A New Way to Improve Crop Quality and Protect the Supply Chain is to use a Trajectory Network and Game Theory

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Article Info
Page Number: 10600 - 10610
Publication Issue:
Vol 71 No. 4 (2022)

Abstract
Andhra Pradesh is based on agriculture. The majority of the state's residents work as farmers on land that belonged to their ancestors. Many agricultural goods are exported from Andhra Pradesh. The local crops include tobacco, mango, rice, cotton, sugarcane, chilli paper, and sugarcane. Every farmer wants good seeds and a quality growth crop, which are both needed and desired by everyone; retailers want quality food and a secure supply chain, but crop quality, reliability, and transparency are currently lacking. There are many people involved in the agriculture sector, from farmer to retailer, the majority of whom inject and manipulate data quality while also adding chemicals to crops. Everything is hazardous to our health in this manner, so we must immediately discontinue this method of dealing with third-party actors. So definitely, we use technologies to reduce the above issues. We proposed to A new way to improve crop quality and protect the supply chain is to use a trajectory network and game theory. Trajectory networks can play a key role in improving crop quality and protecting the supply chain by providing real-time data and promoting transparency, accountability, and efficient decision-making. Game theory can play an important role in improving crop quality and protecting the supply chain by modelling the interactions between stakeholders, identifying incentives, and promoting cooperation and coordination. By reducing risks and encouraging investment, game theory can help ensure a reliable and high-quality supply of crops.

Article History
Article Received: *15 September 2022*
Revised: *25 October 2022*
Accepted: *14 November 2022*
Publication: *21 December 2022*

Keywords: Machine learning, trajectory network, game theory, supply chain

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Introduction: The quality of crops and the security of the supply chain are critical concerns in the food industry. Ensuring that crops are grown, transported, and stored in a manner that protects their quality and safety is essential to maintaining a stable and sustainable food system. A new approach to improving crop quality and protecting the supply chain involves the use of trajectory networks and game theory. Trajectory networks are mathematical models that simulate the movement of crops from the farm to the market, taking into account various factors such as weather conditions, transportation routes, and storage facilities. Game theory, on the other hand, is a mathematical approach that analyses the behaviour of different actors in the supply chain and identifies strategies that lead to mutually beneficial outcomes for all parties involved. By combining these two approaches, it is possible to improve crop quality, reduce waste, and increase the efficiency of the supply chain.

Using a trajectory network and game theory can be a new way to protect the supply chain and improve crop quality. Trajectory network the trajectory network could be used to track the movement of crops from farm to market and monitor various stages of the supply chain for quality control purposes. By using this network, it's easier to find the places in the supply chain where crops are most likely to have quality problems. Game theory can be used to model and analyse decision-making processes in the supply chain, such as those made by farmers, suppliers, distributors, and consumers. By understanding the incentives and constraints faced by each player, it becomes possible to design strategies that improve the overall quality and efficiency of the supply chain.

By combining these two approaches, a new way to improve crop quality and protect the supply chain can be created that leverages the strengths of both trajectory networks and game theory. This can lead to improved decision-making, increased transparency, and ultimately higher-quality crops for consumers. Early detection of risks: By using a trajectory network to model the growth of crops over time, it is possible to detect potential risks to crop quality early on, such as disease outbreaks or environmental factors. This early detection lets people act quickly and effectively to stop or lessen the risks. Optimal decision-making: By using game theory to model the interactions between different actors in the supply chain, it is possible to determine the optimal strategies for each actor to achieve their objectives while maintaining the quality of the crops. This helps to ensure that the crops are grown, harvested, and distributed in the most optimal way, leading to better-quality crops and a more efficient supply chain. Improved collaboration: The use of game theory to model the interactions between actors in the supply chain can help foster collaboration and coordination between these actors. This improved collaboration can lead to better communication and information sharing, helping to ensure that everyone is working together towards the common goal of producing high-quality crops. Increased efficiency: By using both a trajectory network and game theory, it is possible to identify inefficiencies in the supply chain and determine the best course of action to address these inefficiencies. This can make the supply chain more sustainable and profitable by making it more efficient and cutting down on waste.

