SOD Assignment
Solution Space

Service Oriented Design 2023

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Contents

Change Log

Number	Name	Feedback	Description
1.	1st Assignment		Initial submission of section 1 to 6
2.	Modification of 1st Assignment		Modify Assignment 1 based on the feedback received after submission and incorporate any necessary changes due to Assignment 2.
3.	2st Assignment		Initial submission of section 7 to 12

Individual Responsibility

No.	Section	Team Member
1	Section 7: Software decomposition of business services	Robel Amare Gebrewold
2	Section 8: Participant service inventory identification	Cindy Aprilia
3	Section 9: Service contract identification	Niurguiana Borisova
4	Section 10: Business service network	Niurguiana Borisova
5	Section 11: Service interactions and behavior	Robel Amare Gebrewold
6	Section 12: Design view	Cindy Aprilia

Part 1. Assignment 1: Design Space

1 Business Domain

1.1 Background Problem

Child malnutrition is a pressing concern in the Global South, particularly in the East African countries. Typically, it becomes apparent only when children reach a severe level of malnutrition and are visibly starved. This issue is made worse by social, economical and political problems that are unique to these regions. 23.1 million children in this area suffers from malnutrition in these areas [1], emphasizing the urgency of addressing this problem. In addition, agriculture plays a significant role in the livelihood of the great majority of people in these areas. Because of the changing weather patterns and little resources in East African agriculture, it is difficult for farmers to produce enough nutrient-dense food for themselves and their communities, which feeds the cycle of malnutrition.

1.2 Goal of the Project

The primary goal of this project is to use business and software services to help farmers become more productive in the face of climate change concerns. In addition, this business service project aims to improve these farmers' economic sustainability so that it is possible to ensure children in East African nations have access to nutritional foods. This comprehensive strategy will benefit not just agricultural output and economic sustainability, but also the well-being and nutrition of the region's children. The vital link between sustainable farming methods and the fight against malnutrition in these areas is the subject of this study.

1.2.1 Solution and Connection to the Case Problem

The proposed solution is providing several essential business services interrelated to one another to solve the problem at hand. These services include crop yield prediction, fair pricing advice, international investment guidance. These services are specifically designed to empower farmers in East Africa and improve their economic conditions. By making these services accessible, the project aims to create a direct link between sustainable farming practices and the reduction of child malnutrition.

1.3 Functionality

The project has several essential functionalities:

- Crop Yield Prediction Service (BS-CYP): Provides data-driven predictions and forecasts to farmers in order to maximize crop production.

- Fair Price Advisor Service (BS-FPA): Assists farmers in making pricing decisions for their produce based on sound information.

- International Agriculture Investment Dataspace Service (BS-IAI): Help farmers access foreign funding for buying better farming technology by increasing trust of foreign investors through a transparent and legal-auditing service.

CYP works in tandem with other project services, such as the Fair Price Advisor (FPA) service. The collaboration between CYP and FPA enables farmers to access not only yield predictions but

also future price estimates for their crops. This integration provides a comprehensive view, allowing farmers to make decisions that maximize both their yield and their profitability.

CYP collaborates with the Investment Advisor Service to provide farmers with comprehensive insights. By combining crop yield predictions from CYP with investment advice, farmers can make informed decisions about resource allocation, access to international markets, and potential investments that enhance their agricultural practices and economic sustainability.

