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Optimization path of agricultural products marketing channel based on innovative industrial chain

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Abstract
Optimization path is a complicated issue to manage the manufacture and distribution of fresh food, influenced by several parameters, such as its perishability. Producers cannot ensure that manufacturing and distribution decisions will be efficient and accurate. Using 15 prefecture-level cities in China as a case study, this paper gathers and organizes relevant data indicators of rural economy and agricultural ecological environment economic recovery for the period between 2008 and 2020, builds the composite evaluation index, determines the development index using the reporting system function, and finally employs a novel digital evaluation scheme to assess the coupling and coordination between the cities over time. The following inferences are made. To begin, linear growth with uneven regional development may be seen in the rural economy's complete level index (values from 0.422 to 0.622). The objective of the study is to address the two-stage collaborative planning challenge to maximize farmer income by promoting the economic recovery. This article offers a mixed-integer processing paradigm to account for these restrictions. Calculations show that the suggested collaborative planning model may increase farmers' distributing revenue by 7.98% compared to the existing independent decision-making distribution channel. Management thoughts have been developed based on various decision scenarios. Agricultural producers must sort and bundle their products with care and work with a fast and reliable delivery business and on time to deliver their items. Furthermore, the approach can assess the influence of distribution routes on producers' revenues.

Keywords Path optimization · Industrial chain · Agriculture marketing · Internet of Things

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1 Introduction

Fresh agriculture goods are a daily need for most people. China's fresh goods market has grown at an annual pace of more than 7 percent since 2019, and the market has exceeded 1.81 trillion. Uncertainty, circulatory loss, availability, and transportation are all aspects of perishable agricultural goods (Aly et al. 2017). Due to the multiple circulation connections and lower returns in the multi-echelon production process, the need for fresher agricultural goods cannot be met using the conventional multi-echelon distribution network pattern of manufacturers of agricultural commodities, multi-echelon processed businesses, and retail businesses. Because it omits many intermediary connections and can move fast, agriculture super docking becomes a new distribution chain type (Yu et al. 2021). The agriculture super docking style of the new goods distribution chain has been implemented by many firms, such as Amazon, eBay Company Enterprise, and Alibaba (Goh and Ang 2019).

Local produce e-commerce and agriculture supplier ordering priorities have shifted due to changes in distribution networks. It offers a combined growing and selling choice model for fresher product producers based on an extracting matrix that considers pricing, projected demand, and commodity risk (Barroco and Herrera 2019). The model described in this study can also handle other decisions and planting date, growing area, labor demand, and distribution system choice (Chica-Olmo et al. 2020). The following are two important study approaches in the decision-making process for fresh produce supply chains. Distribution network coordination was examined by Vyhmeister et al. due to the asymmetry of financial data and data on production (International Energy Agency 2019) carried out a strategy decision-making research on the coordinating of interests in a three-tier production process for agricultural goods that are volatile (Khan et al. 2021). According to Xiao et al., farmers might make quick and correct planting and storing decisions based on rainfall unpredictability in the plateau by using a random optimization method. The organization of fresh food has been the subject of several studies. Manufacturing, harvest, transportation, and inventories are the four key decision-making phases in prepared supply chain management models. The applicable model also took into account other options, such as manufacturing resources inputs and technological choices. Through blossoming control throughout transportation and supply monitoring following output, Sun et al. utilized analytical models to predict the development and waste of fresh food and satisfy the highest power projected and investigated citrus production in Brazil and the practical issues that arise (Baek et al. 2020). Certain experts also optimized the manufacturing and delivery of fresh agricultural goods to maximize income. Flower growth seasons and market norms were taken into account in the scheduling algorithm.

The agricultural supply chain is an intricate network that moves food and other agricultural goods across the economy. Commercial agricultural resources must be made available to ensure that the requirement for agricultural goods is met and that their quality and security are not compromised. There are now about

220,000 agricultural businesses in China, most small to medium-sized. The spread of agricultural and commercial resources is generally quite high. Interest-driven accumulation results in abundant agricultural enterprise resources in economically advanced areas. However, coverage is exceedingly poor in rural and impoverished areas, and agricultural enterprise firms have difficulty meeting the needs for agricultural goods, revealing glaring inconsistencies in society. The key to resolving the conflict between the requirement for and supply of corporate agricultural resources has become a public service platform with the goals of "centralized administration of decentralised resources and decentcentralized service of centralised resources." Through virtual aggregation and scheduling of decentralized agricultural business resources, a public service platform may deliver high-quality and inexpensive standardized service to the resource demand side in the point-to-point form. The typical steps are: First, the parties involved in the supply and demand of agricultural business resources make their respective identifiers, the quantities of desired and available resources, the categories of resources, and their rent-seeking statuses available on the public service platform. Second, the public service platform uses multiple cloud-based innovations to realize the "centralised administration of decentralised resources" (Ullah et al. 2020). This is accomplished through the virtual integration of various decentralized agricultural business resources (Xie et al. 2021), the encapsulation of these resources, and the formation of standardized service. Thirdly, the public service platform accomplishes the "decentralised service of centralised resources" via the implementation of dynamic rent-seeking and balancing of the demand and supply of agricultural business resources (Freire-González and Ho 2019). When allocating resources, the public service platform is accessible to supply and demand. It can also offer a "user-centered" push public service, simplifying resource administration for both supply and demand. The public service platform alters the single service mapping partnership among the supply and requirement sides in the conventional mode of resource administration, removes the subordinate relationship among resources and their owners, standardizes the contents and prices of resource services, and coordinates the operation of resources across all levels and links. It is an all-encompassing answer that can improve the macro-level distribution of distributed resources. Some pertinent previous evaluations linked to agri-supply chain administration are described in this part to generate proper support for this study and to situate it in the context of the current scientific research. The agricultural supply chain is the series of steps that begin with harvesting and end with the finished product being consumed. Administration of operations at all levels, from strategic to operational, is necessary for effective coordination. As a result, it comes as no surprise that planning issues constitute one of the most often debated topics in agriculture. The government of the art in manufacturing and allocation planning models for several agri-food commodities was evaluated by Malerba. The authors presented and analyzed a categorization based on key aspects such as optimization method (linear vs. stochastic programming), agri-food commodity studied and study goal. (Malerba et al. 2021), in another critical examination of planning models with an eye toward agriculture, proposes using multi-criteria analysis. There are now three primary areas in China where the rural industrial chain's resilience must be reinforced. To start, the supply chain structure of an industry is quite weak. Agricultural products are generated in rural areas but processed, sold, and serviced in cities. Because of this, the integration of the three industries proceeds slowly, with poor connection for entities of the sector chain, low-level organization, unequal profit allocation among entities, and weak ability to resist emergencies; the sector chain itself is incomplete and has only one variety.

The model included decision factors like planting timing and variety choosing, and the findings showed that it was beneficial in boosting the farm's modest profit. Between the published work and what they are doing now, there are two distinctions. IoT technology significantly influences greenhouse output, and the available literature is intended to assist firms who employ conventional greenhouses. Furthermore, it has not intended to distribute its products using a multi-channel distribution system (MDS). Färe and Grosskopf (2004) designed a planning framework to demonstrate the need for various energy supplies for olive processor firms, while the mitigated investment risks induced by the fact that olives increase every three years.. As a part of their research assessment, Song et al. identified potential study directions in new distribution chain operation management. It was suggested that a linear scheduling algorithm would be used to tackle the retailer's distributing issue supplying fresh fruits and vegetables (He and Shen 2019). IoT agriculture technology advancement and implementation give a strong boost to agricultural modernization. That adds another element to smart agriculture by allowing real-time observation of farming productivity and precise management using fog computing and remote connection technologies. Instruments, controllers, and equipment are connected over the Internet in farming IoT to allow for material-derived power and decision via the Internet. A smaller workforce will be required, leading to an increased number and quality of items produced. Farming IoT helps achieve precision farming, but additional study and practice are needed in economic assessment and business management (Datta et al. 1992).