Create a trajectory network in smart agriculture based on crop quality estimation: A trajectory network in smart agriculture based on crop quality estimation can be created by collecting data on crop quality, analysing the data to estimate crop quality, predicting future quality, connecting all key stakeholders in the supply chain, facilitating information sharing, continuously monitoring crop quality, and providing data visualisation tools. By providing real-time data and promoting transparency and collaboration, a trajectory network in smart agriculture can help improve crop quality and protect the supply chain.

In smart agriculture, you can make a trajectory network based on crop quality estimation in the following ways:

1. Data collection: The first step is to collect data on crop quality at each stage of the supply chain. This can include information about the crop's size, color, texture, and chemical makeup. This information can be gathered using different technologies, like sensors, spectroscopy, and image analysis.

2. Data analysis: The collected data is then analysed to estimate crop quality and predict future quality. This could involve using machine learning algorithms and predictive models to process data and make accurate quality predictions.
3. Network creation: The next step is to create a network connecting all key stakeholders in the supply chain, including farmers, distributors, retailers, regulators, and others. The network should let people get data on crop quality in real time and get predictions about crop quality in real time.
4. Sharing information: The network should make it easy for stakeholders to share information, so they can work together on decisions and actions about crop management and distribution.
5. Continuous monitoring: The trajectory network should be made so that crops can be tracked and watched all the time, so that any problems with quality can be found early and fixed quickly.
6. Visualizing data: The network should also offer tools for visualising data to help people better understand it and make better decisions about how to manage and distribute crops.

Pseudo code:

```
# Define the function to create a trajectory network in smart agriculture based on crop quality estimation
def create_trajectory_network(crop_data, stakeholders):
    # Initialize the network with all stakeholders
    network = Network(stakeholders)
    # Collect data on crop quality at each stage of the supply chain
    crop_quality_data = collect_crop_quality_data(crop_data)
    # Analyze the collected data to estimate crop quality and predict future quality
    quality_prediction = predict_crop_quality(crop_quality_data)
    # Add the quality prediction to the network
    network.add_quality_prediction(quality_prediction)
    # Facilitate information sharing among stakeholders
    network.share_information()
    # Continuously monitor crop quality
    network.monitor_crop_quality()
    # Provide data visualization tools
    network.visualize_data()
    return network
# Define the function to collect data on crop quality
def collect_crop_quality_data(crop_data):
    # Collect data using various technologies, such as sensors, spectroscopy, and image analysis
    crop_quality_data = collect_data(crop_data)
    return crop_quality_data
# Define the function to predict crop quality
def predict_crop_quality(crop_quality_data):
    # Use machine learning algorithms and predictive models to process the data
    quality_prediction = analyze_data(crop_quality_data)
    return quality_prediction
# Define the network class
class Network:
    def __init__(self, stakeholders):
        self.stakeholders = stakeholders
    def add_quality_prediction(self, quality_prediction):
        # Add the quality prediction to the network
        self.quality_prediction = quality_prediction
    def share_information(self):
        # Facilitate information sharing among stakeholders
        share_data(self.stakeholders, self.quality_prediction)

    def monitor_crop_quality(self):
        # Continuously monitor crop quality
        monitor_data(self.quality_prediction)
    def visualize_data(self):
        # Provide data visualization tools
        visualize(self.quality_prediction)
```

Secure supply chain in smart agriculture using game theory: Game theory can be used to secure the supply chain in smart agriculture in the following ways:

a) Collaborative decision-making: Game theory can be used to model the interactions between stakeholders in the supply chain and help make optimal decisions that are beneficial for all parties. This can help reduce the risk of fraud, counterfeiting, and other forms of supply chain disruption.
b) Contract design: Game theory can be used to design contracts between stakeholders in the supply chain to incentivize cooperation and reduce the risk of opportunistic behavior. This can help make sure that everyone has the right incentives to protect crop quality and keep the supply chain's integrity.
c) Strategic planning: Game theory can be used to help stakeholders in the supply chain plan their strategies in advance, taking into account the potential reactions of other stakeholders.