1.4   Stakeholders and Users

Stakeholders in this project include AGRA (Alliance for a Green Revolution in Africa), which will be the owner of the Crop Yield Prediction service, government bodies (such as the Ministry of Agriculture, owner of the Fair Price Advisor Service; the Ministry of Economy/Finance, owner of the International Agriculture Investment Dataspace Service; and the Ministry of Foreign Affairs), as well as The World Bank. AGRA, or the Alliance for a Green Revolution in Africa, is a non-profit organization that works to improve the productivity and incomes of smallholder farmers in Africa. The World Bank offers financial and developmental support to drive positive change. Farmers are the primary users of the business services supplied, relying on them to increase their revenue and sustainability. Investing companies help farms by providing cash and expertise, while government agencies help with regulation and larger anti-malnutrition projects. Organizations such as the World Bank can provide financial and developmental assistance to promote economic sustainability. Each of these stakeholders collaborates with the business services, united in their efforts to bolster the financial capacity of farmers, with the ultimate goal of eradicating child malnutrition in East African countries.
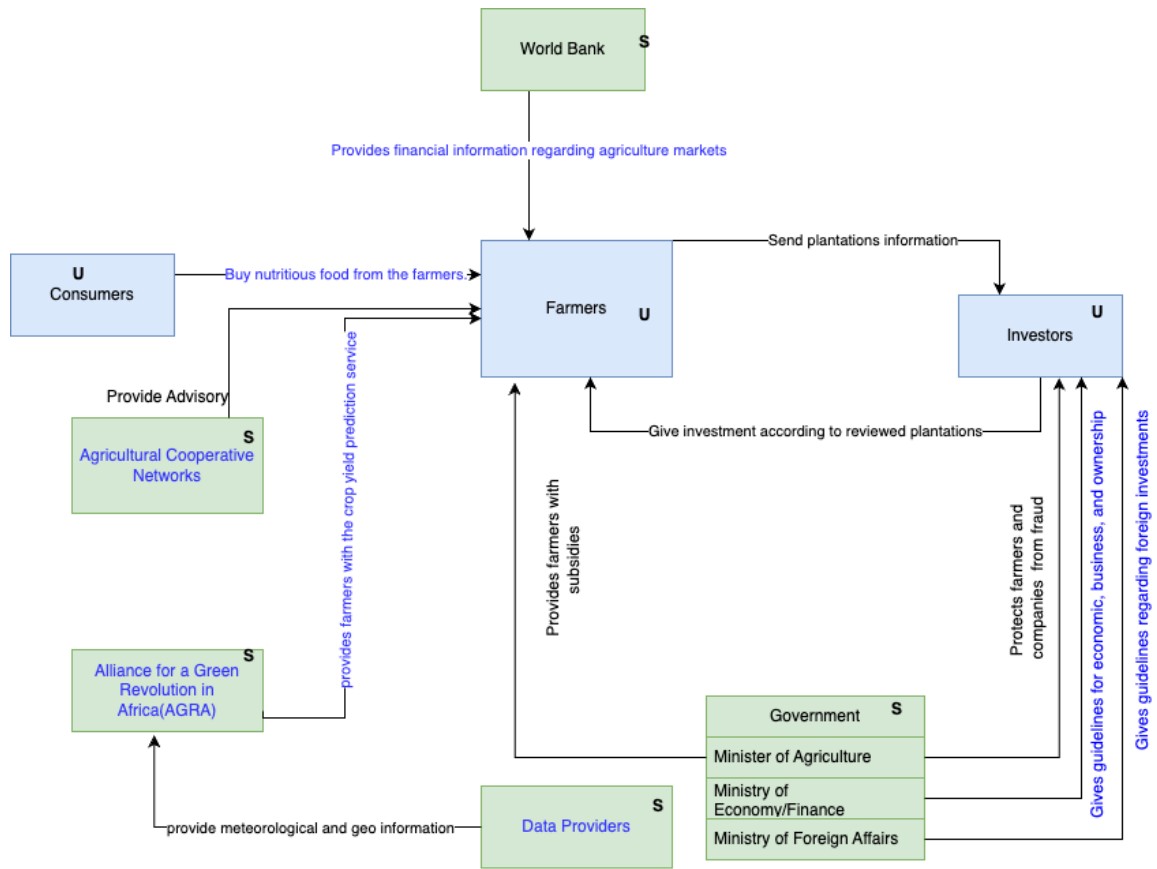
Figure 1: Business Domain Model

2 Functional Requirements

Requirement ID	FR1-CropAnalysis
Business Service	Crop Yield Prediction Service (BS-CYP)
Definition	Service is designed to generate in-depth analytical insights about the farming land quality, by tailoring recommendations and information. It provides customised advice for improving the crop quality and farming practice by taking into consideration the geographic location of each farmer as well as particular regional climate and soil variances, enabling farmers to maximise their crop yields sustainably. Analysed results are shared securely to data requesters, whether in its raw form or as in-depth analytical insights.
Motivation	Early prediction tools should be able to mitigate the prevalence of harvest failures. These predictions are based on sensor data, which offers essential information about different agricultural elements. This functionality assists farmers in making quick adjustments regarding how to better care for their land by offering information about the current health state of the land as well as its predicted future. Additionally, the service should be able to suggest tips for land care. This functionality ultimately produces better amount harvest. Moreover, by sharing both sensor readings and prediction data, the service will be able to collaborate with other services. This co-operative sharing approach generates significant value for the participating services by building a positive economic ecosystem for farmers, raising harvest amounts, reducing hunger, and improving farmer livelihoods.

