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Research Article

Business Model of Integrated Food Security Information System

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ABSTRACT

Introduction: The rapid advancement of technology in the Industrial Revolution 4.0 era has transformed various sectors, including agriculture and food security. Ensuring sustainable food security is crucial due to its impact on social resilience, economic stability, and political equilibrium. In Indonesia, Law No. 18 of 2012 and Government Regulation No. 17 of 2015 mandate the development of an integrated Food Security Information System (FSIS) to manage multi-sectoral and multi-disciplinary food affairs effectively.

Objectives: This study aims to design a business model for an Integrated Food Security Information System (IFSIS) that enhances food availability, affordability, and utilization. The research also seeks to align technological capabilities with strategic policy frameworks, providing a comprehensive and sustainable solution for managing food security challenges.

Methods: The research employs the Enterprise Architecture Planning (EAP) methodology to assess current system capabilities and define future technological needs. Data collection involves legal document reviews, policy analysis, and system gap evaluations. The study also includes conceptual modeling and a structured implementation roadmap to guide the system's development over three years.

Results: The study proposes a business model for IFSIS that integrates food availability, affordability, and utilization processes. The model outlines key subsystems, including food production, storage, distribution, and consumption monitoring. The implementation roadmap provides a phased strategy for adopting advanced technologies and improving data management. The proposed system facilitates real-time monitoring, early warning mechanisms, and strategic decision-making, ensuring compliance with legal frameworks.

Conclusions: An integrated food security information system is vital for addressing food security challenges in Indonesia. The proposed architecture, grounded in the EAP methodology, supports efficient planning, monitoring, and evaluation while enhancing compliance with national policies. This model can serve as a reference for other regions aiming to implement sustainable food security systems through digital transformation.

Keywords: business model; food security; integrated information system; architecture design; implementation roadmap; sustainable food consumption

INTRODUCTION

The role of technology in the Industrial Revolution 4.0 era has taken over almost the majority of economic activities. Apart from driving economic growth, this trend has changed many areas of human life, including the world of work and even the human lifestyle itself. In the industrial world, the existence of cyber technology and automation has caused major changes in production, resulting in increased efficiency of time, energy and costs, thereby increasing competitiveness. In the agricultural sector, the process of providing fertilizer, feed or water is carried out automatically, which is known as smart farming. In the fisheries sector, fishing in the ocean also uses a technology known as smart fishing. In the field of education, the teaching and learning process now does not only have to be carried out in the classroom but can be done anywhere and at any time. At the societal level, the benefits of digitalization developments can also be felt by all levels of society, in the form of retrieval and exchange of information that can be easily done anytime and anywhere via the internet network.

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With the industrial revolution 4.0, the government was also forced to change, by carrying out a government transformation from Government 1.0 to Government 4.0. Regional governments gradually need to change their role from government as Administrator (Government 1.0) to government as "Service Provider" (Government 2.0), "Facilitator" (Government 3.0), to "Collaborator" (Government 4.0). One of the important roles of the government is how to collaborate all existing potential in creating food security. Food security is currently an important priority because it has strategic value because it concerns fundamental aspects of human needs which will greatly influence social resilience, economic stability and political stability. In accordance with Law Number 18 of 2012 concerning Food, regional governments are obliged to build, compile and develop an integrated Food Information System. Considering the breadth of things handled by food affairs which are multidimensional in nature, the handling of food affairs must be multi-sectoral and multi-disciplinary as well as collaborating with various parties. Therefore, the Food Information System that is built must also be able to integrate various sectors or related parties into a comprehensive and integrative system.

The sustainability of the global food system is a major focus in multidisciplinary research, which includes policy integration, technological adaptation, and natural resource management. Fanzo et al. (2020) introduced the Food Systems Dashboard, an innovative tool designed to inform better food policy by integrating multidimensional data about global food systems. This research shows the importance of visualization tools to support evidence-based decision making in the food sector. On the other hand, Birner and Resnick (2010) highlight the political economic dynamics in small-scale agricultural policy. They emphasize the importance of understanding the political and institutional forces in supporting smallholder farmers, who are the backbone of food security in many developing countries. Meanwhile, Ahmed and Stepp (2016) examined the impact of climate change on the quality of agricultural products, especially specialist crops, as well as the importance of agroecological management to maintain productivity and sustainability.