While many researchers have examined the interplay between the economic and the natural world, certain crucial questions remain unanswered. Few studies have examined rural economics and the natural context of agriculture together. However, the coupling model is rarely applied to studying the interplay between rural economics and the ecological environment system in agriculture to promote economic recovery. There is a lack of studies examining time and space from multiple viewpoints because most studies focus on a single view. Using China's 15 prefecture-level cities as a case study, this article will develop a quantitative evaluation index system for the state's rural economy and agricultural and environmental quality, then use a cutting-edge digital evaluation scheme to assess the relationship between the two over both time and space, as well as to discuss the implications of this finding for policy. The goals of this paper are multifaceted. (1) It thoroughly comprehends the state of the rural economic development and agroecological environmental conservation in Guangxi, investigates the coupling and collaboration between the two, and identifies opportunities for the two systems to grow sustainably. (2) To further, enhance the theoretical system in similar industries, we conduct a thorough and systematic investigation into the intrinsic coupling mechanism between the two. (3) We propose relevant mitigation strategies based on the research findings to serve as a guide and reference for the promotion of economic recovery in China, the promotion of high-quality agricultural production and the assembly of rural ecological sustainability, the improvement of the efficacy and science of agricultural and rural environmental international environmental work, and the realization of humankind's goal of living in harmony with nature. According to the study cited, the distribution network for fresh produce is highly complicated, and internet streaming methods have grown fast with creating the Technology of Things and IoT technologies. A product that is susceptible to spoilage has an impact on production, advertising, and shipping. Current research has given less emphasis to the influence of expanded distribution networks on producers' selling behaviors. In contrast, the influence of fresh produce's obsolescence on its manufacturing and distribution plans was rarely considered. This research considers the perishable nature of fresh food and creates a combined implementation strategy of manufacture and distribution in agriculture IoT to offer farmers appropriate project planning. Four types of distribution networks are included in the concept, including crop insurance, fresh e-commerce, wholesaling, and traditional retailing. The architecture of this paper is as follows. First part introduces the research background. Section 2 presents the theoretical methodology and literature review. The third part gives the data and methods adopted in this paper with the results in Sect. 4. And part 5 shows the discussion and analysis. The final part concludes the summary.

2 Theoretical methodology and literature review

2.1 Literature review

With the COVID-19 epidemic under phased control, governments around the world have begun to work for economic recovery. Compared with the traditional economic recovery plan to stimulate the heavy industry and fossil fuel industry, the "green recovery" of the economy can pull the economy out of the trough. And in the long run, "green recovery" has a stronger role in promoting sustainable economic development. "Double carbon "The vision has brought a huge demand for funds (Kamirul et al. 2023). On the one hand, we should play the role of financial resources allocation, stimulate investment in low-carbon projects, and curb investment in energy-intensive projects. We should guide social capital to flow more to green and low-carbon fields, and promote the realization of the dual-carbon goal. On the other hand, financial funds can play a limited role in supporting the green development of the real economy, and still need to guide social capital investment in a market-oriented way. Carbon formed by financial support, the financial market gives market carbon price signals to encourage and attract resources to lean toward low-carbon projects. A fresher produce's manufacturing process starts with planting and continues through development, harvesting, and storing (Chien et al. 2021). The sale of fresh food is part of the transport process. It is the seeding step that sets the scene for subsequent execution and decision-making in both phases. So long as distributing decisions are based only on expertise, they will likely depart from optimal solutions in a multidimensional context, making it more difficult for producers to maximize their profits.

Subsequently, the outer atmosphere of the industrial chain is weak, and the technological R&D and technology capacities are poor due to increased low-level duplication, a lack of awareness of independent growth, and inadequate expenditure on scientific research (market environment, economic support, government policy, legal environment, public pressure, etc.). However, the kind, quantity, and quality of goods can rarely match consumer demand because the agricultural manufacturing cycle is too protracted to adjust swiftly to changes in the external environment and market scenario. The lack of concern for environmental preservation during the production, processing and distribution of agricultural products has led to severe environmental pollution, putting these businesses in the position of having to contend with both government regulations enforcing environmental protection policies and farmers' efforts to improve the quality of life in rural areas. (Schoderer et al. 2021) The resilience of the rural industrial chain must, therefore, be strengthened to increase the rural economy's ability to weather the effects of the outbreak. The rapid transformation has directly impacted each participant in the agricultural supply chain that the industry has seen over the last several decades (cf. Figure 2). The effects of research at the farm level are the focus of many reviews. In this context, Bessembinder (1991) examined simulation-based techniques to assist innovations in agricultural systems, drawing on a literature study and the authors' own experience. Previously, offered an operations research-focused assessment of issues in agricultural planning, especially at the farm level, that applied to both the crop and animal sectors. Cropping strategy, harvesting procedures, capital expenditure for crop manufacturing, and pest and disease management are the four primary lenses through which this discussion of the agricultural manufacturing industry has been conducted. Diet and ration design, feeding strategy for intensive livestock manufacturing, pasture-based livestock production, animal breeding and replacement, waste management, and livestock manufacturing unit planning have all been examined as they pertain to livestock manufacturing.

As a result of globalization, population growth, commercial strategies, consumer preferences, climate change, and technological advances, not only the financial factor, but also the social and ecological ones are under close examination. Sustainable agriculture is a hot subject in the global strategy arena because it considers all three dimensions—economic, social, and environmental. The sustainability viewpoint in the decision-making process encompassing simultaneously: financial profitability, ecological health, and social and financial equality is one of the most remarkable study fields in agri-supply chain management. According to (Smith and Stulz 1985), the past ten years have dramatically increased theoretical and applied for work in this area. (Pincus and Winters 2019) reviewed the literature in the food sector to explain how sustainable supply chain administration strategies help businesses maintain control of their supply chain and gain an edge in the marketplace via adaptive systems. As a bonus, Akkerman et al. highlight the benefits of quantitative operations administration strategies for food distribution administration. Before this, (Diao et al. 2019) proposed using operations research to analyze farmers' food security issues in emerging nations. (Jiang et al. 2020) offered a comprehensive inventory of operation research applications. They highlighted their capacity to deal with the inherent complexity of agricultural value chains, especially in cases where system resilience and sustainability are paramount. Also, the book by Jinzhou (2011) is noteworthy because it provides a summary of the mathematical models available to agriculturalists and how they can be used to address practical issues faced by decision-managers in the field of crop and animal management, such as the impact of digestion on animal growth rates and the effect of photosynthesis levels on crop yield.

Determination is further complicated by the perishable nature of fresh food, which forces workers to grow short-term distribution judgments. Time and amount of seed sowing directly impact agricultural yield and dispersion of fresh fruit and vegetables. Since farmers earn more money from fresh products, the proposed model concentrates on the manufacturing and transportation processes. This section tries to convey the problem's origins and the context in an intuitive manner.

The architecture of the new e-commerce distribution chain of the proposed MIPP has planted, cultivating, harvesting, and warehouse modules. The consumer can buy goods from contract farming, wholesale, retail, and order evaluation. The agricultural IoT devices are used to collect the data from the farmlands and are given to the industrial supply chain. Conversely, wholesalers and retail marketing channels remain the conventional routes for most farmers because of their lower occupancy barrier (Erahman et al. 2016). As a study target, it selects good agricultural producers of a specific size that use IoT technologies and engage in online marketing.

