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Karnataka is Gateway for Investment Opportunities in Agro Based Industries

Laxman Yadav
Research Sholar and Assistant Professor of Economics, Government First Grade College Sirawar

Abstract: ***Karnataka is one of India's leading states in agro-based and food processing industries, supported by its diverse agro-climatic conditions and strong agricultural base. Despite rapid growth in IT and technology sectors, agriculture continues to be the backbone of the state economy, providing livelihood to a majority of the population. The study examines the concept, characteristics, types, and importance of agro-based industries in India, with special reference to Karnataka. It highlights the strong linkage between agricultural production and industrial growth through value addition and processing. The paper also analyzes segment-wise growth, export performance, and structural transformation of the agri-business sector. Findings reveal that processed and value-added food products are growing faster than traditional sectors. Karnataka's leadership in key crops and high export growth demonstrates its investment potential. The study identifies problems such as regional concentration of units and infrastructural gaps. Finally, it suggests promoting rural-based processing units to ensure balanced regional development and inclusive economic growth.***

Keywords: ***Agro Based Industries , Karnataka , Technology ,Cultivation.***

I. INTRODUCTION

Karnataka is a leading state in IT, BT, engineering, R&D, and other technology sectors.Despite technological growth, agriculture remains a backbone of the economy. Over 60% of the population depends on agriculture directly or indirectly for livelihood and agri-business.A significant share of the population is rural and agriculture-dependent.Agriculture is a natural focus sector for the government to achieve inclusive and sustainable growth.

Karnataka is the 7th largest state in India, with a geographical area of 19.10 million hectares.About 65% (12.40 million hectares) of the area is under cultivation.The state has the second-largest arid zone in the country.Despite climatic diversity, Karnataka has a strong agri-business and food processing sector.Output in this sector grew by 20% in 2009–13, higher than the national growth rate of 15%.

The government aims to increase profitability in agriculture and allied activities.Farmers are encouraged to adopt new technologies and modern equipment.Emphasis is laid on value addition to agricultural produce.Food processing sector reduces wastage and promotes crop diversification.Value addition ensures better returns to farmers and generates employment.

II. REVIEW OF LITERATURE

From the literature survey conducted for this study it is noted that there are few doctoral studies based on agro processing industries and those studies mainly deal with performance, financial aspects, location aspects, size, structure and socio-economic aspects. Agro based industries are mainly in the small scale sector. Most of this research .work in this field has been done from the point of view of economist.

The work of V.Venkiah (1987) dealt with manifold aspects of the rural economy and further he gave importance of this industry at a macro level. He also gave a comparison between agro based industries and non agro based industries and it is known that agro based industries are more labour intensive and are oriented to rural development.

As agro based industries is concerned, Austin categorized agro based industries into three stages on the basis of degree of processing in 1981. He mentioned that higher degree of processing is accompanied by higher capital investment, technological complexity, management requirement and it is characterized by higher value added. Apart from this, Austin also suggested that raw materials are usually the major cost component in agro based industries which are characterized by seasonality, perishability and variability. Backward linkages, concentration of raw material and size of market can be used as important factors in planning size and structure of agro based industry.

Y.G. Reddy (1996) in his study on rural industrialization examines the process of rural industrialization and its potential in the drought prone regions and agriculturally prosperous region. Further he also studied the growth of the rural industries in different agro climatic regions considering the intensity of drought process.

Srivastava (1989) observed that Indian agro based industry is divided into mineral mechanical, mechanical, mechanical-chemical and chemical, signifying higher degree of processing of order. He also observed some movement of agro industries from mechanical based to chemical based processing, but still mechanical processing dominates.

Unni Jeeno observed that agricultural prosperity and nonfarm employment are two inter linked sectors. According to him growth of agricultural production and productivity may create a surplus which may be invested in nonfarm enterprises. He argues that both the generation of agricultural surplus and changing pattern of consumption demand lead to an increase in the demand for labour in the non farm sector.

Bhattacharya S.N. (1985) studied economic growth and its problems in five backward districts of North Bengal, and concluded that in order to achieve higher economic growth, the potential exists for developing smaller and more disbursed agro related industries. These should be systematically identified for each local area and to be exploited to the fullest extent.

Puttaswamaiah favored the establishment of those industries, which are local resource based. He also pointed out that the aim should be to create more opportunities per unit of output and investment. This study pointed out the industrialization which leads to an increase in agricultural productivity as a consequence of change in structure and the intensive use of given resources in association with industrialization and high agricultural productivity, leading to better living standard.

Some other economists like Lewis, Nurks, Rostan, Mellor, Kuznets etc., have argued that transformation of agriculture is a pre-condition for the development of industrial sector as well as for the overall development of the economy. If agricultural sector expands it provides cheap food, cheap and abundant raw material for agro based industries and will provide a vast market to industrial sector.

The Central Food and Technological Research Institute (CFTRI), Mysore also made pioneering contribution in the area of food packaging. A profile on food packaging was published by Dr. V. Prakash (1995). In his report he also covered all the updated information on the subject of food packaging especially applicable to India.