In a broader context, Béné et al. (2020) explore global drivers of food system unsustainability through multi-country correlation analysis. This research identifies key factors influencing food system sustainability, which are important for formulating effective policies. Lal (2020) highlights the importance of land management in resolving conflicts between agriculture and nature, with an approach that emphasizes resource sustainability. Godfray and Garnett (2014) introduced the concept of sustainable intensification as a solution to achieving food security while conserving natural resources. They suggest innovative approaches that combine production efficiency with environmental sustainability. Finally, Wilkinson and Pickett (2019) highlight the social and psychological impact of inequality in society, which also impacts access to adequate and quality food.

OBJECTIVES

The primary objective of this study is to design a comprehensive business model for an Integrated Food Security Information System that addresses the challenges of food availability, affordability, and utilization. By leveraging advanced technologies from the Industrial Revolution 4.0 era, the study aims to create a system that integrates multi-sectoral and multi-disciplinary efforts, ensuring a holistic approach to food security. This system is intended to provide accurate and timely information to policymakers, enabling them to make informed decisions to stabilize food supply and prices while addressing regional and national food security needs.

A secondary objective is to align the proposed information system with existing legal frameworks, particularly Law No. 18 of 2012 concerning Food and Government Regulation No. 17 of 2015 on Food Security and Nutrition. Ensuring legal compliance is crucial for the successful implementation and operational sustainability of the system. This alignment involves incorporating regulatory requirements into system functionalities, such as data collection, monitoring, and reporting mechanisms. By doing so, the Integrated Food Security Information System can serve as a reliable tool for supporting government initiatives and enhancing the overall governance of food security policies.

Additionally, the study seeks to develop a practical implementation roadmap to guide the deployment of the IFSIS over a three-year period. This roadmap outlines key stages, including the assessment of current technological capabilities, gap analysis, and the phased adoption of new technologies. By providing a structured approach, the roadmap ensures the gradual and systematic realization of the Integrated Food Security Information System, fostering collaboration among government agencies, private sectors, and local communities. The ultimate goal is to

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enhance the resilience of the food system, promote sustainable food consumption, and ensure equitable access to nutritious food for all populations.

METHODS

The framework used to prepare the Architectural Design of the Food Security Information System is shown in the following Figure 1:

Fig. 1. Framework for Preparing System Architecture

Information:
1. To: Where are we now?
Explain the description and capabilities of current information systems and technology and their support for the implementation of business processes.
2. Tn: Where do we want to go?
Explain the expected information systems and technology that are in line with strategic plans (strategic policies and programs).
3. How to?
Explain the architecture along with the implementation roadmap according to the results of the gap analysis results (1) and (2).

Based on the above framework and the Enterprise Architecture Planning (EAP) method, an approach for preparing a Food Security Information System Architectural Design can be determined as shown in Figure 2 below:

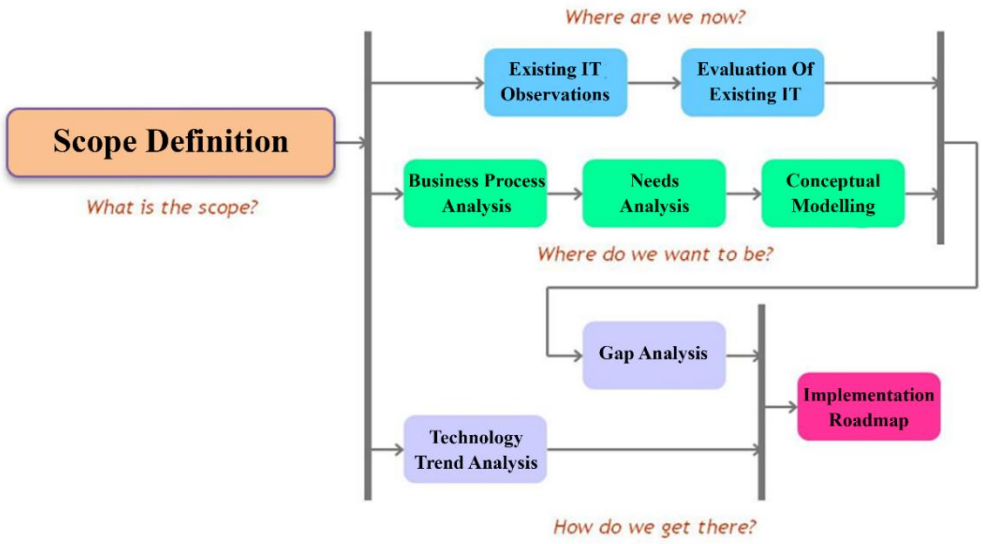

Fig. 2. Approach to Preparing System Architecture Design

Information:
1. Definition of Scope, determine the scope in accordance with what has been determined in the Work Terms of Reference (TOR).
2. Business Process Analysis, analyzing the Government Administration process carried out by regional apparatus organizations in accordance with applicable laws and regulations.

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3. Observation of Existing Information Systems and Technology, carrying out surveys and interviews to get an overview of the information systems and technology used today, including computer hardware and network systems, databases, application software.
4. Evaluation of Existing Information Technology, evaluate and assess existing information systems and technology to assess how much they support the business processes being implemented.
5. Needs Analysis, define and specify the needs that must be met by new information technology to support business processes according to policies and programs related to food security.
6. Conceptual Modeling, develop conceptual models of data architecture, applications and information technology by referring to the results of needs analysis (Chukurna, O., et.al 2024).
7. Gap Analysis, carry out a gap analysis based on the results of stage 4 and stage 6 so that you can find out what factors cause gaps in realizing the conceptual modeling that has been prepared.
8. Technology Trend Analysis, estimating technological trends or trends that will be used when implementing the Food Security Information System.
9. Implementation Roadmap, explain the stages of implementing the Food Security Information System in the next 3 (three) years.

The results of the preparation of the Food Security Information System Architectural Design in the future will be used to develop an Integrated Food Security Information System. To develop an Integrated Food Security Information System, stages are required which must be carried out in a structured, systematic and logical manner. The following are the implementation stages of developing an Integrated Food Security Information System as in Figure 3.

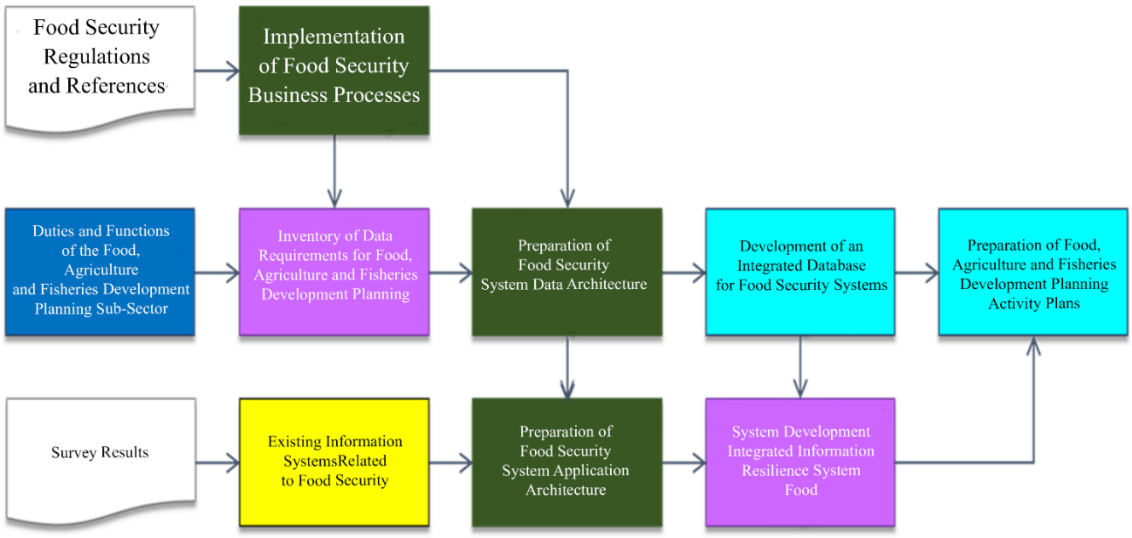

Fig. 3. Implementation Stage of Development of an Integrated Food Security Information System

RESULTS

1. Understanding Food and Food Security

According to the Republic of Indonesia Government Regulation Number 68 of 2002 concerning Food Security, food is anything that comes from biological sources and water, whether processed or unprocessed, which is intended as food or drink for human consumption. In Law Number 18 of 2012 concerning Food, the definition of food is further expanded, especially the scope of types of food. In the Food Law, food is defined as anything originating from biological sources, agricultural products, plantations, forestry, fisheries, animal husbandry, waters and water, whether processed or unprocessed which is intended as food or drink for human consumption, including ingredients food additives, food raw materials, and other materials used in the process of storing, processing, and/or making food and beverages.