Four alternative supply chains, including agriculture insurance, wholesale markets, traditional retailing, and fresh e-commerce, are expected to be used by the producers. Market pricing, timeliness constraints, and projected demand are all features of distinct channels. Examples of explicit rules are higher and lower supply levels, product standards, and selling prices in agriculture insurance. As part of the contract, producers must deliver items that fulfill the quality criteria within an acceptable resource utilization. Distributors of agricultural goods typically acquire products on-site and inspect them before making a formal acquisition. Thus, producers are not responsible for the loss or degradation of products once sold to a distributor.

Customers will have access to commodities just as they do in the dealer networks, and producers are not responsible for improved yield after products have been sold. Costs associated with transporting, packing, and labor will increase when producers sell their commodities on an e-commerce site that sells fresh fruit. For customers to get fresh food on time after placing an order online, producers must guarantee that the manufacturer's quality can be controlled during transit.

This paper's study challenge considers the features of different distribution networks and their interaction with seed sowing to accomplish collaborative decision-making on the manufacture and distribution of fresh fruit and vegetables and optimize farmers' revenue (Hafner et al. 2020). IoT agriculture technology advancement and implementation give a strong boost to agricultural modernization. When IoT uses cloud technology and remote communications technology, it is feasible to monitor and operate farms quickly, giving smart farming a different element.

The IoT-enabled smart agriculture model of the proposed MIPP is depicted in Fig. 1. It has two modules such as monitoring equipment, terminal equipment, and control

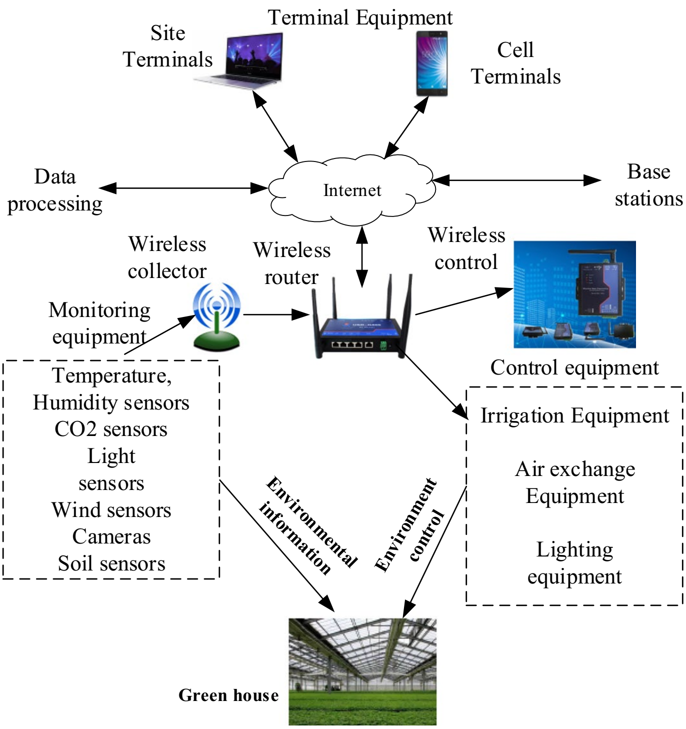


Fig. 1 IoT-enabled smart agriculture model of the proposed MIPP

equipment. Instruments, controllers, and devices are interconnected through the Internet in agriculture IoT. That allows for remote interactive analysis and decision generation. Thus, workforce and manufacturing processes will be reduced, while ownership and revenue will grow. But additional study and practice are needed to understand the economics of agriculture IoT and the financial and e-commerce methods based on IoT.

This research shows that agriculture IoT operations are very real-time, accurate, and analytical (Brunner and Norouzi 2021). Real-time monitoring of the field environment and exact management of that environment can improve agricultural production and quality while decreasing pesticide, fertilization, and financial impact investments. The following subsection examines the manufacturing and distribution of fresh food in agriculture IoT and develops a collaborative conceptual framework for the issue.

2.2 Theoretical methodology

2.2.1 Strategic planning

Farmers of fresh food are classified as the initial stage in planning. First, it looks at the types of fresh fruit and vegetables that farmers are growing, and then it looks at the distribution networks that farmers are now using and those that they may use in the potential. A farmer's projected income can be calculated after determining their attributes (The World Bank 2015). When it comes to determining duration, there is a big gap between cost and returns. It may utilize intermediary techniques to determine the temporal difference in cost and yield when healthy food, especially biennial plants, is produced regularly. Crop management matrices are used to resolve this issue in this study.

The workflow of the proposed MIPP is shown in Fig. 2. The expected price and yield of the area are considered as the inputs. Base on demand, the planning and harvesting matrix is calculated and the expected return. The joint decision model is designed based on the characteristics of features and optimal decisions. The resultant parameters are denoted as resource constraint, channel demand, and production cost. The yield and quality of each harvesting season may be calculated by combining history yield and quality with a planted and harvested matrix. Farmers may then calculate the predicted rate of return on the mix of yield in each period and the projected price (based on previous prices). It is integrated with the variables and features of rural farmers in joint modeling to get the best choice.

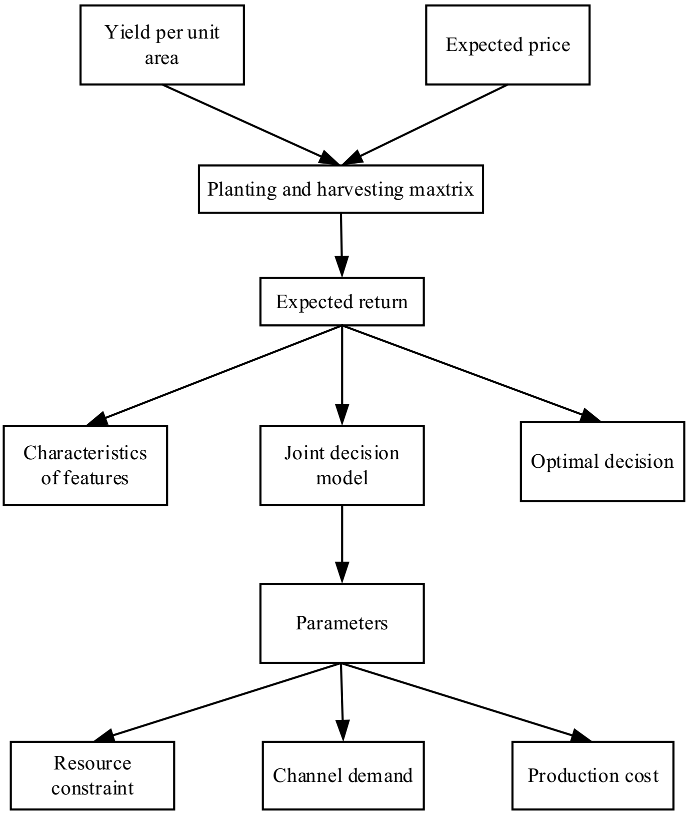


Fig. 2 Workflow of the proposed MIPP

MIPP is a strategy that optimizes revenues for farmers. As a result of the model's outputs, suggestions are made for both strategy and tactics matters, such as which marketplaces are targeted and what type of agriculture IoT technology will be used.

2.2.2 Industrial supply chain model

Variables of industrial supply chain model are shown in Table 1.