III. OBJECTIVES

The main focus of the study is to emphasize the impact of agriculture on agro based industry in India. Therefore, the study is based on the following objective:

1) To study the definition, characteristics and types of agro based industry in India.
2) To study the impact of agriculture on agro based industry of India.
3) To examine agro based industry of India.
4) To highlight the importance of agro based industry in India.
5) To analyze the problems and prospects of agro based industry in India.
6) To suggest the remedial measures to improve the status of agro based industrial units for effective development of economy.

IV. METHODOLOGY

This seminar paper is mainly based on the collection of reliable secondary data and this study is mostly descriptive in nature. The sources of the data are published and unpublished sources like books, journals, research papers, internet sources etc.

A. Defination, Characteristics And Types Of Agro Based Industries

A common and traditional definition of agro-based industry refers to the subset of manufacturing that processes raw materials and intermediate products derived from the agricultural sector. Agro-based industry thus means transforming products originating from agriculture, forestry and fisheries. Today, however, it is becoming even more difficult to provide a precise demarcation of what should be considered an agro-industrial activity: the impact of innovation processes and new technologies suggests a widening of the range of agro-industry inputs that could be considered, including biotechnological and synthetic products.

Seasonality (b) Perishability and (c) Variability. (James E. Austin) But all agro based industries do not share these characteristics equallyThe food processing industry in India comprises of three groups. The first group consists of primary food processing units mainly rice mill, oil mills etc. The second group consists of unorganized cottage industries including of traditional food units, processing units of fruits, vegetables and spices. The last group is the organized sector of food processing units with further division into the following sub sectors.

(a) Primary food processing
(b) Fruit and vegetables processing
(c) Dairy and live stock products
(d) Fish and fish products and
(e) Consumer goods industry (processed foods)

The project ideas from Network Consultancy Services Pvt. Ltd., Smt. Amin Savitaben presented at the National Seminar on food and Agro based industries at Hyderabad in 1991 classified ABI into seven broad categories as follows.
(a) Marine and animal products
(b) Cereal and confectionery products
(c) Biotechnology products
(d) Dairy products
(e) Fruit and vegetable products
(f) Edible oils and non conventional source
(g) Miscellaneous items

The Central Food Technological Research Institute, Mysore had given a list of major processed product groups which they classified as ABI and food processing industries into nine groups as follows:
(a) Animal Products
(b) Beverage products
(c) Cereal products
(d) Confectionery and convenience food
(e) Equipment and machinery
(f) Fruit and vegetable products
(g) Microbial and fomentation technology
(h) Plantation and spice products
(i) Protein and specialty foods
All the classifications given by different government and non government agencies for food processing and agro based industries come under three broad groups i.e.(1) Primary food processing, (2) unorganized cottage industries and (3) organized food processing units.

V. CONCEPT OF AGRO BASE INDUSTRIES

Types of Agro Based Industries
Agro-Produce Manufacturing Units
Agro-Produce Processing Units:

A. Some Agro Based Industries Of India

1) Tea industry
2) Cotton Textile industry
3) Paper industry
4) Jute industry
5) Silk industry
6) Woolen industry
7) Food processing plants
8) Others

B. Importance Of Agro Based Industries In India

Viewing in a historical prospective agro based industries are pioneering types in the initial stage of economic development of developing countries like India. In the initial stage, such industries are usually dispersed in rural areas using simple techniques of productions. These are labour intensive industries based on local raw materials.

There is an urgent need to develop ABI to reduce the problems of pressure of population on land, under-employment, unemployment in rural areas on one hand and overcrowding, environmental problems in urban areas on the other hand. The development of ABI will check people from migration from rural areas to urban nodes. Some of the importance of agro based industries is discussed below:

1) Door towards Agriculture Resources.
2) Milestone of the Manufacturing Sector
3) Integration with Global Markets
4) Income and employment generation:
5) The Nutrition Dimension
6) Promotion of Socio-Economic Development

Food processing sector in Karnataka has delivered 20% CAGR from 2009-2013, out performing the national average of 16 % . Exports of USD 2billion in 2014-2015, growing at CAGR of 22%.

Karnataka has 10 agro-climatic zones.These zones are based on soil type, topography, vegetation, elevation, and rainfall.The diversity supports the cultivation of a wide variety of crops.This agro-climatic advantage strengthens agricultural productivity and diversification.

Karnataka leads national rankings in the production of several agricultural raw materials.The state's diverse agro-climatic conditions support high and varied output.Strong raw material availability boosts agro-based and food processing industries.

Rank-1 Coffee ,Gherkins,Rose Onion,Silk,Capsicum,Green Chilli

Rank -2 Pomehranate,Maize,Cut Flower,Cloves,Tamato

Rank-3 Sugarcane ,Mango,Onion,Dry Chillies,Cardamom,Coconut,Cinnamon,Cocoa

Other Notable Products : Papaya, Cashewnut, Turmeric, Banana, Lime/Lemon, Orange, Soyabean, Grondnut, Bengal gram, Carrot, Eggs, Guava, Ginger,Sweet potato,Garlic.