Table 1: Functional Requirement of Crop Yield Prediction Service

Requirement ID	FR2-PriceInformation
Business Service	Fair Price Advisor Service (BS-FPA)
Definition	Service should be able to provide current market price specific to the crop species and plantation area of the requesters. Moreover, the service should be able to predict the future price of requester crops, which is mapped to their personalised crop yield prediction.
Motivation	In many East African countries, farmers often lack awareness of the market prices for their agricultural products, resulting in the sale of their produce at undervalued prices by intermediaries who inflate market. The intermediaries will resale the crops with high price in the other places, which ultimately results in people being unable to afford food, leading to malnutrition problems. By providing users with access to current market prices and allowing farmers to align these prices with their personalised crop yield predictions, this functionality empowers farmers and buyers with fair buying and selling price, which ultimately contributing to economic improvement, better food affordability, and malnutrition reduction.

Table 2: Functional Requirement of Fair Price Advisor Service

Requirement ID	FR3-InvestmentDataspace
Business Service	International Agriculture Investment Dataspace Service (BS-IAI)
Definition	The service facilitates the international sharing of data, responding to specific requests from the requesters and adhering to the regulations of the involved nations. Additionally, there is an extensive audit trail covering all user interactions and data alterations within the system. All access and data changes, both recent and historical, are logged and timestamped as part of this careful record-keeping, laying a solid foundation for accountability and auditing needs.
Motivation	The motivation behind this service is rooted in the potential for major agricultural development in East African nations through additional finance. Better financial access has the ability to change farming technologies and outcomes in the area. However, to instil trust in foreign investors, a strong basis in research and auditing is required. The challenge arises from the fact that different countries have different rules and regulations regarding data exchange, which can make the procedure more difficult. Establishing a standardised and secure dataspace that complies with local legislation while also enabling overseas investors to confidently analyse and consider their funding options is critical. Based on credible data, the investment potential might result in significant monetary assistance for East African farmers, which gives them the chance to improve their agricultural technologies and outcomes. Ultimately, this service plays a pivotal role in bridging the gap between the potential for agricultural improvement and foreign funding.

Table 3: Functional Requirement of International Agriculture Investment Dataspace Service

3 Quality Requirements

Requirement ID: QR1-Accessibility
Name: Accessibility
The domain of business services should ensure accessibility for users. This pertains to two key aspects of accessibility. Firstly, it addresses the ease of access for users, farmers and investing companies, who need to provide personal and plantation data to use these services. Secondly, it relates to ensuring accessibility to food. The services are specifically designed to enhance food accessibility by optimizing resource efficiency within the agricultural supply chain.

Requirement ID: QR2-Accuracy
Name: Accuracy
The crop yield predictions need to have a high degree of accuracy to be useful for users. The accuracy of crop yield prediction has to be extremely high since other estimations like price estimations and investment insights highly depend on that. Predictive models need to be trained on datasets specific to East Africa, capturing variances in soil, climate, crops, agricultural practices, etc. Domain experts should be involved in evaluating the accuracy. Clear accuracy metrics need to be defined and measured. The services should be upfront about the expected accuracy levels so users have calibrated expectations.

Requirement ID: QR3-DataSecurity
Name: Data Security
Farmer data collected by the services includes sensitive information like locations, yields, profits etc. This data needs to be properly secured and access controlled to maintain privacy. Encryption needs to be implemented during data transfer and storage. Access control mechanisms should allow farmers to control which services can access their data. Auditing capabilities are required to detect breaches or misuse. Personally identifiable data should be anonymized or omitted when possible. Consent needs to be obtained before sharing data with third parties. Security measures should follow established standards and best practices.