One entry for every m kinds of fruits and vegetables may be found at this facility $s_x\left(s_x \in S,\ S\ \left\{s_1,\ s_2, \cdots, s_m\right\}\right)$. For each of the n distinct packing orders $p_x\left(p_x \in P,\ P = \left\{p_1, p_2, \cdots, p_m\right\}\right)$, m various kinds and amounts of produce $s_x\left(s_x \in S, S = \left\{s_1, s_2, \cdots, n\right\}, 1, 2, \cdots, m\right)$, and q_{xy}., respectively, are required for the order p_x. The numerical value of the proposed logistics planning phase may be represented in Equation (1, 2 and 3):

$$\max\,(\text{size}) = f(p) \tag{1}$$

$$\text{sub} : p_x \in \left(P\left(ifp_x = \frac{\sum_{y=1}^{m} q_{xy}}{m}\right)\right) \tag{2}$$

$$q_{xy} = q_y \in Q \tag{3}$$

A fruit or vegetable has been assigned to Q in Eq. (3). This data is calculated when C_x is coordinated (Yi et al. 2021). Finding a sequence of backpacks that minimize the value function $f(p)$ is the goal of this exercise. The quality of the agricultural products are represented $q_y(y = 1, 2, \cdots, m)$. The likelihood function is denoted p_x. The two-dimensional matrix input is denoted q_{xy}. A fresh produce type and quantity are specified in the order p_x. The number of fruits and vegetables that fulfill the order's requirements cannot surpass the inventory's quantity of fresh vegetables. Traditional scheduling problems have an optimal solution based on totaling up all requests that were fulfilled. Equation (4) is used to calculate the functional value:

Table 1 Variables of industrial supply chain model

Number	Variables	Meaning
1	m	kinds of fruits and vegetables
2	s_x	Entry for m
3	p_x	Distinct packing orders
4	q_{xy}	Two-dimensional matrix input
5	$f(p)$	minimize the value function
6	$\tau(x, y)$	The use of pheromones quantity
7	τ_O	The accessibility function of the input
8	$\tau(x, d)$	The intensity of the decision function
9	$\eta(x, d)$	The accessibility of the decision function

$$f(p) = \sum_{y=1}^{m} p_x \tag{4}$$

For the optimization problem, the ant colony method is employed. The likelihood condition of the given input is denoted p_x. The output is maximized under the determined appropriately. It is the fundamental ant colony method concept—the use of pheromones quantity $\tau(x, y)$ in determining node access rate. In general, the concentration increases when the frequency of visits to the site is increased.

This relationship between visibility and distance $\eta(x, y) = \frac{1}{c_{xy}}$ may be seen by looking at the relationship. The visibility $\eta(x, y)$ decreases as the gap between the two locations increases. A likelihood value that a vertex will be picked when moving from one vertex to the next. The method for transferring funds is shown in Eq. (5):

$$P(x, y) = \begin{cases} \frac{\tau(x,y)^{\gamma}\eta(x,y)^{\beta}}{\sum_{d=0}^{n}\tau(x,d)^{\gamma}\eta(x,d)^{\beta}} & y \in M_d \\ 0 & \text{else} \end{cases} \tag{5}$$

It is represented by M_d in Eq. (5). They are used to adjust the relative importance of the relationship between $\tau(x, d)$ and $\eta(x, d)$ Pheromones intensity and accessibility are denoted γ, β. There is some evidence to suggest that the best value of α is approximately one and that the maximum value of β is between 3 and 6.

$\eta(x, y) = \frac{1}{c_{xy}}$ is the accessibility, defined by $\eta(x, y)$. Local updating of agricultural item transportation in new chain management pheromones (Eq. (6)) indicates the leftover coefficients of logistics and transport pheromones and is the residual variable of fresh produce distribution network pheromone $\mu(0, 1)$ renewing Eq. (7). As the first pheromones of logistics operations, τ_O is released.

$$\tau_u(x, y) = \mu\tau_l(x, y) + (1 - \mu)\tau_O \tag{6}$$

$$\nabla\tau(x, y) = \begin{cases} \frac{1}{D} & if \text{ dges are in the optimum pat}h \\ 0 & \text{else} \end{cases} \tag{7}$$

The accessibility function of the input is denoted τ_O. The intensity and the accessibility of the decision function are denoted $\tau(x,\ d)$ and $\eta(x,\ d)$. In terms of agricultural logistics, D provides the best route length to date. More ants can pick the ideal marine transportation route using the optimum path's information input, (Kiranyaz et al. 2021) accelerating convergence. Including this algorithm, it chooses the next transportation client from the consumer point x if ant y is located at that place is indicated in Eq. (8)

$$Pr_d(x, y) = \begin{cases} \min\left(\tau(x, y)^{\gamma}\eta(x, y)^{\beta}\right) & q < q_O \\ p & \text{else} \end{cases} \tag{8}$$

q is the random integer between (0,1) in Eq. (8) and $q_O(0 < q_O < 1)$ is the consistent. When $q < q_O$, the optimal path, or the one with the maximum likelihood, is selected from the gathered data, which is termed deterministic searching. $\tau(x, d)$ and $\eta(x, d)$ are denoted the input decision function. The likelihood function is denoted p.

This method guides marine logistics paths based on (Banerjee et al. 2021) the information provided, which increases the convergence speed. Mutation operator occurs when $q > q_O$. By changing q_O, the method's conversion reactions are increased.

It has been shown that when it is too big, the likelihood of selecting the sought path is raised. That harms the universal search capabilities of the agricultural logistics node allocation according to the fundamental evolutionary algorithm. μ is too high in that case. Creating a locally optimum solution is a simple process (Ren & Dong 2018). Equation (9) is used to modify in this article:

$$\mu(x+1) = \begin{cases} \min\left(\beta\mu(x),\ \mu_{\max}\right) & d = d_{\max} \\ \mu(x) & \text{else} \end{cases} \tag{9}$$

They include $\beta(0 < \beta < 1)$, a variable used to controller's lowering speed μ, and μ's maximum value, minimum, which avoids the computational efficiency from being affected when's valuation are too little. In other words, d is the number of times that must pass until the outcome is no longer variable. $d_{\max}$ is a constant that (Hotel et al. 2013) cannot be changed and indicates the maximum value.

After the consumer has ordered the product, the delivery location is noted, and then custom inspection is done and then shipped to the final destination. This article presents the notion of $\tau(x, y)$ balancing in the proposed framework and utilizes mean and variance for constraint. The marine logistics node dispersion patterns on each edge are limited to $\left[\tau_{\text{mn}}, \tau_{\text{mx}}\right]$. Equations (10) and (11) are used to determine τ_{mn} and τ_{mx}.

$$\tau_{mn} = \frac{\tau_{mx}}{25} \tag{10}$$

$$\tau_{\text{mx}} = \frac{1}{3(1-\mu)} \times \frac{1}{D} \tag{11}$$

If $\tau_n(x, y)$, then $\tau_n(x, y) = \tau_{\text{mn}}$; if $\tau_n(x, y) > \tau_{\text{mx}}$, let $\tau_n(x, y) = \tau_{\text{mx}}$. Each iteration $\nabla\tau(x, y)$ of the agricultural transportation node dispersion path pheromones increases by $1/D$. Therefore, τ_{mn} and τ_{mx} may be determined using the above equations.

A vegetable and fruit distribution system has now been optimized concerning the organic organization. Field research was used to simplify variables that would assist the creation of an MIPP framework and focus on collaborative decision-making difficulties.

