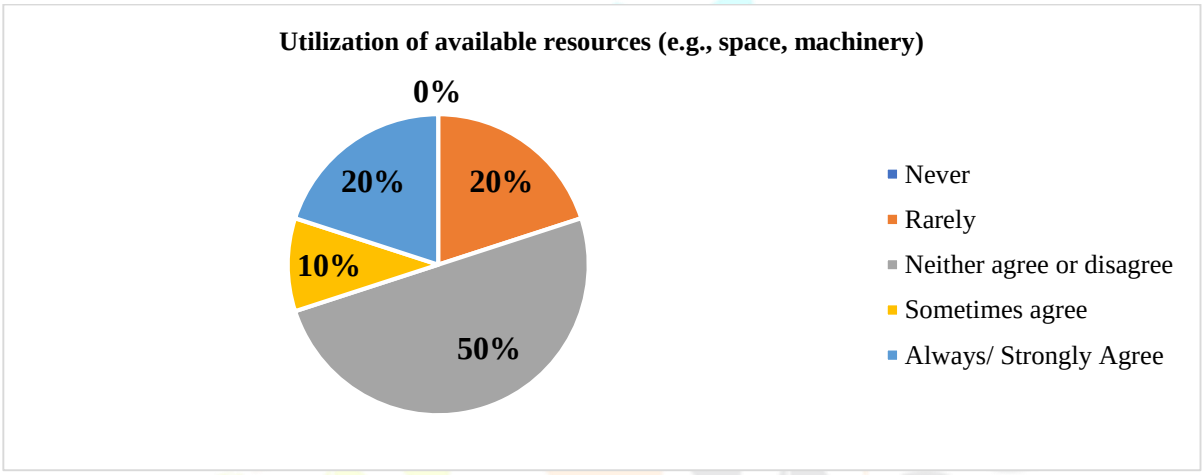

Fig.3 The layout does not optimize utilization of available resources (e.g., space, machinery)

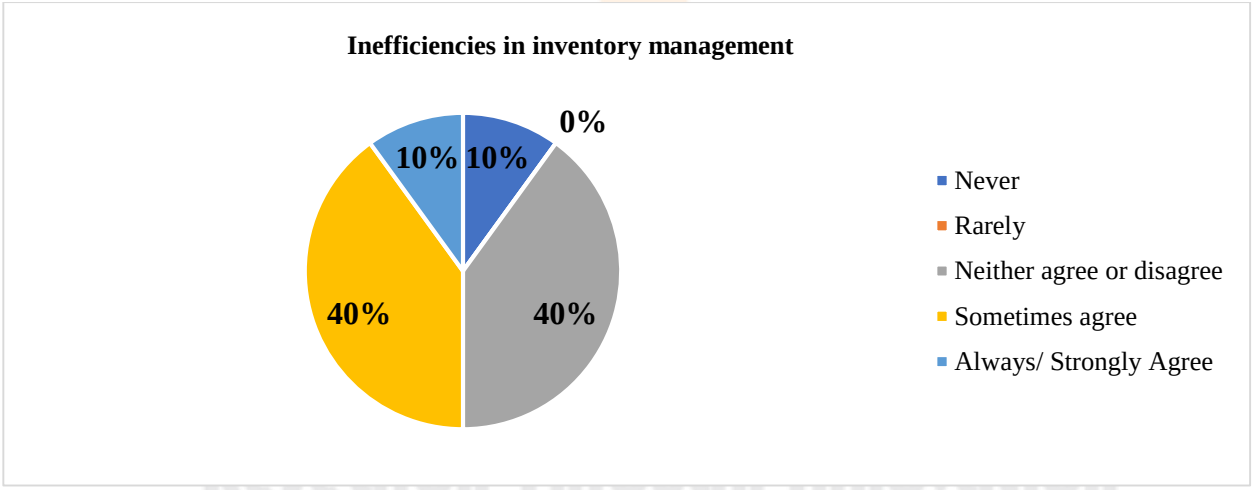

Fig.4 Poorly designed storage areas lead to inefficiencies in inventory management