The concept of food security began to develop in 1943 when a conference of food and agriculture was held which launched the concept of a secure, adequate and suitable supply of food for everyone. Food security is the ability of a

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nation to guarantee that its entire population obtains food in sufficient quantities, of adequate quality, safe and halal, which is based on optimising utilisation and based on the diversity of domestic resources. In the era of regional autonomy, food security is part of every region's affairs which must be managed and pursued. Food security is a mandatory non-basic service matter with 4 matters that must be carried out by the Regency/City Government, namely providing infrastructure and all supporting food independence in various sectors according to Regency/City regional authority, implementing food security, handling food insecurity, and monitoring security. fresh food. Food availability can be realized through the process of food sovereignty and food diversity. Meeting food needs is the right of the state and nation to independently determine food policies that guarantee the right to food for the people and that give the people the right to determine a food system that is in accordance with local resource potential.

Food security is a condition where individuals or households have physical or economic access to food for all household members and are not at risk of losing both FAO (2016). According to FIVIMS (2005), food security is a condition when all people at all times physically, socially and economically have access to sufficient, safe and nutritious food to fulfill consumption needs and according to their tastes (food preferences) for an active life and healthy. Food security is a condition when everyone at all times has access and control over sufficient quantities of food and good quality for an active and healthy life. Two meanings are listed here, namely: availability in terms of quality and quantity and access (the right to food through purchase, exchange or claim). According to the Ministry of Agriculture (1996), food security is the ability to meet the food needs of household members in quantity, quality and variety according to local culture from time to time in order to maintain a healthy life.

2. Legal Studies Concerning Food Security

According to Law Number 18 of 2012 concerning Food, Article 1, Food security is "the condition of fulfilling food for the country and individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable and affordable and does not conflict with the religion, beliefs and culture of the community to be able to live." healthy, active and productive in a sustainable manner."Law Number 23 of 2014 states the division of affairs in the food sector between the Government, Provincial Government and Regency/City Government. Implementation of Food Security in Districts/Cities includes 4 matters and 9 sub-affairs, namely:

- Food administration based on sovereignty and independence (Regency/City affairs are the provision of infrastructure and all supporting food independence in various sectors according to the Regency/City regional authority);
- Implementation of food security for Regency/City affairs is:
  - Provision and distribution of staple food or other food according to the needs of the Regency/City area in the context of stabilizing food supply and prices,
  - Management of Regency/City food reserves,
  - Determination of regional minimum prices for local food which are not determined by the Central Government and Provincial Government,
  - Implementation of achieving per capita/annual food consumption targets in accordance with nutritional adequacy figures;
- Handling food insecurity by district/city affairs is:
  - Preparation of sub-district food vulnerability and security maps,
  - Handling district/city food insecurity,
  - Procurement, management and distribution of food reserves for food insecurity covering district/city areas;
- Regency/City food safety is the implementation of fresh food safety supervision

3. Legal Studies of Food Security Information Systems

There are several legal bases that are used as references in Preparing Food Security Information System Architectural Design activities such as Law Number 18 of 2012 and Government Regulation Number 17 of 2015. According to Law Number 18 of 2012 concerning Food, Article 113, Food Information Systems include collecting, processing, analyzing, storing and presenting as well as disseminating data and information about food. Therefore, in Article 114, The Government and Regional Governments are obliged to build, compile and develop an integrated food information system. This information system includes collection, processing, analysis, storage and presentation as well as dissemination of data and information about Food. The food information system is used for at least:

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- Planning
- Monitoring and evaluation
- Stability of food supply and prices
- Early warning system for food problems and food and nutrition insecurity.