- The output of fresh food, the market value of distribution routes, and the projected demand may all be forecasted when planning decisions are made. Inanities of making important decisions, producers can develop empirical estimations of future industry trends and agricultural production. In addition, producers may receive more competitive market and agricultural information through expert consultations and other methods. The applicability of this hypothesis is therefore unaffected.
- On the field trip to Jingyang Town, Xian Province, China, farmers quickly sell fresh food. The poor penetration level of processing and packaging is to blame.

Producers in this circumstance have difficulties acquiring cold storage space directly, which leads to a scenario where fresh crops are sold immediately after harvest to minimize post-harvest wastage.

- Every week, producers make the decisions on growing and marketing. Fresh food is produced in cycles, which means that its output fluctuates. As a result, the producers' decision-making procedure is likewise cyclical. According to a research analysis and field investigation, weekly management decisions are appropriate for producers who yearly cultivate fresh fruits and vegetables.
- For e-commerce distributing, third-party transportation can ensure that fresh product is transported in a healthy atmosphere. Prepared food post-harvest losses are determined by time and the transporting conditions, with time being the most important element among factors. To the extent that the proposed research is concerned with the influence of time on customer satisfaction, it believes that the transporting atmosphere can be optimized.
- Distributors can sell all items to producers. That is a reasonable premise, so because high selling production of natural products, such as cheap veggies damage producers, is more responsible for the delayed sales of farm commodities than the lack of outlets.

2.2.3 Experimental analysis procedure

A structured framework integrating the DEMATEL technique is developed to discover cause-effect relationships and mutual interrelationships, examine the influencing power and dependence amplitudes of the optimized formulation of problems in the Chinese scenario. DEMATEL is well-suited to crucial and complicated circumstances. Due to their complementarity, DEMATEL may be used to improve the methodology and help the decision-making processes. DEMATEL helps discover cause-effect interrelationships amongst criteria, whereas it helps establish relationships between them.

As a result of DEMATEL's technique, it is easier to see causal links between requirements. Graphs (or phonetic symbols) illustrating a causal connection between parameters are produced using DEMATEL analysis. That is especially important for parameters playing a major role or holding the highest influence power.

DEMATEL's process may be described as follows:

2.3 Phase 1:

By getting the connections, build a pair-wise straight interactions vector between the controller parameters.

2.4 Phase 2:

The direct connections matrix is normalized to get the starting influence vector.

2.5 Phase 3:

A whole relation matrix is found by completing.

2.6 Phase 4:

Using the causal graph, determine the relative intensities of the various factors.

2.7 Phase 5:

Phase 4 results are then divided into several levels.

2.8 Phase 6:

The directional graph is created by examining the interrelationships from the attribute table. Eventually, the inferential linkages are broken.

2.9 Phase 7:

By substituting the nodal numbers with assertions, the digraph is converted into the proposed framework of critical issues.

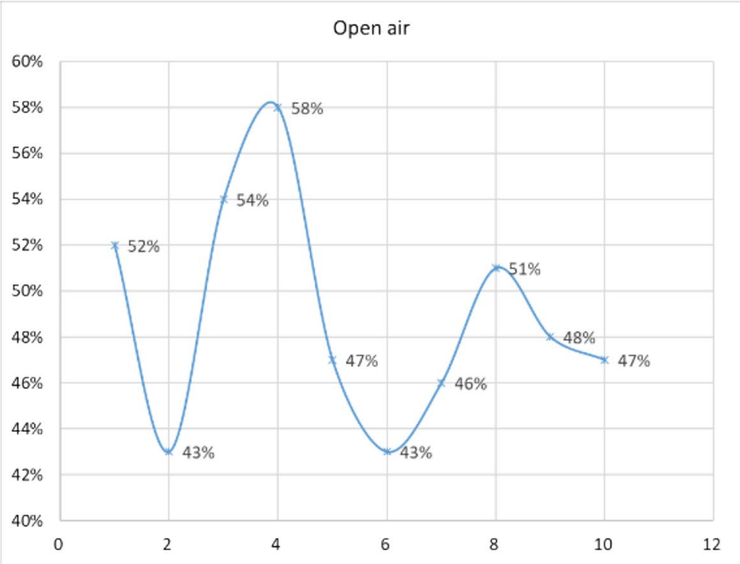
2.10 Phase 8:

There are no discrepancies in the proposed framework. Therefore, it is validated and evaluated.

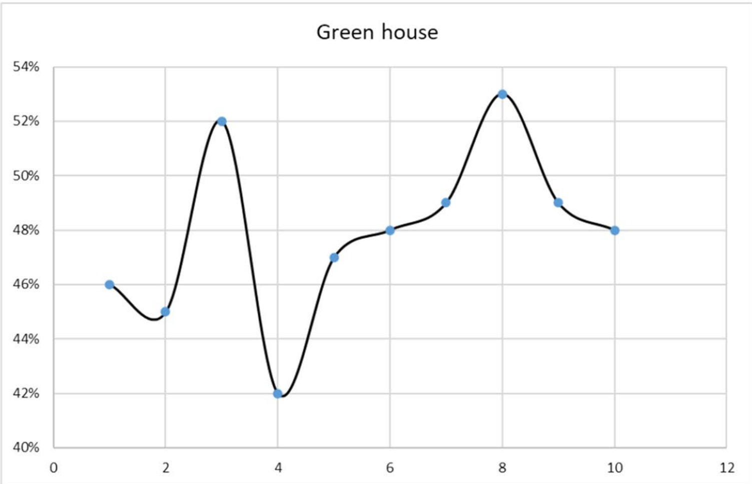
3 Data and methods

The simulation analysis is carried out on an analysis of tomato producers in Qinghai Province, China, who utilize agricultural IoT to verify the adequacy of the scale. In the joint planning model, pricing and projected yields are the two most important elements influencing manufacturing and distribution. Chinese agricultural goods' (Ju et al. 2015) financial data from the public sector platform shows the pricing variations for tomatoes from November 2017 to January 2020 at Yunyang Vegetables Retail Market in Jingyang, Shandong, which are considered for the analysis.

The yield analysis of the open-air and greenhouse condition of the proposed MIPP are depicted in Fig. 3a and 3b. The simulation is carried out using the simulation tool with the help of the given dataset. The simulation is analyzed for ten months, and the yield of the particular area is measured monthly and noted. The measured results for the open area and greenhouse are plotted in the above figures



(a) Yield analysis of the open-air condition



(b) Yield analysis of the greenhouse condition

Fig. 3 **a** Yield analysis of the open-air condition, **b** Yield analysis of the greenhouse condition

(Ghorbanpour et al. 2021). The result in Table 2 indicates the effectiveness of the proposed MIPP model in detecting and producing yields based on consumer demands.

Table 2 shows the yield analysis of the proposed MIPP model. The simulation is analyzed using the simulation tool by varying the monitoring period from a minimum to a maximum of 10 months. The simulation analysis of the open-air and

Table 2 Yield analysis of the proposed MIPP model

Period (month)	Open air (%)	Green house (%)
1	52	46
2	43	45
3	54	52
4	58	42
5	47	45
6	43	48
7	46	49
8	51	53
9	48	49
10	47	48

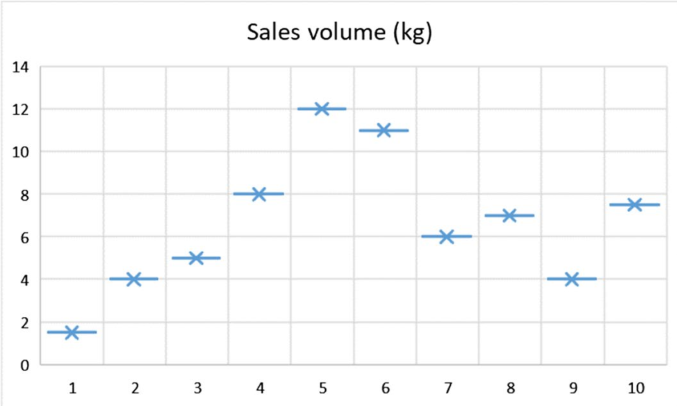
greenhouse is considered for the simulation analysis. (Apostoleris et al. 2019) The yield analysis of the particular area is analyzed and tabulated in the above table. The simulation outcome of the proposed MIPP model is analyzed and noted for every month. The results in Table 3 indicate the effectiveness of the proposed MIPP model in all the conditions.