This can help reduce the risk of supply chain disruption and ensure that the supply chain remains secure and resilient.

d) Risk management: Game theory can be used to model the risk associated with different supply chain scenarios and help stakeholders make informed decisions about how to manage that risk. This can help to ensure that the supply chain remains secure, even in the face of unexpected events.

e) Monitoring and enforcement: Game theory can be used to develop monitoring and enforcement mechanisms to ensure that stakeholders in the supply chain are following the rules and regulations. This can help reduce the risk of fraud, counterfeiting, and other forms of supply chain disruption.

```
1. Define the actors in the supply chain and their objectives
2. Model the supply chain as a game with multiple players
3. Use game theory to analyze the behavior of each actor
4. Identify mutually beneficial strategies for all actors in the supply chain
5. Integrate smart technologies into the supply chain
6. Continuously monitor and optimize the supply chain using data analysis
Algorithm for Secure Supply Chain in Smart Agriculture using Game Theory:
Input: Data on the actors in the supply chain and their objectives
Output: Improved supply chain with increased efficiency and sustainability
Step 1: Define actors and objectives
    - Identify all actors in the supply chain (e.g. farmers, processors, distributors, consumers)
    - Determine the objectives of each actor (e.g. maximize profits, improve crop quality)
Step 2: Model supply chain as a game
    - Use game theory to model the interactions between actors in the supply chain
    - Analyze the behavior of each actor in response to different scenarios
Step 3: Identify mutually beneficial strategies
    - Use game theory to identify strategies that lead to mutually beneficial outcomes for all actors in the supply chain
    - Implement these strategies in the supply chain
Step 4: Integrate smart technologies
    - Use sensors, IoT devices, and blockchain to improve the efficiency and transparency of the supply chain
    - Automate processes and reduce manual labor to improve efficiency
Step 5: Continuously monitor and optimize
    - Continuously monitor the supply chain using data analysis and feedback from all actors in the chain
    - Optimize the supply chain to improve efficiency and sustainability
End Algorithm
```

x_i: The action taken by player i
u_i: The payoff received by player i
s_i: The security level of player i
c_ij: The cost incurred by player i as a result of player j's action
maximize: u_i = f_i(x_i, x_{-i}) - c_i(x_i, x_{-i}) for all i
subject to: s_i >= 0 for all i

In this optimization problem, the objective is to maximize the payoffs for each player, taking into account the costs incurred as a result of the actions taken by other players. The constraint ensures that the security level for each player is non-negative.