Requirement ID: QR4-Sustainability
Name: Sustainability
Sustainability, with a particular focus on food accessibility, is a vital quality requirement for the application, given its direct relevance to the primary goal of addressing global food challenges. Ensuring food accessibility is a multifaceted, long-term food security goal by providing continuous support to food producers. Moreover, achieving sustainability in this context involves several key considerations:

- Environmental food accessibility: The application should encourage and facilitate sustainable farming practices.

- Economic sustainability: The application should strengthen local food systems and enhance livelihoods. Providing transparent pricing, fair market access, eliminating intermediaries' exploitative practices, and allowing foreign investments ensures that farmers and producers can remain in the agricultural sector over the long run, guaranteeing the consistent availability of food.

- Technical sustainability: The services are designed and supported with scalability in mind. As the user base and data volume grow, the system can handle increased demand without significant performance degradation.

4 Business Services

4.1 Crop Yield Prediction Service

Unique ID: BS-CYP
Short Name: Crop Yield Prediction Service
Involved Participants:

- Users - Farmers

- Stakeholder: Alliance for a Green Revolution in Africa(AGRA) non-profit organization that works to improve the productivity and incomes of smallholder farmers in Africa.

4.1.1 Detailed Operational Description

The Crop Yield Prediction Service (CYPS) is a crucial component of the broader agricultural support ecosystem within this project. CYPS is designed to assist farmers in East African countries in optimizing their crop production and increasing their yields. It achieves this by utilizing data-driven analytic and predictive algorithms to estimate future crop yields based on various factors including weather patterns, historical data, and current agricultural practices.

First the CYPS journey begins as the service is initiated, next step is the gathering of input data from diverse sources through the Data Retrieval Service. This data serves as the foundation for the subsequent analytical processes which is through the data processing service where the process of comprehensive analysis and data processing takes place, laying the groundwork for accurate predictions.

Historical prediction and yield data is of high importance for this service hence historical crop data is seamlessly integrated into the dataset through the Crop Management Service this will be combined with the data coming from the data processing service to enhance the precision of predictions.

The Prediction Service employs predictive algorithms to estimate future crop yields. This phase plays a pivotal role in providing farmers with invaluable insights and making the needed yield prediction. If, during the verification step, the predictions are identified as inaccurate, the Optimization Service may be invoked. This optional service seeks to enhance the accuracy of predictions further. Then follows the Advisory Service. It is the service tasked with providing recommendations and advice based on the predictions made, helping farmers make decisions to mitigate risks and increase productivity.

Finally, farmers receive advice and prediction results in a timely manner through the Notification Service.

This comprehensive set of software services, working together cohesively, allows for the effective and accurate prediction of crop yields while supporting informed decision-making in agriculture.

Key characteristics include:

- The BS-CYP Service collects various data provided by its data providers.

- Predictive Modeling: Advanced algorithms evaluate gathered data to estimate crop productivity. These forecasts provide farmers with an idea of what crop yields to expect for the coming season.

- Risk Mitigation: Farmers can take proactive actions to limit crop production risks such as droughts and excessive rains by knowing the possible hazards connected with crop production.

4.1.2 Service Behaviour

The activity diagram in Fig. 2 illustrates the behavior of the Crop Yield Prediction Service (CYPS). This service is designed to provide valuable support to farmers engaged in agricultural activities across East African countries.

4.1.3 Service Candidates Decomposition

In the Fig .3 are illustrated 7 software services of the Crop Yield Prediction Service business service. It includes: Data Retrieval Service, Data processing Service, Yield prediction service, Crop Management Service, Optimization Service, Advisory Services and Notification Service. The following is the detailed operational description of this business services and its six software services.

Data Retrieval Service: The Data Retrieval Service is responsible for collecting various types of input data crucial for crop yield prediction. This includes Weather, satellite and soil data provided by the data provider stakeholder.

Data Processing Service: The Data Processing Service is responsible for analyzing, cleaning, and preparing the collected data to make it suitable for use in yield prediction. This service encompasses the following activities like data cleaning, data integration, and data preprocessing.