Global agri business and food processing market presents a large opportunity for an export led growth ,through development of high value -added products .

VI. USD 3.2 TRILLION GLOBAL FOOD PROCESSING INDUSTRY

India's total Exports have grown from USD 13 billion in 2009 to USD 37 billion in 2013

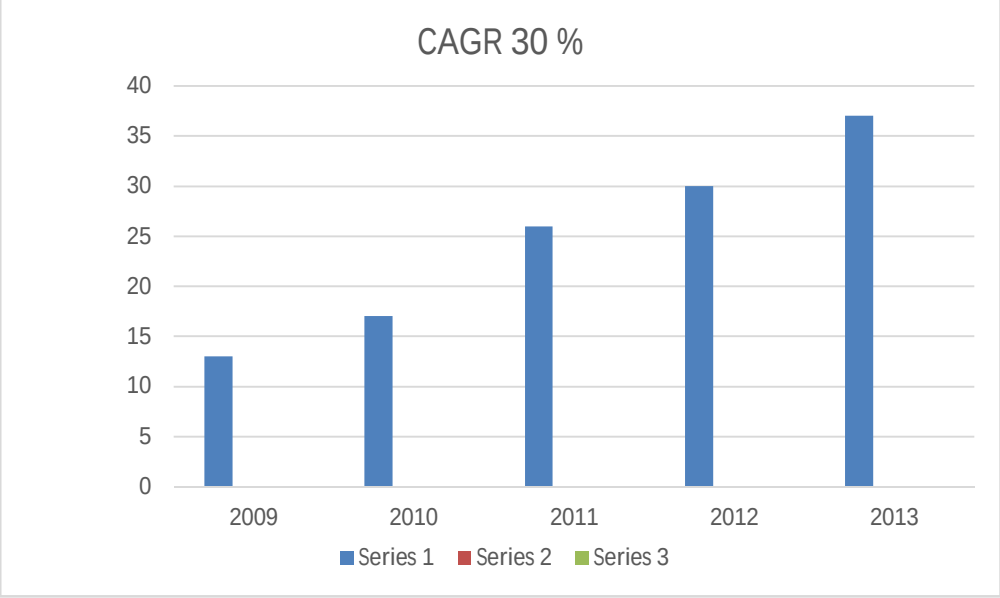

Figure 1 SOURCETrade statistics for international business development

Each of the subspectus have witnessed I growth and success in export markets

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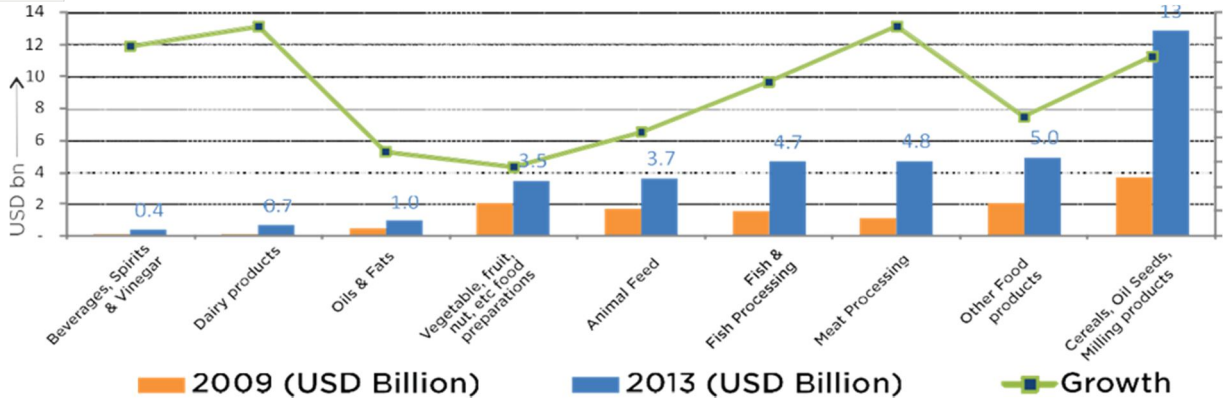


Sources International Trade Cent re intrasen.org.pwc analysis

A. Explanation of the Diagram

Segment-wise Output and Growth of Agri-Business & Food Processing Industry

The chart presents a comparative analysis of output value (in USD billion) for different segments of the agri-business and food processing industry in 2009 and 2013, along with a growth trend line indicating percentage growth across segments.