Agriculture approach to trajectory network and game theory for quality crop growth and supply chain: Agriculture can benefit from the use of trajectory and game theory for quality crop growth and the supply chain for several reasons: Trajectory planning can be used to optimise crop growth and yield by considering factors such as weather patterns, soil quality, and water availability. This can lead to increased efficiency and productivity in agriculture. Game theory can be used to model the interactions between various players in the supply chain, such as farmers, processors, distributors, and consumers. This can help identify the most efficient and secure allocation of resources in the supply chain. The Nash equilibrium, which is the solution to the game theory model, represents a secure and efficient allocation of resources in the supply chain. This can help reduce the risk of fraud, counterfeiting, and other security threats in the supply chain. By modelling the interactions between players in the supply chain, game theory can also help identify potential areas for improvement and collaboration. This can lead to better coordination and cooperation among players, which can lead to increased efficiency, productivity, and profitability in agriculture.

```
# Pseudo code for Agriculture approach to trajectory network and game theory for quality crop growth and supply chain
# Step 1: Define objectives for crop growth and supply chain
OBJECTIVES = [
    "maximize crop yield",
    "ensure quality of crops",
    "minimize supply chain costs"
]
# Step 2: Create a trajectory network for crop growth
GROWTH_TRAJECTORY = [
    "soil preparation",
    "sowing seeds",
    "irrigation",
    "fertilization",
    "pest control",
    "harvesting"
]
# Step 3: Use game theory to optimize crop growth and supply chain
for step in GROWTH_TRAJECTORY:
    # Step 3a: Identify players in the system
    players = [
        "farmers",
        "suppliers",
        "consumers"
    ]
    # Step 3b: Define payoffs for each player based on objectives
    payoffs = {
        "farmers": [
            "profit from crop sales",
            "investment in agriculture"
        ],
        "suppliers": [
            "profit from sales of inputs",
            "investment in supply chain infrastructure"
        ],
        "consumers": [
            "quality of crops",
            "price of crops"
        ]
    }
    # Step 3c: Use game theory algorithms to find an optimal solution
    result = solve_game_theory_problem(players, payoffs, OBJECTIVES)

    # Step 3d: Implement the solution
    implement_solution(result)
# Step 4: Monitor and evaluate the system to ensure objectives are met
monitor_and_evaluate(OBJECTIVES)
```

x_i: The action taken by participant i
u_i: The utility received by participant i
q: The quality of the crops
c_ij: The cost incurred by participant i as a result of participant j's action
maximize: sum(u_i) for all i
subject to: q >= q_min for all i
sum(c_ij) <= budget for all i

Optimization problem provides the optimal strategies for each participant in the supply chain, which can be used to incentivize them to act in a way that leads to improved crop quality and a secure supply chain. This method can be used in different supply chains in the agriculture industry to get better results and promote practises that are good for the environment.

Parameters use to improve Crop Quality and Protect the Supply Chain Is to Use a Trajectory Network and Game Theory: When using a trajectory network and game theory to improve crop quality and protect the supply chain, some of the things that would need to be taken into account could be:

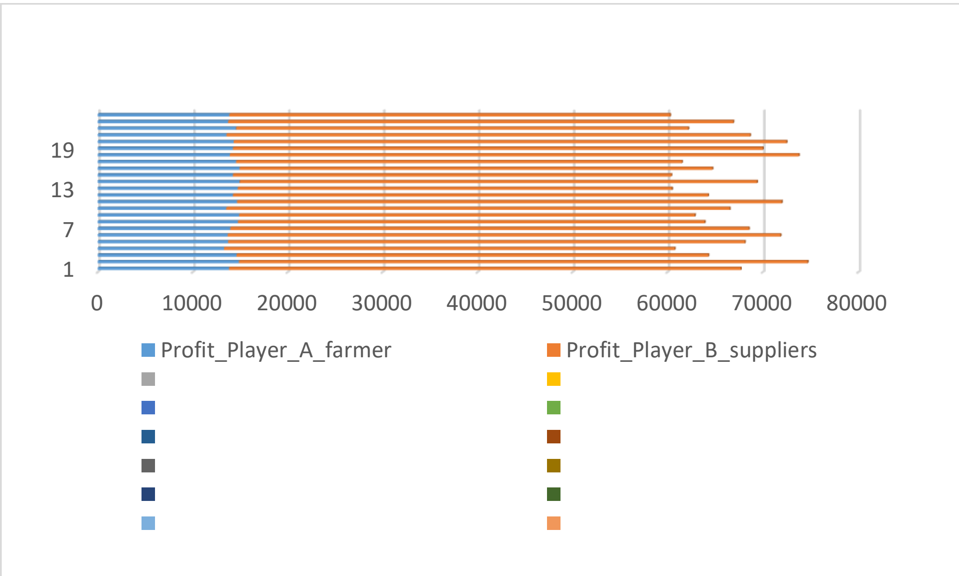
a) Quality control measures: To effectively use a trajectory network for quality control, it's important to have clear and well-defined measures of crop quality. This could include factors such as the size, color, shape, and freshness of the crops, as well as the presence of any contaminants.
b) Supply chain participants: The trajectory network would need to account for all participants in the supply chain, including farmers, suppliers, distributors, and consumers. To come up with good strategies for improving crop quality, it's important to know what each participant wants and what they can't do.
c) Information flow: to be effective, the trajectory network would need to be able to gather and disseminate information about crop quality in real-time. This could require the use of sensors and other technology to monitor crops throughout the supply chain.
d) Decision-making processes: Game theory would need to take into account the decision-making processes of each participant in the supply chain. This could involve modelling the incentives and limits that each player faces, as well as their ability to gather and use information about crop quality.
e) Collaboration and coordination: Improving crop quality and protecting the supply chain would likely require close collaboration and coordination among participants. This could be done by sharing information, making sure everyone uses the same quality control measures, and putting in place plans that help everyone.