Yield Prediction Service: The Yield Prediction Service is at the core of the services, tasked with generating accurate crop yield predictions. It utilizes both the prepared input data and historical data acquired from the Crop Management Service. The key steps include: Data Analysis, AI models for the prediction and prediction outputs.

Crop Management Service: The Crop Management Service complements the yield prediction process by providing information related to the crops themselves and the historical prediction data:

Crop Information: Details about the type of crops being cultivated, planting dates, growth stages, and crop-specific requirements.

Historical Crop Data: Past yield records, crop performance, and related historical information that informs the prediction models.

Optimization Service: The Optimization Service plays a crucial role in fine-tuning the predictions generated by the Yield Prediction Service. It ensures the highest level of accuracy by error correction and model refinement.

Advisory Service:

The Advisory Service is responsible for offering personalized guidance and recommendations to farmers based on the yield prediction service.

Notification Service: The Notification Service acts as an outlet for the farmers and stakeholders to get information: by sending timely alerts, reports, and insights to farmers, agricultural organizations, and other stakeholders.

4.1.4 Data Model

The Class diagram in Fig .4 illustrates data interaction of all 6 software services. The BS-CYP software services are represented as 7 classes (entities) in this data model, which is depicted as a class diagram. The first class is the farmer class. The Farmer class has a composition relationship with the Field class with a cardinality of 1 to many. The reason behind this is that our service assumes that a field cannot exist without a farmer to own it. If a farmer is deleted, all of their fields are also deleted. A farmer can own more than one field, as is the case in East African countries.