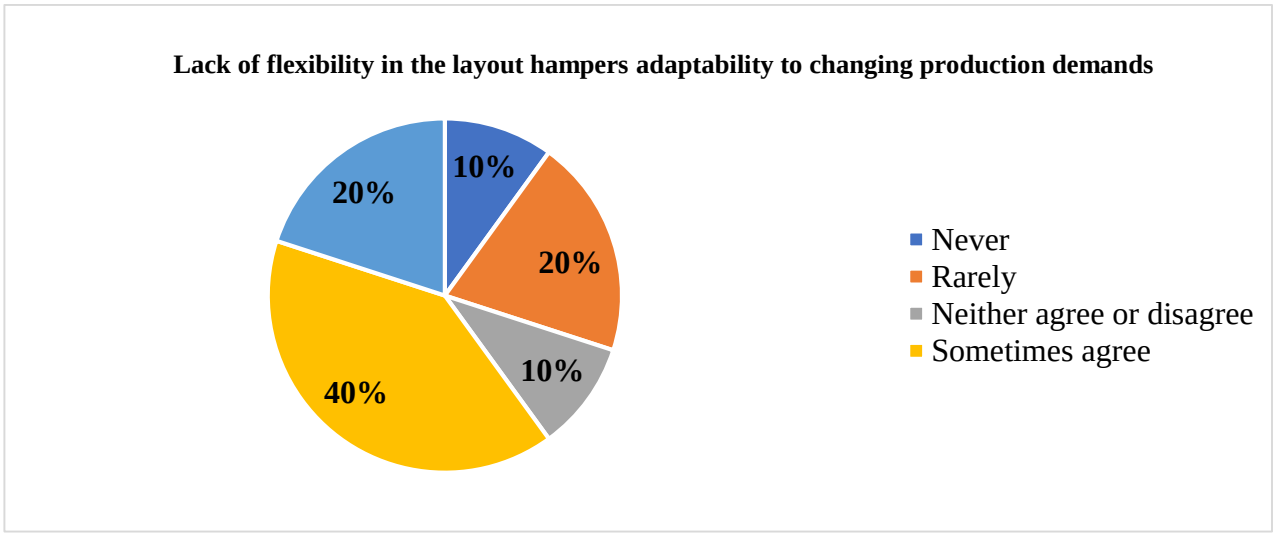

Fig.5 Lack of flexibility in the layout hampers adaptability to changing production demands