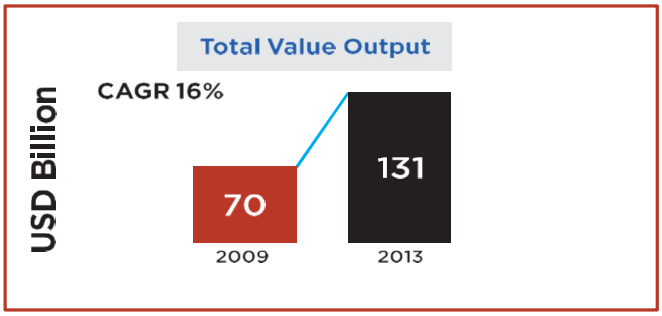
1. Beverages & Tobacco
   - Output increased marginally from USD 0.4 billion (2009) to USD 0.4–0.5 billion (2013).
   - Growth is relatively low and stagnant, mainly due to regulatory controls and changing consumption preferences.
   - This segment shows limited expansion potential.
2. Dairy Products
   - Output rose from USD 0.7 billion in 2009 to USD 0.7–0.8 billion in 2013.
   - Growth is moderate and stable, reflecting consistent demand for milk and milk products.
   - Dairy continues to be a reliable rural livelihood sector.
3. Oils & Fats
   - Increased from USD 1.0 billion (2009) to about USD 1.0–1.2 billion (2013).
   - Growth rate is moderate, indicating steady but not rapid expansion.
   - Consumer shift towards healthier alternatives affects growth.
4. Confectionery & Other Consumables
   - Shows a sharp rise from USD 2.2 billion in 2009 to USD 3.5 billion in 2013.
   - One of the fastest-growing segments, supported by: Urbanization,Rising incomes,Demand for ready-to-eat foods.
   - This segment forms the core driver of industry growth.
5. Animal Feed
   - Output increased from USD 2.0 billion to USD 3.7 billion.
   - Growth is strong due to expans ion of: Poultry, Dairy ,Livestock sectors
   - Indicates increasing commercialization of agriculture.
6. Fish Processing
   - Output grew from USD 1.8 billion in 2009 to USD 4.7 billion in 2013.
   - High growth reflects export demand, cold-chain development, and coastal advantages.
   - Represents a high-potential export-oriented sector.
7. Meat Processing
   - Increased significantly from USD 1.2 billion to USD 4.8 billion.
   - Growth is driven by: Rising protein consumption ,Export opportunities
   - One of the fastest-growing agro-processing segments.
8. Other Food Products
   - Output rose from USD 2.1 billion (2009) to USD 5.0 billion (2013).
   - Includes bakery items, ready meals, noodles, chocolates, etc.
   - Reflects diversification and modernization of food habits.

9. Confectionery & Other Manufacturing Products
- Shows the highest growth, rising from USD 3.5 billion to USD 12 billion.
- The growth line peaks here, indicating maximum expansion rate.
- Demonstrates strong scope for investment and value addition.

Overall Interpretation
- All segments show positive growth between 2009 and 2013.
- Processed and value-added food segments are growing faster than traditional sectors.
- Growth line indicates strong momentum, especially in: Meat,Fish,Confectionery, Other food products

The chart clearly highlights a structural transformation of the agri-business and food processing industry from basic processing to high-value, export-oriented products. Rapid growth in multiple segments confirms Karnataka's role as a major investment destination and gateway for agro-based industries.

Domestic agree business and food processing is on the cusp of explosive growth fuelled by changing food habits and consumption Increasing disposable income and changing socio-economic structure of family are expected to be growth driver of food processing industry.

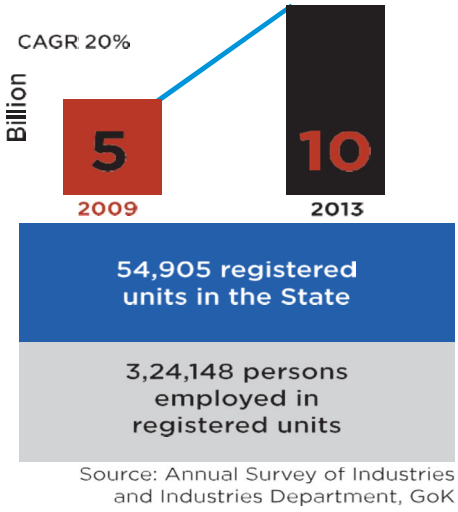


Source: Annual survey industries

Share of major Segments of Agri-Business and Food Processing an Processing industry in total output -2009& 2013
Karnataka's agricultural business and food processing sector is growing at 20% CAGR out performing the national average growth rate.