The Field class belongs to the Data Retrieval Service as it serves as input to the business service. It has an association relationship with a many to many with the CropSpecies class. This is because we assume that a crop type can exist independently of a field, and a field can exist independently
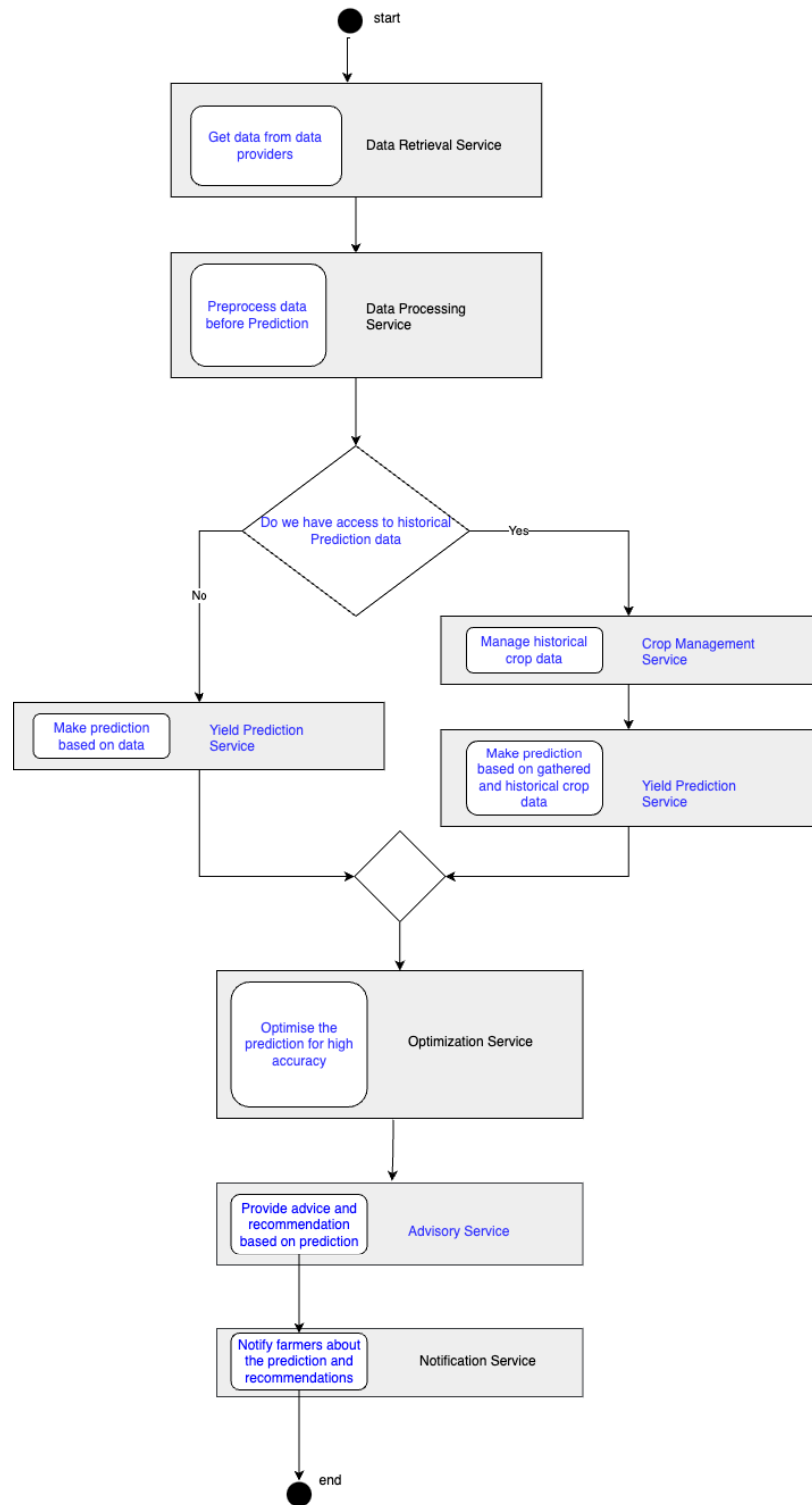
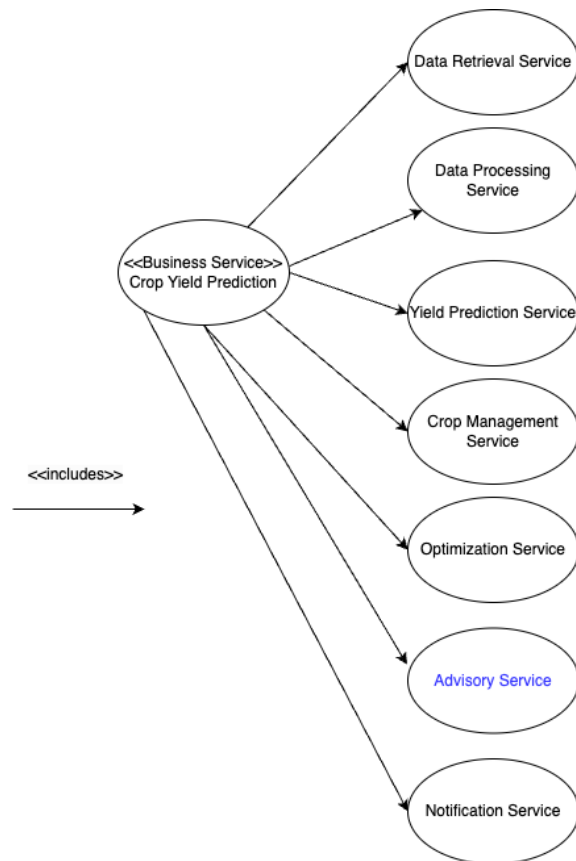Figure 2: BS-CYP Activity diagram