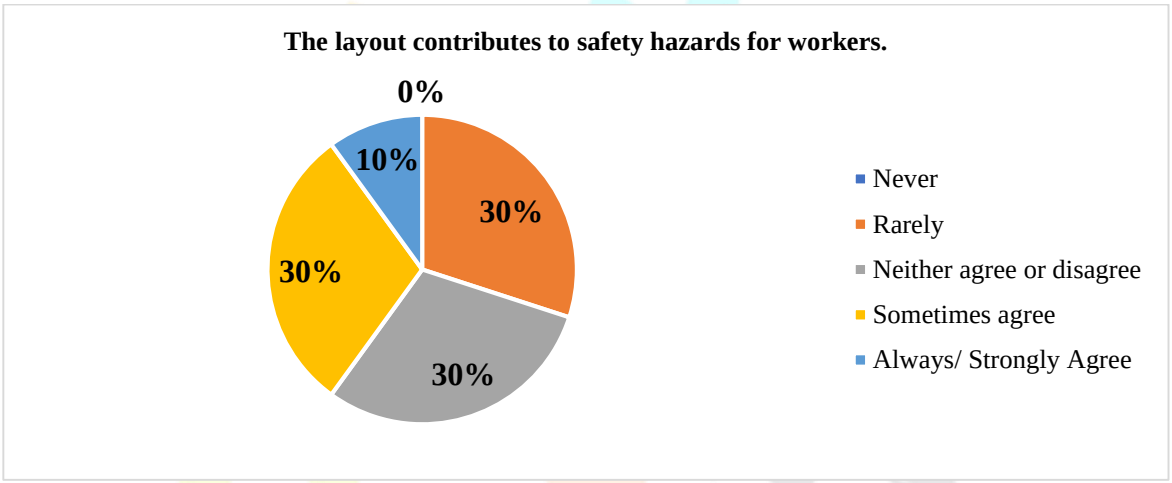

Fig.6 The layout contributes to safety hazards for workers

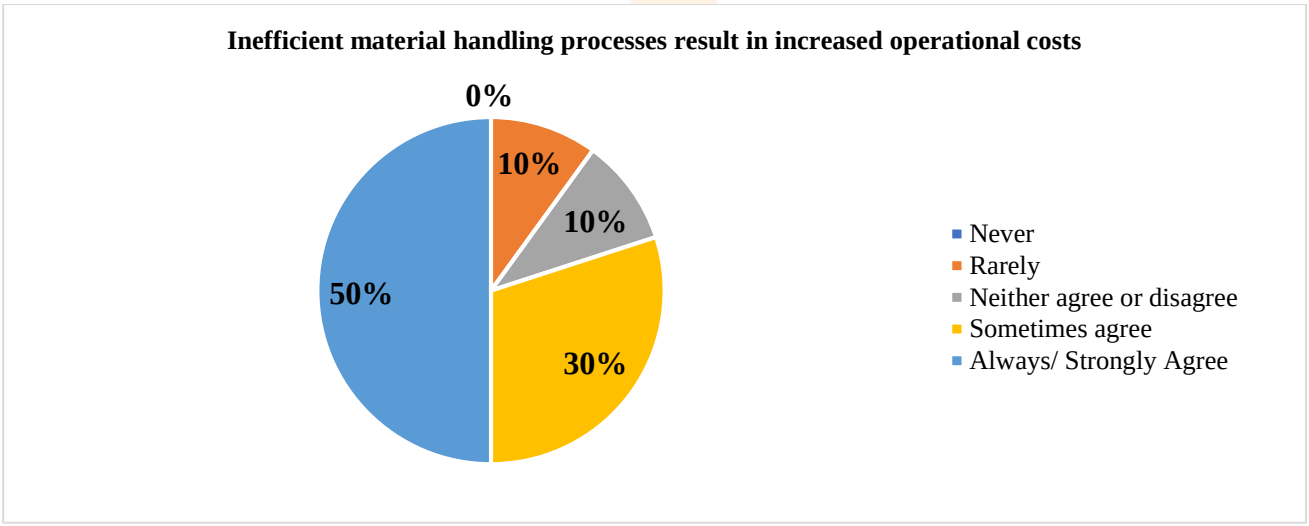

Fig.7 Inefficient material handling processes result in increased operational costs

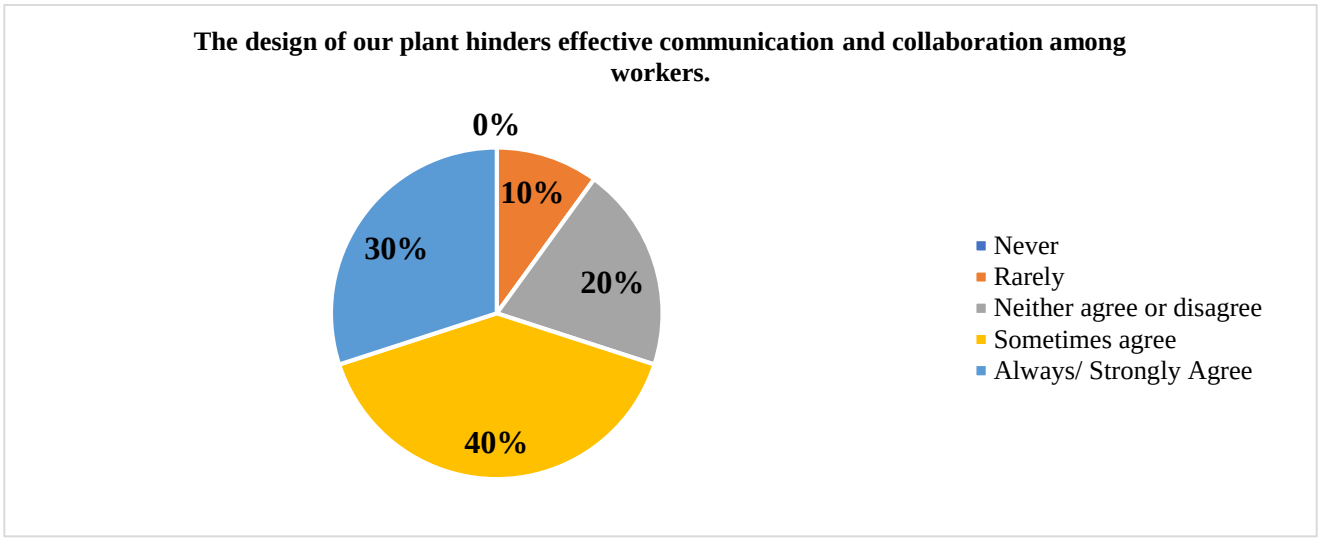

Fig.8 The design of our plant hinders effective communication and collaboration among workers