The simulation outcome analysis of the proposed MIPP model is shown in Table 2. The planting area for the simulation analysis is varied from a minimum of 1H to a maximum of 8H with a step size of 1H. The average planting ratio and the average revenue increase in the particular area are measured and tabulated in the above table. (Wang et al. 2021) The variations in the outcomes are measured and compared with each other. The result indicates the effectiveness of the proposed MIPP model in all the conditions.

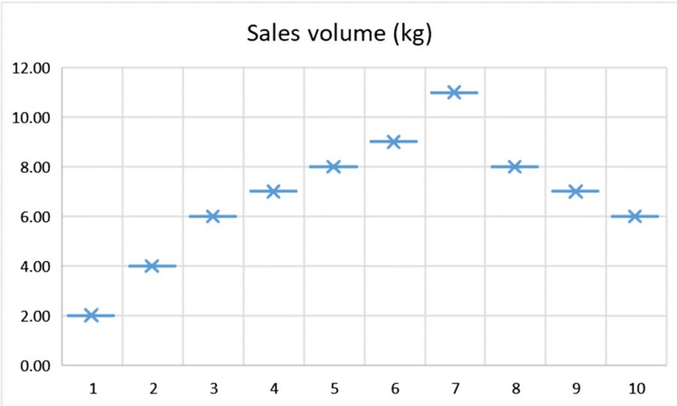
Figure 4a and 4b shows the sales volume analysis of the open-air and greenhouse conditions, respectively. The simulation is analyzed by varying the distribution week from a minimum of 1 week to a maximum of 10 weeks with a step size of 1 week. The simulation outcome of the proposed MIPP model is analyzed for two different

Table 3 Simulation outcome analysis of the proposed MIPP model

Planting area (*H*)	Average planting ratio (%)	Average revenue increase (%)
1	9.72	7.82
2	7.24	6.42
3	3.24	3.54
4	4.95	4.24
5	3.65	4.59
6	1.68	4.85
7	1.95	4.21
8	2.54	5.67



(a) Sales volume analysis of the open-air condition



(b) Sales volume analysis of the greenhouse condition

Fig. 4 **a** Sales volume analysis of the open-air condition, **b** Sales volume analysis of the greenhouse condition

conditions and plotted in the above figures. As the distribution week increases, the respective sales volume of the model increases and decreases after some time.

The proposed MIPP model is designed, analyzed, and the performance is compared in this section. The simulation outcomes of the proposed MIPP model are analyzed and shown. The measured results indicate the effectiveness of the proposed MIPP model in all the scenarios.

4 Results

The word “resilience,” created in the engineering sector, initially referred to the power or capacity of a substance to return to its former shape, position, etc., after being bent, crushed, or stretched. Higher resilience means the importance is less prone to crack under stress. The idea gained popularity in natural ecology in the 1970s (Suzigan et al. 2020), when it was used to highlight the resilience of natural ecosystems in the face of disruption. In the 1980s, it began to spread to the social system, with a shift in emphasis from the capacity to adapt to one's environment to the capability to provide novel solutions to problems posed by a tainted social order. In recent years, resilience theory in Table 4 has been broadly concerned with psychology, engineering, natural catastrophes, risk administration, energy system, hospital data systems, supply chains.

The study on resilience in China is still in its infancy, primarily concentrating on the research on the strength of urban engineering after acute shock (Zhang et al. 2019). The outcomes of resilience research overseas are centered on urban planning, engineering, and ecology. The Western equivalents of the Chinese concept of "sector chain" are "supply chain" and "value chain," respectively. Researchers have looked at supply chain robustness, specifically at its evolution process, assessment, control, and optimization (Baloch et al. 2021). The agility of the supply chain and entity cooperation potential (B. Lin & Zhu 2019); the adaptability of coding, transportation, and operation administration. and the resilience of the supply chain itself all contribute to the operational and economic achievement issues in the dynamic corporate of integrated businesses in the mutation atmosphere of Table 5. The degree of supply chain dislocation relies on both the design characteristics and availability of the supply chain (J. Tu et al. 2019), and resilience may be employed to cope with supply chain susceptibility to harm and its harmful repercussions (Xu et al. 2019).

China might create a closed network by establishing energy recycling connections within and beyond industries in Table 6. It can potentially increase the effectiveness of biomass energy generation and use and will shift conventional farming away from a growth model predicated on increased energy consumption. As a new concept, the resilience of the eco-industrial chain emphasizes the utilization of resources to improve environmental effectiveness and reduce environmental pollution. The related study adheres to the current needs for green growth of the contemporary industrial chain. While household research on eco-industrial chain resilience is still in its infancy, some progress has been achieved in international settings (Kuzemko et al. 2020). Currently, this research has three problems.

To begin with, the resilience of agriculture products has not yet been included in the study, but that of regional eco-industrial chains has. The second issue is that resilience's management for various stages of eco-industrial chain growth is lacking. There has not been enough practical study on eco-industrial chain resilience throughout the growth phase. Thirdly, authorities were not provided with strategic guidance and a realization road to increase the eco-industrial chain's strength due to a shortage of research on the resilience development approach.

Supporting the decoupling of financial development and human well-being from primary resource usage, reducing pressure on land, minimizing negative impacts on biodiversity, and ensuring global food security all depend on the efficient transformation of wastes. However, effectively monetizing waste is a challenging interdisciplinary issue that requires familiarity with the material, technology, market, and socio-economic concerns associated with the side-stream valorization (Bank 2010). Agricultural waste and by-products have been studied from a technological

Table 4 Secondary index weight of rural economic index system

Target layer	Index layer	2008	2009	2014	2020
Agricultural input level	Share of total government spending on agriculture	0.0765	0.0776	0.2345	0.0564
	Statistical distribution of agricultural scientists and technologists	0.0765	0.0776	0.0765	0.0876
	The electrical output of farm equipment in agricultural production	0.0834	0.0432	0.0856	0.0776
	The screen selected land	0.5543	0.0548	0.5672	0.6657
Agricultural output level	Economic benefit of key industries	0.0886	0.0548	0.0776	0.0665
	Produced cereal per person	0.0876	0.0943	0.0887	0.0776
	Land productivity	0.1665	0.2776	0.7654	0.2265
	Gains in Efficiency from agriculture workers	0.2567	0.4567	0.8876	0.4356
Farmers' living standards	Money made per person in rural regions	0.0876	0.0765	0.0665	0.0887
	Comparative analysis of urban and rural per income level	0.0865	0.0654	0.0665	0.0776
	The Engel Constant of Rural Communities	0.0665	0.2876	0.0821	0.0887
	Area of rural dwellings on a per unit expenditure	0.2876	0.0765	0.0776	0.0865