The food information system as intended in Article 114 is organized by the food data and information center. The food data and information center is obliged to update data and information. The food data and information center provides data and information at least regarding:

- Type of food product
- Food balance
- Location, area and food production areas
- Market demand
- Market opportunities and challenges
- Production
- Price
- Consumption
- Nutritional status
- Export and import
- Supply forecast
- Estimated planting season and harvest season
- Climate forecast
- Food technology
- Food needs

According to Government Regulation Number 17 of 2015 concerning Food Security and Nutrition, Article 75, The Government and Regional Governments in accordance with their authority are obliged to build, compile and develop an integrated Food and Nutrition Information System. The Food and Nutrition Information System as intended in paragraph (1) can be used to:

- Planning;
- Monitoring and evaluation;
- Stabilization of food supply and prices; And
- Development of an early warning system for food problems and food and nutrition insecurity.

The Food and Nutrition Information System includes collecting, processing, analyzing, storing, presenting and disseminating data and information about Food and Nutrition. Food and Nutrition Data and Information at least contains:

- Type of Food product;
- Food balance;
- Location, area and food production area;
- Market demand;
- Market opportunities and challenges;
- Production;
- Price;
- Consumption;
- Nutritional Status;
- Export and import;
- Supply estimates;
- Estimated planting season and harvest season;
- Climate forecasting;
- Food technology
- Food needs of each region
- Estimated fish catch season

Food and nutrition data and information is prioritized for staple foods, certain staple foods and local foods.Collection of Food and Nutrition data and information is carried out through Primary data collection and Secondary data collection. Primary data processing is carried out through Editing and coding; Initial tabulation; validation; and Final

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tabulation. Secondary data processing is carried out through consistency check and checking coherence or comparability with other data.

Analysis of Food and Nutrition data and information is carried out through:

- Determining the analysis method;
- Implementation of analysis;
- Interpretation of analysis results; And
- Formulation of analysis results.

Storage of Food and Nutrition data and information is carried out in printed and electronic form. Data storage must guarantee ease of tracking and data security. The presentation and dissemination of Food and Nutrition data and information is carried out through:

- Data access and usage settings;
- Publishing periodically and/or at any time;
- Inclusion on the page; And
- Reporting through print and electronic media.

Ingram (2011) presents a food systems approach in researching food security and its interaction with global environmental change. This research supports the development of an integrated food system to overcome multidimensional challenges in food security. Thornton and Herrero (2015) further highlight the importance of adaptation in mixed farming systems in sub-Saharan Africa in response to climate change. They emphasized the need for innovation in agricultural technology and practices to improve sustainability.

The Food and Nutrition Information System is organized by the Food and Nutrition data and information center which is under and responsible to the Head of the Government Institution. The provincial Food and Nutrition Information System is organized by the provincial regional work unit which carries out tasks or carries out functions in the field of Food Security. The district/city regional Food and Nutrition Information System is organized by the district/city regional work unit which carries out tasks or carries out functions in the field of Food Security.

Food and Nutrition data and information is delivered quickly, precisely and accurately. Food and Nutrition data and information is delivered in Indonesian and can be supplemented with international language that is easy to understand. The Food and Nutrition Information System is implemented based on norms, standards, procedures and criteria determined by the Head of Government Institutions.

DISCUSSION

1. Food Security System

Food security is a condition where food is met for the country and individuals, which is reflected in the availability of sufficient food, both in quantity and quality, safe, diverse, nutritious, equitable and affordable and does not conflict with the religion, beliefs and culture of the community, to be able to live. healthy, active and productive in a sustainable manner (Law Number 18 of 2012 concerning Food). The general section of the explanation of Government Regulation Number 17 of 2015 concerning Food Security and Nutrition states that the Food Security System includes 3 (three) subsystems, namely:

- Availability of food with the main source of provision coming from domestic production and food reserves.

  Food availability is the condition of food being available from domestic production and national food reserves as well as imports if the two main sources cannot meet needs. This means that the source of food supply comes from domestic food production and national food reserves. In the event that food supply sources are insufficient, food can be met by importing food according to needs. The government prioritizes domestic food production to meet food consumption needs. In the event that food availability for consumption needs and food reserves are sufficient, excess domestic food production can be used for other purposes.

  Food provision is realized to meet the food needs and consumption of communities, households and individuals in a sustainable manner. To realize food availability through domestic food production, this is done by:
  - Develop food production that relies on local resources, institutions and culture.