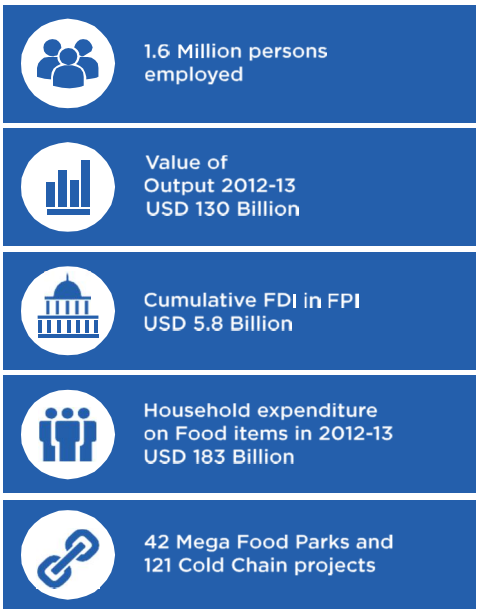
USD 10 billion food processing industries value of output in 2013 12 and 13
120 lakh hectare *total cropped area net Sony area is 98 lakh hectare 120% cropping intensity*
16% contribution of agriculture and allied sector to the gstp at current prices

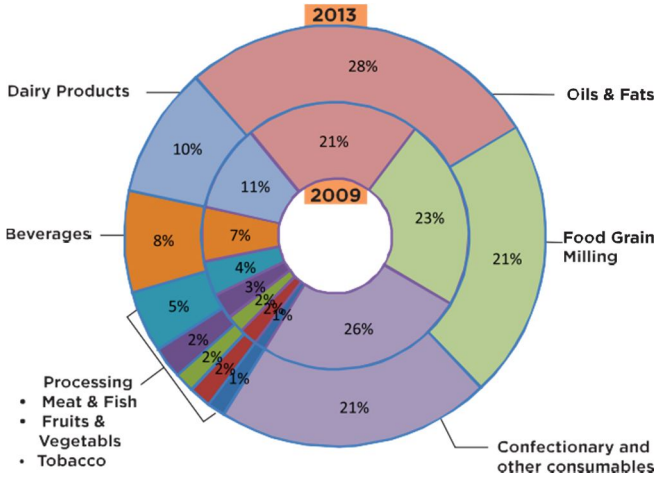
Total Value output in Karnataka

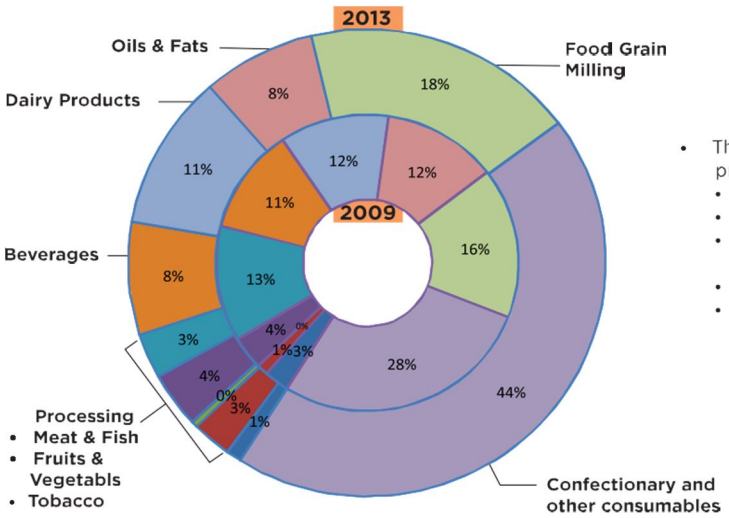


Source: Annual Survey of Industries and Industries Department, GoK

Share of major segments of Business and food processing industry in total output 2009 and 2013







- The segment NIC classified as 'Other food products' includes
  - Bakery Products
  - Manufacture of Sugar
  - Manufacture of Cocoa, Chocolate, and Sugar
  - Manufacture of prepared meals
  - Manufacture of Macaroni, noodles etc

B. Explanation of the Diagram

Share of Major Segments of Agri-Business and Food Processing Industry (2009 vs 2013)

The given diagram is a comparative donut chart showing the percentage share of various segments of the agri-business and food processing industry for the years 2009 (inner circle) and 2013 (outer circle). The chart clearly brings out the structural changes and growth pattern of the industry over time.

1. Confectionery and Other Consumables
   - This segment holds the largest share in both years.
   - Share increased significantly from 28% in 2009 to 44% in 2013.
   - It indicates rapid growth in processed and ready-to-eat foods due to: Changing food habits, Urbanization, Rising incomes
   - This segment has emerged as the dominant contributor to industry output.
2. Food Grain Milling
   - The share of food grain milling increased from 16% in 2009 to 18% in 2013.
   - This reflects steady demand for processed cereals, flour, rice, and pulses.
   - Growth is driven by modernization of mills and higher consumption of packaged staples.

3. Dairy Products
   - Dairy products showed marginal growth from 11% in 2009 to 11–12% in 2013.
   - The stable share highlights the consistent demand for milk and milk products.
   - Dairy remains a strong rural employment generator.
4. Beverages
   - The beverage segment declined slightly from 13% in 2009 to 8% in 2013.
   - This reduction suggests changing consumer preferences and increased competition from other processed food segments.
5. Oils and Fats
   - Oils and fats contributed about 12% in 2009, declining to 8% in 2013.
   - The fall indicates diversification of consumer diets and greater focus on value-added food products.
6. Processing of Meat, Fish, Fruits and Vegetables
   - This segment shows low but gradually increasing shares: Around 3–4% in 2013
   - Though small, it reflects emerging opportunities in: Cold storage,Export-oriented processing, Value addition
7. Tobacco Products
   - Tobacco maintains a very small share (around 1–3%) in both years.
   - Its limited growth is due to health concerns and regulatory restrictions.
8. “Other Food Products” (NIC Classification)

This category includes: Bakery products,Sugar manufacturing,Cocoa and chocolate products,Prepared meals, Macaroni, noodles, and similar products

The growing share of this segment indicates rapid diversification and modernization of the food processing industry.