These are just a few of the parameters that would need to be considered when using a trajectory network and game theory to improve crop quality and protect the supply chain. The actual implementation would have to be tailored to each supply chain's unique needs.

```
Step 1: Define the players in the supply chain:
  farmer, distributor, retailer
Step 2: Define the crops and their quality levels:
  crop1, crop2, ..., cropN
  quality1, quality2, ..., qualityN
Step 3: Define the decision variables:
  x_i = the quantity of crop i that the farmer produces
  y_i = the quantity of crop i that the distributor sells
  z_i = the quantity of crop i that the retailer sells
Step 4: Define the objective function:
  maximize the total profit for the supply chain, i.e.,
  P = (price_i - cost_i) * (x_i + y_i + z_i)
Step 5: Define the constraints:
  farmer: x_i >= 0, sum(x_i) <= total_crop_production
  distributor: y_i >= 0, y_i <= x_i, sum(y_i) <= total_crop_distribution
  retailer: z_i >= 0, z_i <= y_i, sum(z_i) <= total_crop_retail
Step 6: Use an optimization algorithm to solve the model and find the best solution.
```

Implementation work: This table appears to be tracking various information about players in a simulation or game, including their total number of players, number of polluted players, entry fees, selling prices, and profits. It includes three types of players: farmers (Player A), suppliers (Player B), and consumers (Player C). Based on the data, we calculate that nave Bayesian suppliers profit more because they finalise the rate, create demand and supply, and reduce food quality, whereas farmers suffer completely as a result of this approach to technology support.

Player_A_farmer_ToTal_Players	Player_A_farmer_Polluted_Players	Money_Entery_Fee	Money_Sellin_Price	Player_B_suppliers_ToTal_Players	Player_B_suppliers_Polluted_Players	Money_Entery_Fee	Money_Sellin_Price	Player_C_consumers_ToTal_Players	Player_C_consumers_Polluted_Players	Money_Entery_Fee	Profit_Player_A_farmer	Profit_Player_B_suppliers
2	0	11587	13163	27	14	14905	58331	205	10	50000	13836	53878
2	0	11341	14571	30	14	13722	45213	749	11	50000	14875	59823
1	0	11407	13156	26	10	14069	53436	747	14	50000	14622	49695
1	0	11626	13574	15	14	13708	57357	945	10	50000	13296	47486
1	0	10157	14897	18	15	13132	52761	804	11	50000	13733	54412
1	0	10170	14501	21	12	13246	47557	573	12	50000	13683	58178
2	0	10775	13331	27	12	14257	55095	862	15	50000	13958	54602
2	0	11252	13152	18	10	14180	45037	550	13	50000	14779	49145
2	0	11777	14934	25	15	14420	47515	778	11	50000	14893	47995
2	0	11589	13944	27	10	13970	51295	218	10	50000	13530	53022
1	0	11360	13836	27	10	14670	59437	415	15	50000	14679	57309
1	0	10703	13802	18	12	14419	53297	130	12	50000	14248	50051
2	0	11367	13701	24	15	13406	46322	499	13	50000	14747	45737
1	0	11258	13953	24	14	13942	59824	738	10	50000	14938	54468
2	0	10713	14262	30	12	14702	54697	930	15	50000	14245	46175
2	0	11189	13085	15	14	14237	48444	670	10	50000	14946	49805
2	0	10965	14169	17	15	13326	51897	124	12	50000	14580	46955
2	0	11658	14127	24	10	13046	56448	951	11	50000	13910	59875
1	0	10299	14689	18	13	14012	49922	260	13	50000	14248	55771
1	0	10890	13775	19	10	14797	51002	775	14	50000	14326	58165
2	0	10211	14413	21	12	14845	45904	946	12	50000	13550	55133
2	0	10476	14426	22	10	14828	50401	924	14	50000	14556	47647
1	0	10908	14216	21	13	14559	49500	922	15	50000	13743	53192
2	0	11750	14253	24	12	13266	49860	860	14	50000	13862	46435