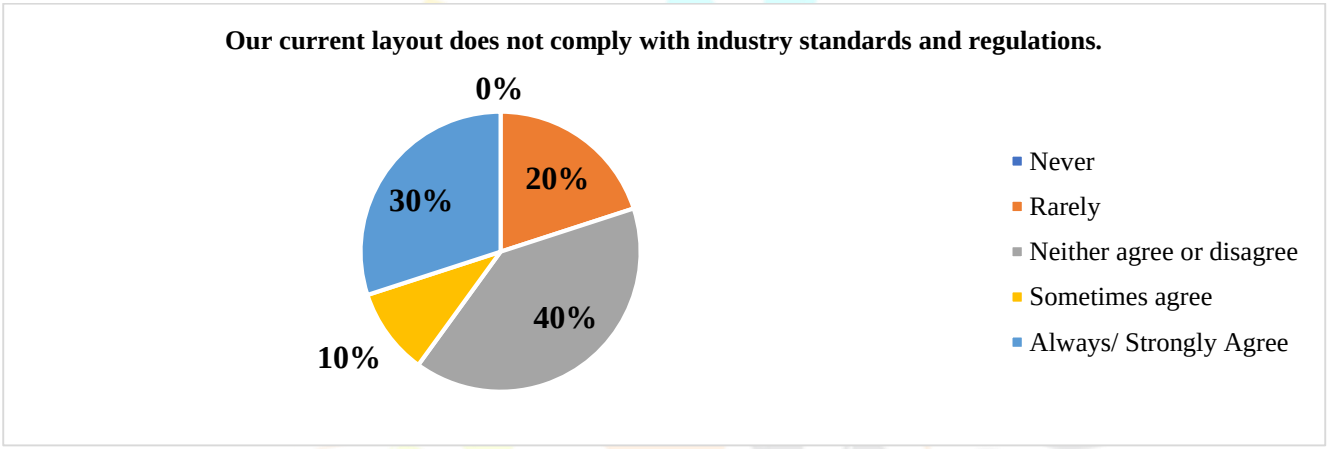

Fig.9 Our current layout does not comply with industry standards and regulations

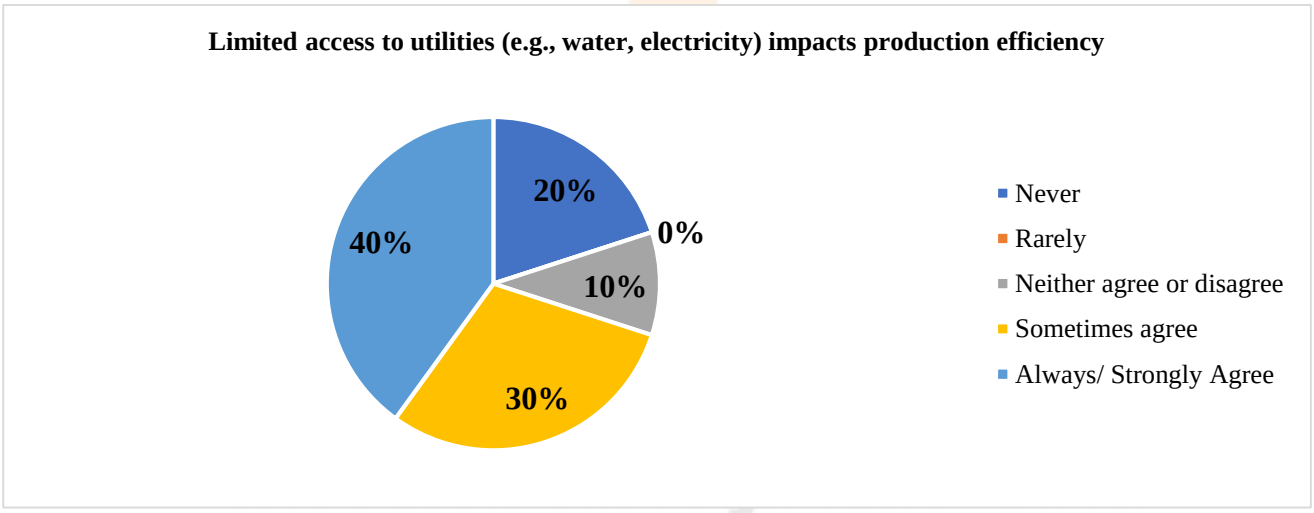

Fig. 10 Limited access to utilities (e.g., water, electricity) impacts production efficiency

Conclusion

The study concludes that the current layouts of small-scale fruit and vegetable industries in Maharashtra significantly hinder productivity and safety. There is a clear need for better-designed plant layouts that optimize space and resource use, enhance flexibility, improve storage and material handling, ensure safety, and comply with industry standards. Implementing these changes can lead to better workflow efficiency, reduced operational costs, and improved overall performance of these industries.

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