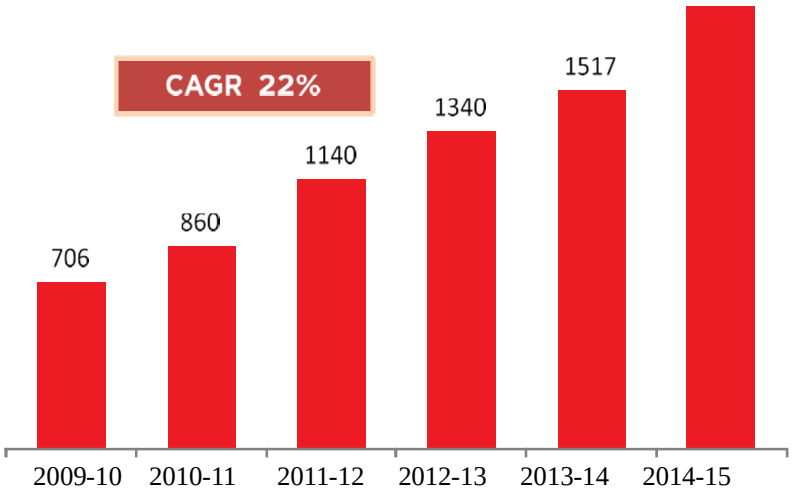
Overall Interpretation

The industry has shifted strongly towards value-added and consumer-oriented food products.Traditional segments like beverages and oils are losing relative share.,High growth in confectionery and processed foods reflects urban demand and export opportunities.The comparison highlights structural transformation of the agri-business sector between 2009 and 2013.

The diagram clearly shows that the agri-business and food processing industry is moving from basic processing to high-value, diversified products. This structural change strengthens Karnataka’s position as a major investment destination in agro-based industries, supporting employment, exports, and economic growth.

Exports from the state have been growing at 22% cagr supported by forward looking policies and supporting infrastructure

Export scenario in the state



Explanation of the Chart: Export Growth at CAGR 22%

The given bar chart illustrates the steady growth of agro-based and food processing exports over a period of time, showing a Compound Annual Growth Rate (CAGR) of 22%. This indicates a strong and consistent rise in

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Explanation of the Chart: Export Growth at CAGR 22%

The given bar chart illustrates the steady growth of agro-based and food processing exports over a period of time, showing a Compound Annual Growth Rate (CAGR) of 22%. This indicates a strong and consistent rise in export performance.

Trend Analysis

- The export value starts at around 708 units in the initial year.
- It increases steadily to 860, then to 1140, followed by 1340, and further to 1517 in subsequent years.
- Each bar shows a continuous upward movement, reflecting sustained growth without major fluctuations.

This consistent rise highlights the increasing global demand for agro-based and processed food products.

Significance of 22% CAGR

- A 22% CAGR represents a high growth rate, much higher than average industrial growth.
- It indicates strong competitiveness of agro-based industries in international markets.
- Such growth reflects improvements in:,Agricultural productivity,Value addition through processing, Export infrastructure and logistics, Government support and investment

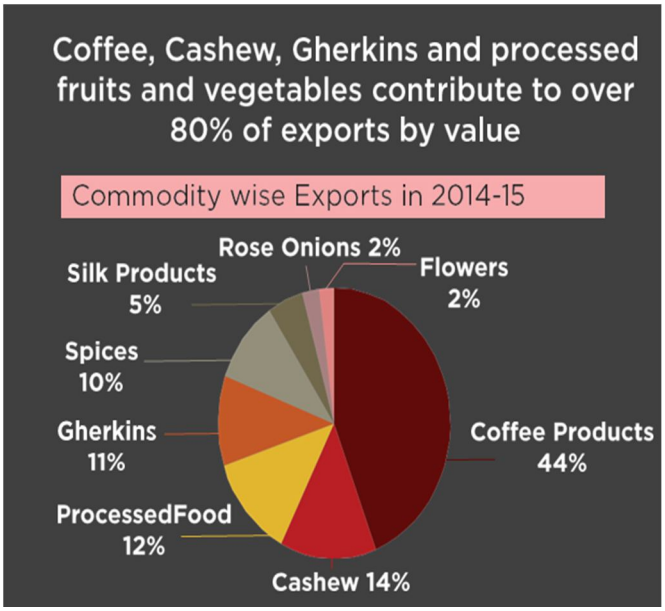
Economic Implications

- Rapid export growth contributes to foreign exchange earnings
- Encourages private and foreign investment in agro-processing industries
- Generates employment, especially in rural areas
- Strengthens farmer incomes through better market access
- Promotes export-led economic growth

Overall Interpretation

The chart clearly demonstrates that Karnataka's agro-business and food processing sector is experiencing robust and sustained export growth. The 22% CAGR confirms that the state has emerged as a major hub for export-oriented agro-based industries, reinforcing its role as a gateway for investment opportunities.