IMPROVE-CROP-QUALITY-SUPPLY-CHAIN-STRATEGY-1: Implementing better storage and transportation practises to reduce spoilage and damage to crops an analysis of the trajectory network and game theory revealed that poor storage and transportation practises were causing significant crop losses. Implementing better storage and transportation practises is expected to reduce spoilage and damage to crops, resulting in improved crop quality and increased market value.

```
Step 1: Collect data on current storage and transportation practices
    - Gather data on the types of containers used
    - Collect information on the storage and transportation conditions (temperature, humidity, etc.)
    - Record the length of time that crops are stored and transported
Step 2: Identify areas for improvement
    - Analyze the collected data to identify factors that contribute to spoilage and damage
    - Determine which storage and transportation practices could be improved to reduce spoilage and damage
Step 3: Develop a mathematical model
    - Represent the storage and transportation process in a mathematical form
    - Capture the relationship between the factors that contribute to spoilage and damage
Step 4: Optimize the model
    - Use optimization techniques to find the storage and transportation practices that minimize spoilage and damage
    - Minimize an objective function that represents the amount of spoilage and damage
Step 5: Evaluate the results
    - Compare the optimized practices to current practices
    - Determine the improvement in crop quality and market value
Step 6: Implement the optimized practices
    - Adopt the optimized storage and transportation practices in the supply chain
```

The implementation of a traceability system can be modelled as an optimization problem, where the objective is to minimise spoilage and damage to crops while maximising the efficiency and consistency of the supply chain.

x_i: The proportion of crop i that is stored and transported properly, where 0 <= x_i <= 1

y_i: The quality of crop i, where 0 <= y_i <= 1

c_i: The cost of storing and transporting crop i

q_i: The target quality standard for crop i

minimize: SUM(c_i * (1 - x_i))

subject to: y_i >= q_i * x_i for all i

In this optimization problem, the objective is to minimise the cost of storing and transporting crops, taking into account the extent to which crops are stored and transported properly (represented by x_i). The constraint ensures that the quality of each crop (represented by y_i) meets the target quality standard (represented by q_i) and that this quality is proportional to the extent to which the crop is stored and transported properly.