Table5 Comprehensive level index of rural economy in Chinese provinces

Provinces	2008	2009	2014	2020
Zhejiang	0.677	0.543	0.876	0.766
Yunnan,	0.176	0.456	0.553	0.562
Sichuan	0.775	0.887	0.887	0.865
Shanxi,	0.365	0.288	0.776	0.567
Shandong	0.265	0.288	0.665	0.887
Shaanxi	0.876	0.298	0.987	0.998
Qinghai	0.528	0.325	0.856	0.884
Liaoning	0.543	0.546	0.776	0.324
Jilin	0.287	0.544	0.554	0.554
Jiangxi	0.657	0.482	0.698	0.776
Hebei	0.176	0.342	0.665	0.776
Hainan				
Heilongjiang	0.234	0.675	0.445	0.765
	0.543	0.987	0.776	0.776
Henan	0.654	0.654	0.776	0.775

Table 6 China rural economic target level index

Particular year	Agricultural input level	Agricultural output level	Farmers' living standards
2008	0.112	0.153	0.041
2009	0.228	0.887	0.066
2010	0.776	0.776	0.077
2011	0.876	0.276	0.065
2012	0.876	0.265	0.043
2013	0.654	0.295	0.065
2014	0.566	0.255	0.076
2015	0.287	0.287	0.276
2016	0.143	0.176	0.275
2017	0.554	0.154	0.243
2018	0.322	0.165	0.253
2019	0.776	0.176	0.278
2020	0.887	0.186	0.234

standpoint (Kougias et al. 2021), such as anaerobic digestion, biorefinery (Lee et al. 2014), or bio-catalysis (Pellis et al. Research on agricultural waste have been performed for over 60 years, mostly in the USA, India, and China, but also in Latin America (Brazil and Mexico, as well as Chile, Colombia, Peru, Trinidad-Tobago and other countries), and in Europe with a particular accentuation on capturing and reprocessing of nutrients in the manufacturing fields themselves(Lin et al. 2021). The number of articles has considerably grown in the last 13 years; this connects with the adoption of the new legislative structures for sustainable growth and new policies and tactics for a circular financial system and a bio-economy.

One viable approach to making biomass valorizations possible is for enterprises to locate in close proximity to one another (Lv et al. 2021). The concept of commercial symbiosis, or cooperation between businesses to increase resource effectiveness, has gained popularity in recent years, drawing attention to eco-industrial parks. While most eco-industrial parks focus on the petrochemical, chemical, or multi-industrial sectors, there are also projects and studies focused on the cross-chain valorization of agricultural by-products in various parts of the world (for agro parks or agro-industrial symbiosis, e.g., increase the potential of agricultural biomass without putting stress on land uses or plant performance through research and development, enterprise modeling, and the establishment of framework conditions that allow for the full conversion of the fresh weight of harvested crops (food plus agricultural waste) into food/feed, bio-energy, and bio-based products. Further, customers' adoption of reused or waste-based goods must be prompted, and knowledge must grow regarding valorization and advertising prospects in alternative industries (Gilal et al. 2020). Innovative upgrading technologies coupled with new enterprise models and marketing strategies are necessary to use agricultural waste and by-products efficiently.

Southern Shaanxi, China's rural economic structure is primarily agricultural, with poor terrestrial energy and slow social development. However, the region's rich natural resources, profound culture, green agriculture, traditional Chinese medicine industry, and ecotourism have flourished thanks to a strong ecological resource foundation. On the other hand, the short eco-industrial chain and poor brand impact of core industries in the area substantially limit the sustainable growth of the rural environmental sector in Southern Shaanxi because of the cumbersome transportation in the mountains. In order to achieve the sustainable growth of the rural environmental sector in Southern Shaanxi, it is crucial to address the vulnerability of RBEEIC and conduct resilience to realize rural revitalization there. This will help to improve agricultural growth, countryside beauty, and rich farmers.

Diosgenin has significant medical value and cost since it is a natural raw material used to produce several medications. The finest growing location for Peltate Yam Rhizome is in Southern Shaanxi, China, where it has been cultivated and processed since the 1990s. The Peltate Yam Rhizome sector is a key pillar in the fight against rural poverty. (Luo et al. 2019) However, it faces two main obstacles to its growth: inefficient use of resources and widespread ecological damage. In this paper, we examine the three stages of Peltate Yam Rhizome eco-industrial chain growth in the countryside of Shangluo, Southern Shaanxi, focusing on the leading enterprises in Qiandianzi Village, Manchuanguan Town, Shanyang County, Shaanxi. We provide a summary of the eco-industrial chain models adopted at each stage and an analysis of the effects of various types of resilience.

5 Discussion and analysis

Founded in June 2002 in Qiandianzi Village, Manchuanguan Town, Shanyang County, Shaanxi, China, Jinchuan Fengxing Chemical Co., Ltd. (in the future referred to as Jinchuan) is a leading business in agricultural modernization and a demonstration enterprise of circular growth in Shaanxi, China. Initially, Jinchuan exclusively used conventional methods for cultivating and harvesting Peltate Yam Rhizome. Since 2007, Jinchuan has collaborated with the Chinese Research Academy of Environmental Sciences and the Shaanxi Academy of Environmental Sciences to establish the demonstration project (Dangelico 2016) of diosgenin cleaner manufacturing, scaling up production from 99 tons per year to 200 tons per year to 1,000 tons per year. The Shaanxi Environmental Protection Department has spearheaded this effort. As a result of this project, not only was the environmental pollution caused by classifying Peltate Yam Rhizome eliminated, but also higher-value starch and cellulose were decomposed in the process of making diosgenin; (Tu et al. 2021) coal, water, acid, and oil usage were reduced by more than 70%; COD was reduced by more than 80%, and the standard discharge of wastewater was achieved; the production cost of the business was decreased, and the financial findings were enhanced. This project helped to establish an eco-industrial complex.

Based on the advantages of Peltate Yam Rhizome resources and the world's leading Peltate Yam Rhizome cleaner technology, the Shanyang Xinfa Dairy Farm Limited, the Shanyang Libo Biological-tech Co., Ltd., the Shanyang Qinnan (Montgomery and Mazzei 2020) Tea Industry Co., Ltd., and the Shaanxi Jinchuan Pharmaceutical Circular Economy Industrial Park were established in 2011 in response to the needs of the province, city, and county to develop the ecological The park's primary focus is on the eco-industrial chain of Peltate Yam Rhizome, from planting and cleaner processing to the comprehensive utilization of Peltate Yam Rhizome by-products in the creation of feed, alcohol, pig breeding, lotus root breeding, tea garden planting, diene, W-oxide, and progesterone production projects. In addition, the park's central focus on recycling helps it turn trash from planting, breeding, and processing into organic fertilizers and clean energy (Hamwey et al. 2013). Thus, the eco-industrial chain is formed as follows: "Peltate Yam Rhizome planting—> cleaner processing—> diosgenin—> diene, W-oxide—> progesterone," "Peltate Yam Rhizome planting—> cleaner processing—> lignin—> alcohol," "Peltate Yam Rhizome planting—> cleaner processing—> starch extraction—> green high-protein feed—> pig breeding—> biogas and Table 7 shows that the amount of waste gas produced by users of biogas is far smaller than that of users of conventional fuels, which has a clear positive influence on the environment.