The rising trend in exports with a CAGR of 22% shows the strong potential and global acceptance of Karnataka's agro-based products. This growth trend supports long-term economic development and highlights the importance of agro-industries in the state's overall growth strategy.



Explanation of the Chart: Commodity-wise Exports (2014–15)

The given pie chart shows the composition of agro-based exports by value during the year 2014–15. It clearly highlights that Coffee, Cashew, Gherkins, and processed fruits and vegetables together contribute more than 80% of total export value, indicating Karnataka's strong specialization in these commodities.

Major Export Commodities

1. Coffee Products – 44%

Coffee products account for the largest share of exports, contributing 44% of total export value. This reflects Karnataka's position as the leading coffee-producing state in India, supported by favorable agro-climatic conditions, established plantations, and strong international demand. Coffee is therefore the backbone of agro-exports from the state.

2. Cashew – 14%

Cashew exports contribute 14% of the total value. Karnataka has well-developed cashew cultivation and processing units, which add value through grading, roasting, and packaging. The high export share shows the importance of value-added agro-processing industries.

3. Processed Food – 12%

Processed food products form 12% of exports, highlighting the growing importance of the food processing sector. This includes processed fruits and vegetables, which reduce post-harvest losses and increase shelf life. It reflects changing global food preferences and strong export potential for value-added products.

4. Gherkins – 11%

Gherkins contribute 11% to total exports. Karnataka is a national leader in gherkin production, mainly grown under contract farming and exported to European and American markets. This sector generates employment and stable income for farmers, especially smallholders.

5. Spices – 10%

Spices account for 10% of exports. The state produces spices such as pepper, cardamom, and chilli, supported by diverse agro-climatic zones. Spices have a steady demand in international markets due to their culinary and medicinal value.

6. Silk Products – 5%

Silk products contribute 5% of exports. Karnataka is known as the silk hub of India, particularly for mulberry silk. Though the percentage is smaller, silk represents a high-value traditional agro-based industry.

7. Flowers – 2%

Floriculture exports form 2% of total exports. This sector has growth potential due to rising demand for cut flowers in global markets, but currently holds a limited share.

8. Rose Onions – 2%

Rose onions also contribute 2%. Despite Karnataka's rank in onion production, export share remains low due to price fluctuations and domestic demand pressures.

Overall Interpretation

- The chart clearly shows that a few high-value commodities dominate exports
- Coffee alone contributes nearly half of total export earnings
- Processed and value-added products form a significant share, indicating industrial growth
- The export structure highlights Karnataka's strength in plantation crops, horticulture, and food processing

There is strong scope to diversify exports by improving processing, storage, and marketing of underperforming commodities

The chart demonstrates that Karnataka's agro-based export performance in 2014–15 was highly concentrated but strong, driven mainly by coffee, cashew, gherkins, and processed food products. This export composition reinforces Karnataka's position as a gateway for investment in agro-based and food processing industries.