IMPROVE-CROP-QUALITY-SUPPLY-CHAIN-STRATEGY-2: Increasing collaboration between producers and processors to ensure consistent quality standards the game theory analysis showed that there was a lack of coordination between producers and processors, leading to inconsistent quality standards for crops. By increasing collaboration and communication between producers and processors, it is expected that consistent quality standards can be established and maintained, resulting in improved crop quality and increased market confidence.

```
Step 1: Identify areas for collaboration
    - Assess the current collaboration between producers and processors
    - Identify areas where collaboration could be improved to ensure consistent quality standards
Step 2: Develop a collaboration plan
    - Develop a plan for increasing collaboration between producers and processors
    - Outline the objectives, activities, and outcomes of the collaboration
Step 3: Implement joint planning
    - Work together to plan the production, storage, and transportation of crops
    - Ensure that the crops are produced and transported under conditions that meet the desired quality standards
Step 4: Share data
    - Share data on crop production, storage, and transportation practices
    - Use this data to better understand the factors that contribute to crop quality
Step 5: Implement joint quality control
    - Conduct joint inspections of the crops
    - Implement joint corrective action plans when necessary
Step 6: Joint training and development
    - Participate in joint training and development programs
    - Improve understanding of quality standards and best practices for crop production, storage, and transportation
Step 7: Joint incentive programs
    - Develop joint incentive programs
    - Reward the production of high-quality crops and encourage the adoption of best practices
```

ISSN: 2094-0343
2326-9865

The problem of increasing collaboration between producers and processors can be modelled as a game-theoretic problem, where the objective is to find a Nash equilibrium that results in both producers and processors working together to achieve consistent quality standards.

x_i: The quality of crop i produced by producer i, where 0 <= x_i <= 1
y_j: The quality of crop j processed by processor j, where 0 <= y_j <= 1
p_i: The profit earned by producer i
q_j: The profit earned by processor j
r_ij: The reward received by producer i for producing crop j of quality x_i

maximize: p_i = r_ij(x_i, y_j) - c_i(x_i) for all i
subject to: x_i >= 0 for all i
maximize: q_j = r_ij(x_i, y_j) - d_j(y_j) for all j
subject to: y_j >= 0 for all j

In these optimization problems, the objective is to maximise the profit earned by each producer and processor, taking into account the rewards received for producing and processing crops of high quality. The constraint ensures that the quality of each crop is non-negative.

```
Step 1: Model the supply chain
    - Use the trajectory network to model the behavior of the supply chain
    - Identify bottlenecks and inefficiencies in the supply chain
Step 2: Optimize crop transportation
    - Use game theory to identify the most efficient and cost-effective transportation strategies
    - Consider the quality of the crops, the cost of transportation, and the impact of transportation on crop quality
Step 3: Design incentives
    - Use game theory to design incentives that encourage producers and processors to prioritize quality
    - Reward producers for producing high-quality crops and incentivize processors to implement best practices for storage and transportation
Step 4: Improve coordination
    - Use the trajectory network and game theory to improve coordination between producers and processors
    - Ensure that the supply chain is protected from the risks associated with inconsistent quality standards
```

Machine learning algorithm for improving crop quality and protecting the food supply chain will depend on the specific problem being addressed. Some commonly used machine learning algorithms in agriculture are: image recognition, predictive modeling, anomaly detection, and soil moisture and other important factors affecting crop quality.

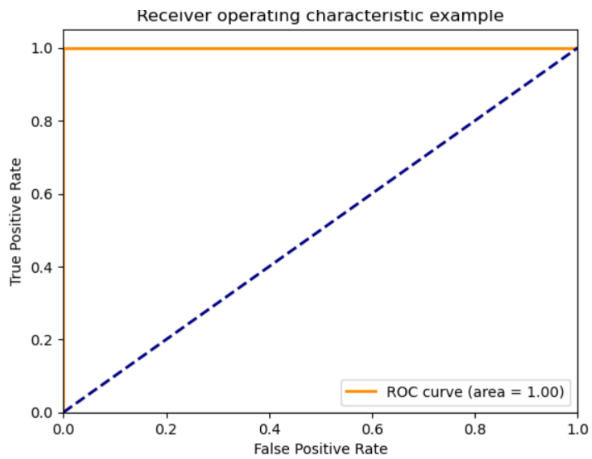
In [23]:

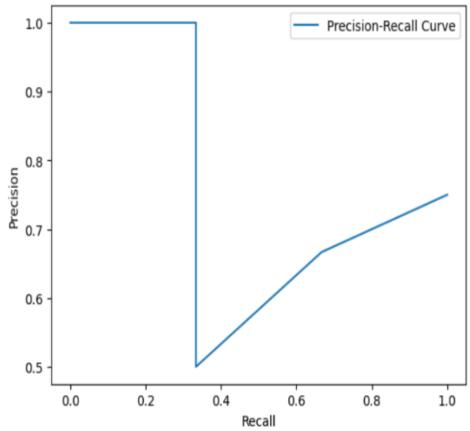
```
import pandas as pd
import numpy as np
from sklearn.model_selection import train_test_split
from sklearn.model_selection import cross_val_score
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier

# Load the data
df = pd.read_csv("D:\Ph.D Work\Ph.D Work Related\Thesis Writing Work\DataSet Work\game.csv")

# Split the data into features (X) and target (y)
X = df.drop("target", axis=1)
y = df["target"]

# Split the data into training and test sets
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2)

# Select the models to evaluate
models = [LogisticRegression(), DecisionTreeClassifier(), RandomForestClassifier()]
model_names = ["Logistic Regression", "Decision Tree", "Random Forest"]

# Evaluate the models using cross-validation
for model, model_name in zip(models, model_names):
    scores = cross_val_score(model, X_train, y_train, cv=5)
    print(f"{model_name} Cross-Validation Accuracy: {np.mean(scores)}")

# Choose the best model based on cross-validation accuracy
best_model = models[np.argmax(scores)]
print(f"Best Model: {model_names[np.argmax(scores)]}")
```

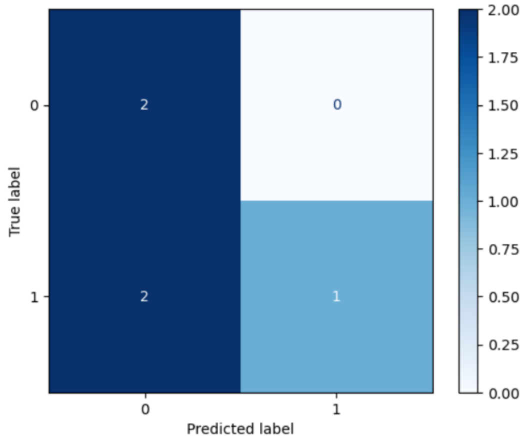
Out[29]:

	Land_Area_Acers	Player_A_farmer_ToTal_Players	Player_A_farmer_Polluted_Players	Money_Entery_Fee	Money_Sellin_Price	Player_B_suppliers_ToTal_Pla
count	24.000000	24.000000	24.0	24.000000	24.000000	24.00
mean	1.541667	1.583333	0.0	11029.291667	14135.958333	22.41
std	0.508977	0.503610	0.0	535.855795	538.310277	4.49
min	1.000000	1.000000	0.0	10081.000000	13035.000000	15.00
25%	1.000000	1.000000	0.0	10686.250000	13796.250000	18.00
50%	2.000000	2.000000	0.0	10948.500000	14187.000000	23.00
75%	2.000000	2.000000	0.0	11350.500000	14573.000000	26.25
max	2.000000	2.000000	0.0	11970.000000	14855.000000	30.00

```
Logistic Regression Cross-Validation Accuracy: 0.4666666666666667
Decision Tree Cross-Validation Accuracy: 0.7333333333333333
Random Forest Cross-Validation Accuracy: 0.4166666666666667
Best Model: Logistic Regression
```







Conclusion: The use of trajectory networks and game theory in crop production and supply chain management can lead to improved crop quality and a more secure food system. These mathematical tools can help model and analyse complex systems, providing insights and recommendations for optimising supply chain processes and reducing waste. By applying these approaches, stakeholders in the food industry can work together to create a more sustainable and efficient food system for the benefit of consumers and the environment and ensure a more sustainable and successful future for farmers in the state.

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