In Qiandianzi Village, Manchuanguan Town, Shanyang County, Shangluo, Shaanxi, China, "Shangluo Qinling Eco-agricultural Demonstration Park" was constructed with support from the state and government in response to a national call to develop ecological agriculture and promote the construction of beautiful countryside. Based on Peltate Yam Rhizome processing, feed manufacturing, special agricultural merchandise cultivation, organic food preparation, bio-natural gas production, and bio-organic

Table 7 Comparison of indoor environmental quality between biogas and coal-burning households (mg/m^3)

	CO	SO_2	CO_2	TSP
Biogas households	3.221	0.121	0.061	0.239
Coal burning households	7.221	0.675	0.080	1.059

fertilizer refining, with the addition of photovoltaic and leisure tourism industries, the park will build a system to advance the main industry, energy, and tourism in Table 8. Feeds containing Peltate Yam Rhizome by-products have been researched and, where appropriate, incorporated into other feeds since a research and development center was set up in collaboration with Northwest Agricultural and Forestry University. Jinchuan has developed a standard (van Vuuren et al. 2017) planting demonstration base and an industry chain technical information service center of Peltate Yam Rhizome, and it regularly provides technical training for locals. A tri-industry eco-chain is formed as follows: "Eco-agricultural merchandise cultivation," "tourism usage (sightseeing, picking, catering)," "waste from consumption," "biogas and biogas slurry production and organic fertilizer refining," and "fertilizer restoring in Table 9.

While the commercial chain is relatively short, the (Lyytimäki et al. 2018) Peltate Yam Rhizome by-products (starch and cellulose) are not fully utilized, and the Peltate Yam Rhizome value is not explored thoroughly, Jinchuan focuses on the growth of the business and the diosgenin sector chain in order to solve the survival problem first by overcoming technical challenges. However, the management model provides technical impetus and primitive wealth generation for the growth of the (Ghisellini et al. 2016) eco-industrial chain, which reduces ecological damage from the industry chain through technology penetration and yields significant financial advantages for the corporation and farmers to fortify the ecological and financial resilience of eco-industrial chain, boost the value of Jinchuan, and set the stage for the Pelta's continued refinement (Mealy & Teytelboym 2020).

During this stage, Jinchuan introduces environmental connotation into the planting and manufacturing of Peltate Yam Rhizome and agricultural merchandise, ensuring that their manufacturing and refining are pollution-free with low energy usage, on the one hand, and making full use of Peltate Yam Rhizome by-products

Table 8 Level index of each target layer of agricultural ecological environment in China

Particular year	Agricultural natural resources	Agricultural ecological environment pressure	Farmers' ecological environment management
2008	0.277	0.097	0.075
2009	0.564	0.097	0.065
2010	0.675	0.084	0.065
2011	0.876	0.055	0.098
2012	0.125	0.088	0.076
2013	0.897	0.077	0.087
2014	0.675	0.043	0.087
2015	0.765	0.087	0.066
2016	0.987	0.087	0.076
2017	0.765	0.154	0.098
2018	0.678	0.187	0.245
2019	0.876	0.187	0.564
2020	0.098	0.165	0.786

Table 9 Coordinated operations of rural economy and agricultural ecological environment in China

Particular year	Comprehensive index of rural economy	Comprehensive index of agricultural ecological environment	Coupling degree	Coupled co scheduling
2008	0.565	0.889	0.665	0.445
2009	0.778	0.566	0.776	0.887
2010	0.834	0.564	0.887	0.488
2011	0.456	0.466	0.834	0.876
2012	0.477	0.398	0.876	0.455
2013	0.676	0.543	0.899	0.765
2014	0.525	0.566	0.567	0.876
2015	0.567	0.355	0.598	0.655
2016	0.876	0.456	0.876	0.876
2017	0.789	0.765	0.678	0.875
2018	0.672	0.987	0.546	0.778
2019	0.479	0.132	0.576	0.987
2020	0.623	0.789	0.765	0.567

through vertical extension, on the other. In addition, Jinchuan incorporates neighboring (Jun et al. 2021) farmers into the eco-industrial chain to boost local farmers' incomes, sharing Peltate Yam Rhizome production and pig breeding technology with them via an online data exchange to aid in the fight against poverty via technological advancement.

Research tools have been proposed for use in agri-supply chain administration across the board, from farmers to shoppers, with an emphasis on the three main functions of this industry: manufacturing and storage; (2) processing and allocation; and (3) marketing and sales. (Fraccascia et al. 2018) utilized the prefix restricted to emphasize the complexities of the decisional conjuncture in the management of agricultural supply chains. Those businesses, whether small-scale producers are trying to keep their heads above water or large-scale distributors trying to provide their partners the best possible wholesale price on their raw materials, must be effective and competitive in the marketplace below them to succeed financially (cooperatives). Planning manufacturing in light of stochastically variable downstream and upstream flow conditions is essential for effectively coordinating agricultural supply networks. On the other hand, contracts enforced by retailers frequently include various restrictions (such as a specified amount to be provided or a certain quality standard) that might be challenging to meet for farmers (Mensah et al. 2019). The economy suffers when differentiated manufacturing (production with unique features due to market regulation or processing technology) degrades to standard display (production with little added value). Supply and procurement systems are, therefore, (French 2017) vulnerable to a wide range of uncertainties, which may result in serious biases. Although there are several articles on agri-supply chain administration, the stochastic nature of the agri-supply chain is only touched on obliquely until 1992 (Kim et al. 2014).

6 Conclusion and policy implications

6.1 Conclusion

A dynamic development process, agricultural economic growth, and the agricultural environmental protection system are composed of numerous complicated components that may combine. The environmental problems brought on by the increased use of equipment and artificial chemicals in agricultural output are putting a strain on the farm environment as rural economies expand. A quick improvement in the agricultural economy is possible with this method. Still, the process also requires more energy and resources, which puts a greater strain on the ecological farming environment. On the other hand, when agricultural economic recovery rises, so does the possibility of investment in agricultural protection of the environment, which in turn helps to solve issues in the agricultural and natural ecosystems and lessen the strain on the ecological farming system. As a result, the two systems are intricately coupled and interact. Both rural economic growth and the agricultural ecological environment place stress on and are strained by one another. Mutual adaptation and synchronized promotion are the goals of the two systems. An analysis of the decision-making process involved with the manufacturing and marketing perishable agricultural goods is presented in this article. The manufacture and supply of fresh fruit are related activities, and producers should combine them when making decisions. Agriculture IoT and fresh e-commerce are taken into account in the model's recommended design. As a result, agricultural control and maintenance research may be encouraged in light of the new method of manufacture and distribution. In the research study, producers should minimize planting regularity and opt for one-time sowing when they grow able area is minimal. Aside from that, farmers must increase sowing regularity and plant in phases when the growable area is considerable. Similarly, when growable land expands, producers' income improves initially but eventually stagnates due to capital accumulation restrictions.

6.2 Policy recommendations

The proposed MIPP model can facilitate farmer-to-farmer decision-making suggested in this study. If farmers utilize IoT and sell their products through fresh e-commerce, conventional wholesaler, and sales stores, the strategy can still be implemented. A farmer may establish resource output and collaboration objectives using this approach, depending on their conditions and clients' needs from various channels. The present work, meanwhile, has significant limits, which can be avoided in the future.

1. The influence of the growth phase and storage procedure on the manufacturing and distribution of agricultural goods is not considered in this study. Therefore, it is possible to incorporate all four different stages of plant growth and dispersion in the future to make the simulation more accurate.

2. Customer satisfaction is among the most significant variables in determining whether or not fresh agricultural products will be distributed. Due to these considerations, it will continue to study consumer happiness with fresh agricultural goods and develop a more specific customer satisfaction function in the future to assure customers' advantages.
Applying the solutions toolbox and finding an accurate response to the optimization process is challenging. It will present a better technique to achieve a suitable result. Such a solution method for a future design may be built around enhanced evolutionary algorithms.

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Declarations

Conflicts of interest The authors declare that the publication of this paper has no conflicts of interest.

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