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- Develop the efficiency of the Food Business System.
- Develop facilities, infrastructure and technology for production, post-harvest handling, processing and storage of food.
- Build, rehabilitate and develop food production infrastructure.
- Maintain and develop productive land.
- Build a food production center area.

- Affordability of food for the entire community, both physically and economically.

  Food affordability is a community's ability to access food, both in terms of economic access and physical access. Food affordability from an economic perspective is influenced, among other things, by the level of income or purchasing power, the stability of food prices, and the level of poverty. Apart from that, expenditure on food can also be used as an indicator of food affordability from an economic perspective because it can show the volume and variety of food purchased by the public.

  Food affordability is determined by the performance of food distribution, food trade and food aid. Food distribution is carried out through the development of a food distribution system that reaches all regions effectively and efficiently, management of a food distribution system that can increase food affordability, maintain safety, quality, nutrition, and not conflict with the religion, beliefs and culture of the community, as well as realizing smooth and food distribution security.

  To stabilize the supply and price of staple foods, manage food reserves, and create a healthy food business climate, smooth distribution and trade of staple foods is needed as well as references regarding mechanisms, procedures and maximum amounts of staple food storage by food business actors. In this regulation, food business actors are prohibited from hoarding or storing staple food beyond the maximum quantity and for a certain time. Meanwhile, food assistance is provided to poor communities and people who are food and nutritionally insecure.

- Utilization of food to improve the quality of food consumption and nutrition, including developing food safety.

  Food utilization or food consumption is the type and amount of food consumed by a person or household at a certain time. Food utilization is reflected by individual or household food consumption which is influenced by food availability, food affordability, food consumption patterns, and knowledge of food and nutrition. Policies in the field of food utilization or food consumption include:
  - Developing diverse, nutritionally balanced and safe food consumption patterns
  - Development of food and nutrition networks and information
  - Increased food safety supervision

2. Implementation of Food Security in Regency/City

Referring to the attachment section to Law Number 23 of 2014 concerning Regional Government, the implementation of government affairs in the food sector in Regency/City includes:

- Sub-affairs of Food Administration Based on Sovereignty and Independence
  - Provision of infrastructure and all supports for food independence in various sectors according to district/city regional authority.
- Food Security Implementation Sub-affairs
  - Provision and distribution of staple food or other food according to district/city regional needs in the context of stabilizing food supply and prices.
  - Management of district/city food reserves.
  - Determination of regional minimum prices for local food which are not determined by the Central Government and provincial Regional Governments.
  - Implementation of achieving per capita/annual food consumption targets in accordance with nutritional adequacy figures
- Sub-affairs for Handling Food Insecurity
  - Preparation of sub-district food vulnerability and security maps.
  - Handling district/city food insecurity.
  - Procurement, management and distribution of food reserves for food insecurity covering district/city areas.

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- Food Safety Sub-affairs
  - Implementation of fresh food safety supervision.

3. Food Security System Business Process

Based on the implementation of government affairs in the food sector in the Regency/City, the food security business process can be depicted using a value chain diagram as shown in Figure 4 below:

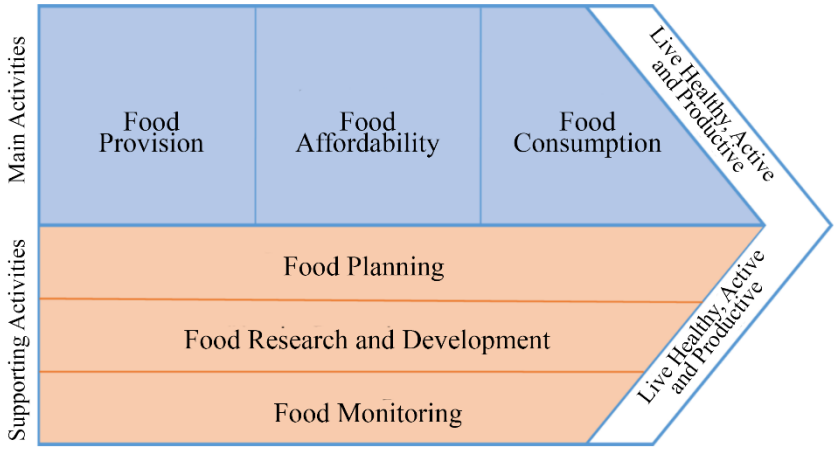

Fig. 4. Food Security Business Process

The main series of activities for implementing food security that are implemented include:

1. Food Provision, activities to ensure food availability so that it can meet the needs of the community (households and individuals), both in terms of quantity, quality, diversity, affordability and safety.
   - Food Production, activities or processes of producing, preparing, processing, making, preserving, packaging, repackaging, and/or changing the form of food.
   - Food Processing
   - Food Storage
   - Food Reserve Management, the process for managing food reserves for human consumption and for dealing with food shortages, supply and price disruptions, and emergencies.
     - Government Food Reserves, management of food reserves by the Government, including Village Government Food Reserves, Regency/City Government Food Reserves, and Provincial Government Food Reserves.
     - Community Food Reserves, management of food reserves by the community at the trader, community and household levels.
2. Food Affordability
   - Food Distribution, a series of activities to distribute food supplies evenly at all times to meet the food needs of the community, so that individuals can obtain food in sufficient quantities, safe, quality, diverse, nutritious and affordable. Food distribution is carried out through the development of:
     - Food Distribution Infrastructure
       - Road infrastructure
       - Railway infrastructure
       - Bridge
       - Freight terminal
       - Suitable warehousing for food distribution
       - Loading and unloading infrastructure
     - Food Distribution Facilities
       - Means of transportation are roads, railways
       - Special transportation facilities for Food Distribution that can maintain safety, quality, nutrition, and do not conflict with the religion, beliefs and culture of the community
       - Loading and unloading facilities
     - Food Distribution Institutions
       - Institutions providing transportation services, loading and unloading services, transportation insurance, and warehousing service institutions

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        - Marketing institute
        - Food distribution arrangements that can facilitate food supply
    - Food Trade, a series of activities in the context of selling and/or purchasing food, including offers to sell food and other activities related to the transfer of food in return for compensation.
        - Stabilization of Food Supply and Prices
            - Food distribution and trade in staple foods
            - Storage of staple foods
        - Food Reserve Management
        - Creation of a Healthy Food Business Climate
    - Food Aid
3. Food Utilization/Consumption, food utilization activities by the community according to the nutritional needs required.
    - Food Consumption
        - Fulfillment of Quantity and Quality of Food Consumption
            - Achieving annual per capita food consumption figures in accordance with nutritional adequacy figures
            - Providing food that is diverse, nutritionally balanced, safe and does not conflict with the religion, beliefs and culture of the community
            - Developing community knowledge and abilities in food consumption patterns that are diverse, nutritionally balanced, high quality and safe
    - Diversity of Food Consumption
        - Handling Food Insecurity, activities to deal with people who are unable to obtain sufficient and suitable food for a healthy and active life, including poor people, people affected by disasters, and/or people who are in geographical conditions where access to food is not affordable.
            - SKPG (Food and Nutrition Awareness System)
            - Food Security and Vulnerability Atlas (FSVA)
    - Implementation of Fresh Food Safety Supervision, activities to monitor the conditions and efforts required to prevent food from possible biological, chemical and other contamination that can disturb, harm and endanger human health and do not conflict with the religion, beliefs and culture of the community so that it is safe for consumption.
        - Providing guarantees for food safety and food quality
        - Supervision

A series of activities that support the implementation of food security which includes:

1. Food Planning, preparing food management plans towards food sovereignty, food independence and food security by taking into account various aspects, such as population growth and distribution, food consumption and nutritional needs, as well as the carrying capacity of natural resources, technology and environmental sustainability.
2. Food Research and Development
3. Food Control, implementation of food supervision which includes monitoring the availability and/or adequacy of staple foods, people's purchasing power, food safety requirements, food quality requirements, food requirements, as well as food labeling and advertising requirements.

CONCLUTION

The development of an integrated food security information system is imperative for ensuring sustainable food security in the face of evolving challenges. The proposed system architecture effectively bridges gaps in current technologies and processes, supporting the availability, affordability, and utilization of food resources. By integrating regional and national data, the system enables efficient planning and timely responses to food security issues. The legal basis and systematic approach outlined in this study ensure that the implementation aligns with national policies, enhancing its practical applicability. This framework serves as a foundational model for other regions aiming to optimize food security through digital transformation.

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