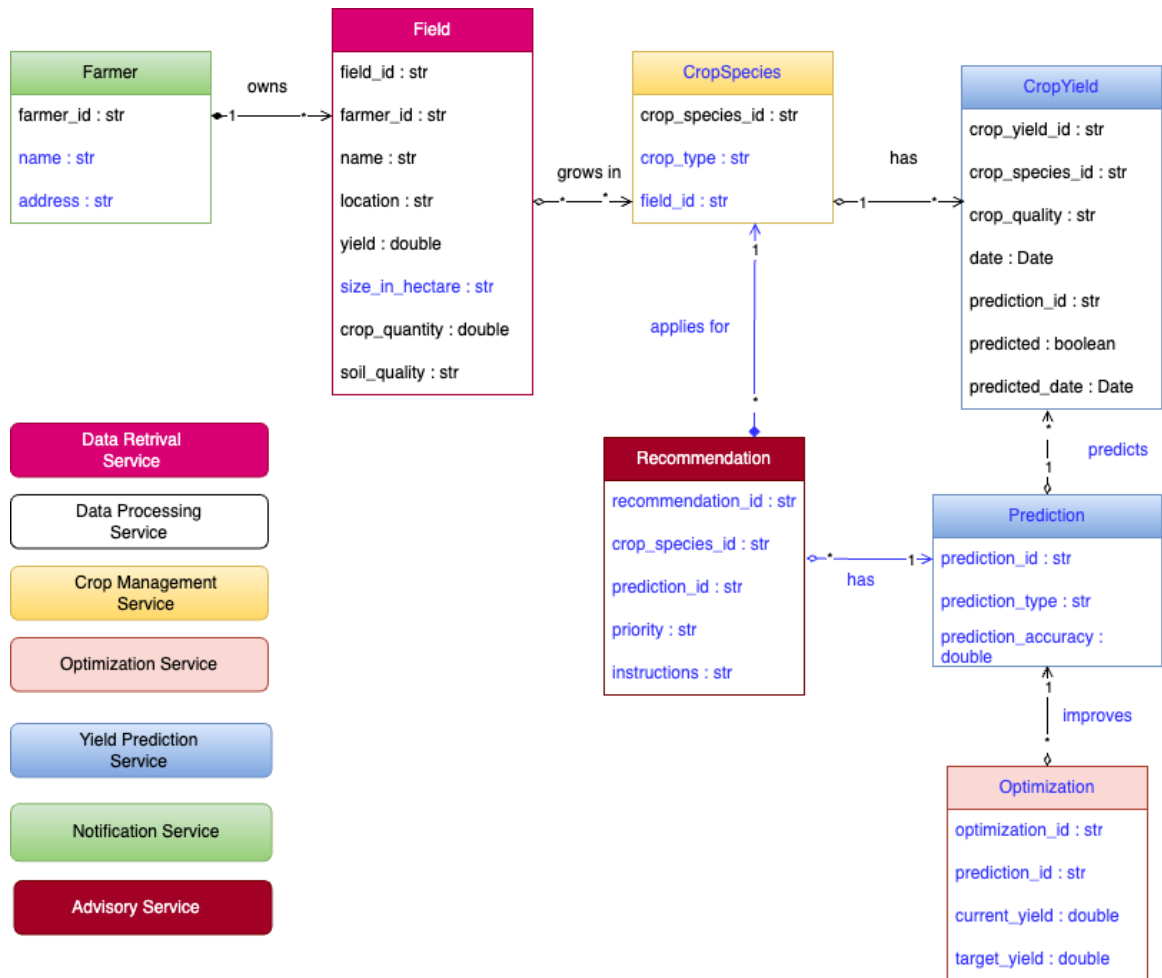Figure 3: BS-CYP Use Case diagram

Figure 4: BS-CYP Class Diagram

of a crop type. For instance, a wheat crop type can exist without a specific field to grow in, and a field can exist without a specific crop type growing in it. Hence, the association relationship. A Field can also grow multiple crop types, and vice versa, explaining the many-to-many cardinality relationship.

Information regarding the crop type is stored and managed in the Crop Management Service, and each crop type under the CropType class has a crop yield, hence having an association relationship with the CropYield class. The relationship here is association because there are two ways of obtaining the crop yield: one is predicted, and the other is the actual yield of the crop. Hence, there is an association relationship instead of a composition relationship, as it can exist without the CropType class. Additionally, it has a one-to-many relationship, as a crop type can have multiple yields.

The Prediction Service contains CropYield and Prediction entities, and these entities are related with an association relationship, just like the previous relationship between crop type and crop yield. One prediction can have multiple predicted yields. This is because we use the Optimization Service to optimize the predictions that this class outputs, hence the association relationship with the Optimization class which will improve the prediction. Another entity is the Recommendation entity. This entity belongs to the Advisory Service and mainly contains the attributes for a recommendation and advise that is given to the farmer. It has a composition relationship with the Prediction class, where a recommendation would belong to a prediction.

4.2 Fair Price Advisor Service

Unique ID: BS-FPA
Short Name: Fair Price Advisor Service
Involved Participants:
  Users: Farmers.
  Stakeholders:

- World Bank: Collaborates to provide access to market prices;

- Farmers Association: Associations in specific areas often have a good understanding of the challenges and issues faced by farmers, including information about common intermediary fees.