VII. FINDINGS AND SUGGESTIONS

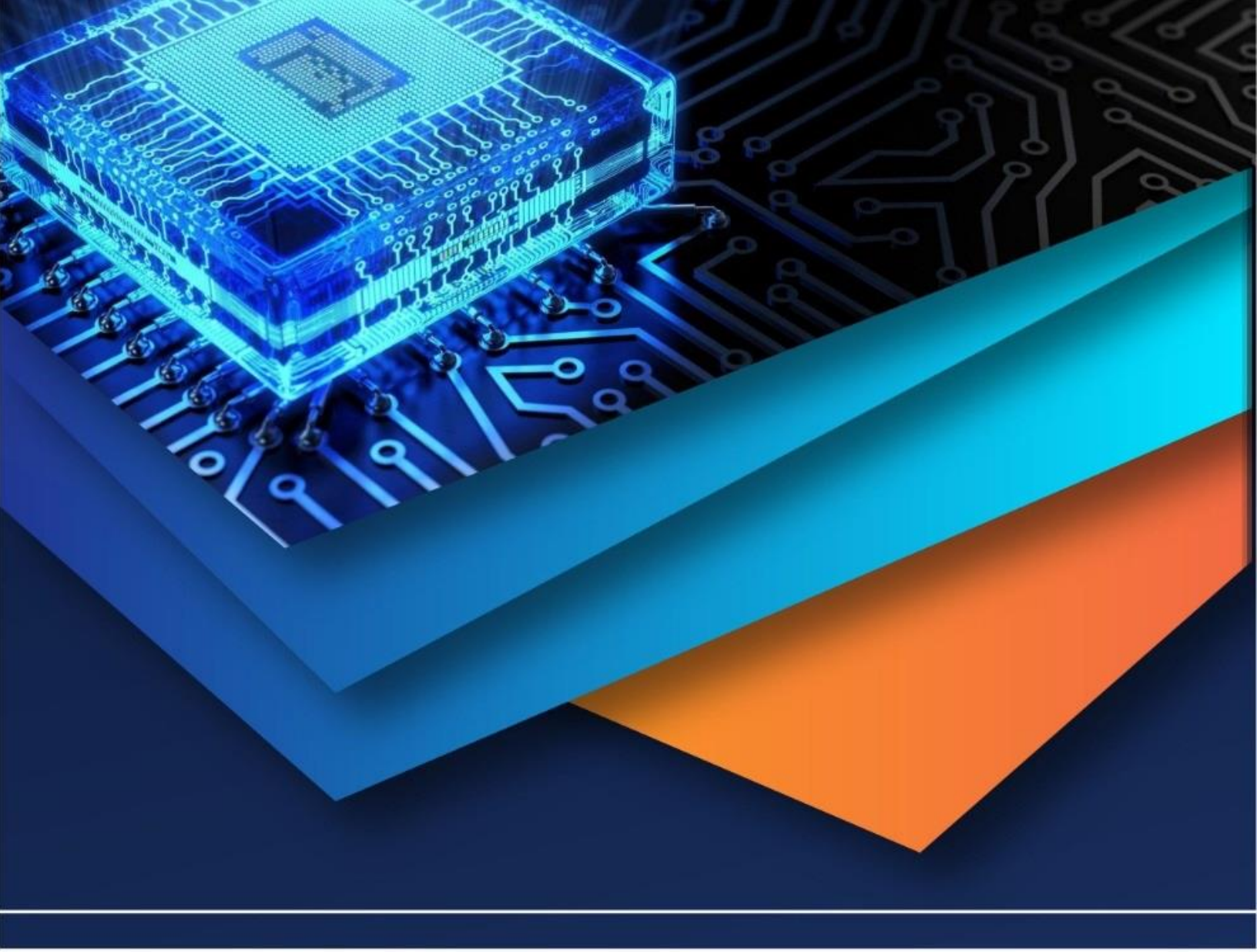
From all the above explanations, it is evident that the state of Karnataka has excellent opportunities in food processing and agro-based industries, including production and processing activities. When compared to the rest of India, Karnataka clearly offers better and more favorable opportunities. The state provides strong prospects for international exports, which makes it highly attractive for investment.

In Karnataka, the government not only encourages investment but also facilitates marketing opportunities, which is a positive and supportive factor. It can therefore be stated that Karnataka offers highly favorable conditions for the establishment of market-oriented processing industries. However, at present, these processing units are largely concentrated in and around urban areas. It is suggested that such units should also be established in rural areas, especially in backward districts, so that balanced regional development can be achieved.

REFERENCES

[1] Dhar, P.K.(2015): " Indian Economy: Its Growing Dimensions", Kalyani publishers, 23rd Edition , ISBN 978-93-272-5517-1
[2] Lekhi R.K., Singh Joginder(2013) : " Agricultural Economics: An Indian Perspective", 9th Edition, ISBN 978-93-272-2894-6
[3] New Media Wing(2017): " India 2017", Ministry Of Information And Broadcasting Government Of India,61st Edition, ISBN 978-81-230-2328-1
[4] Soonity Goswami PGT Economics, Malow Ali Higher Secondary International Journal for Multidisciplinary Research (IJFMR) E-ISSN : 2582-2160.
[5] Dr.N.Honnurswamy. "A Study on Social and Economic States of Agro-based Industrial Entrepreneurs in Kalyana Karnataka Region of Karnataka." IOSR Journal of Economics and Finance (IOSR-JEF), 11(1), 2020, pp. 32-36.
[6] R. P. Kachru -- Agro-Processing Industries in India—Growth, Status and Prospects R. P. Kachru Asstt. Director General (Process Engineering), Indian Council of Agricultural Research, New Delhi.
[7] Dr. Umesh Gupta, Head- School of Business Study MATS University, Raipur IMPACT OF AGRO BASED INDUSTRIES ON SOCIO-ECONOMIC DEVELOPMENT IRJMSH Vol 13 Issue 3 [Year 2022] ISSN 2277 – 9809 (0nline) 2348–9359
[8] 1Dr. C Paramasivan, 2 R Pasupathi Performance of agro based industries in India National Journal of Advanced Research Online ISSN: 2455-216X; Impact Factor: RJIF 5.12 www.allnationaljournal.com Volume 2; Issue 6; November 2016; Page No. 25-28

GOK websites
Invest Karnataka -2016
Trade stastics for International Business Development
International Trade Centre ,intracon.org.Pwc Anaysis
Annual Survey of Industries
KAPPC



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