- Security provider: This provider handles the authentication and authorization of users, ensuring that only authorized individuals can access the system or specific resources.

4.2.1 Detailed Operational Description

Fair Price Advisor is a business service designed to empower farmers in East African countries by maximising their profits from crop cultivation while ensuring fair prices and resisting malnutrition. It does this by providing farmers with updated quarterly market prices, details on common intermediary fees and approximate future prices. The issue at arises from intermediaries who inflate market prices significantly while providing low compensation to farmers. This situation leads to food becoming unaffordable for many in the market and inadequate income for farmers.

Users are able to see upcoming profits, avoiding that they will sell their crop for very low prices. As a result, not only do individual farmers benefit, but the entire economy of East African countries stands to improve. When farmers are well-informed about prevailing and future prices, they can make decisions that lead to more stable incomes and economic growth in their communities.

BS-FPA service collaborates with another business service, BS-CYP (Crop Yield Prediction Service), to provide Future Price Estimation to users. However, it's important to note that BS-FPA can operate independently if a user chooses not to utilize the Price Prediction Service. In such cases, users can still benefit from other features of BS-FPA, such as current market price, even if they opt not to access future price estimates through BS-CYP.

Key Features:

- Farming Data Management: Users can manage their farming data, including changing crop types or planting dates to tailor the prices they see.

- Current Market Pricing: Fair Price Advisor provides farmers with current market prices for their crops, ensuring they are always well-informed about the current value of their produce.

- Future Price Estimates: Approximate future prices, enabling farmers to make informed decisions on when to sell their crops, avoiding the risk of selling at unprofitable rates. The estimation will be calculated by mapping crop yield predictions from BS-CYP to current prices. The time frame of the price estimation is synchronized with the crop yield prediction.

The Activity diagram in Fig. 5 illustrates the behaviour of the Fair Price Advisor business service. It begins by checking whether the user has an existing account. If the user has an account, the service proceeds to the "Login Service" otherwise it directs the user to the "Registration Service" for account creation.

Since only authorised users from BS-CYP service have the possibility to see future price estimates, there is another checking of whether a user has access to predictive data. If yes, the service collects personalised crop prediction data from the BS-CYP, if not, this step is skipped to the next step.

Next, all the general data is being collected from:

1. Market data, including current prices from The World Bank , including data on the current prices of agricultural commodities in the region. This data is sourced from market reports and is used to provide users with pricing information for their crops;

2. Farming data provided by the user, especially in cases where the user is not connected to the BS-CYP.

If a user wishes to change the personal data, it takes place in "Farming Data Management Service". This service allows users to make changes such as adjusting crop types or planting dates to customise the prices they view.

Next, all the data is being processed and analysed in "Data Processing and Analysis Service". The result of this analysis is then made available to the user through two entity services:

1. "Current Price Service" providing users with access to updated quarterly market prices. Moreover, users are provided with information about common intermediary fees. As a result, users have access to both market prices and the associated logistics fees charged by third-party companies, enabling them to make more informed calculations. This output is accessible for all users.

2. "Future Price Estimation Service" which maps current market prices to personalised crop prediction data, offering users insights into approximate future prices based on the BS-CYP predictions. This output is accessible for users who have an authorization to the BS-CYP.

This comprehensive flow ensures that users are well-informed and equipped with the necessary data to make informed decisions regarding their crop sales.

4.2.2 Service Behaviour

BS-FPA behavior is illustrated in Fig. 5.

4.2.3 Service Candidates Decomposition

In the Fig.6 are illustrated 9 software services of the "Fair Price Advisor Service" business service. It includes: Registration Service, Login Service, Authorised Data Collection Service, Market Data Collection Service, Intermediate Data Collection Service, Farming Data Management Service, Data Processing and Analysis Service, Current Price Service and Future Price Estimation Service.

4.2.4 Data Model

The Class diagram in Fig.7 illustrates data interaction of all 8 software services.

Farming Data Class:

- *cropType:* This attribute stores the type of the crop being cultivated. It identifies the specific crop that a farmer has planted or will be planted.

- *location:* String: This attribute holds information about the geographic location of a plantation.
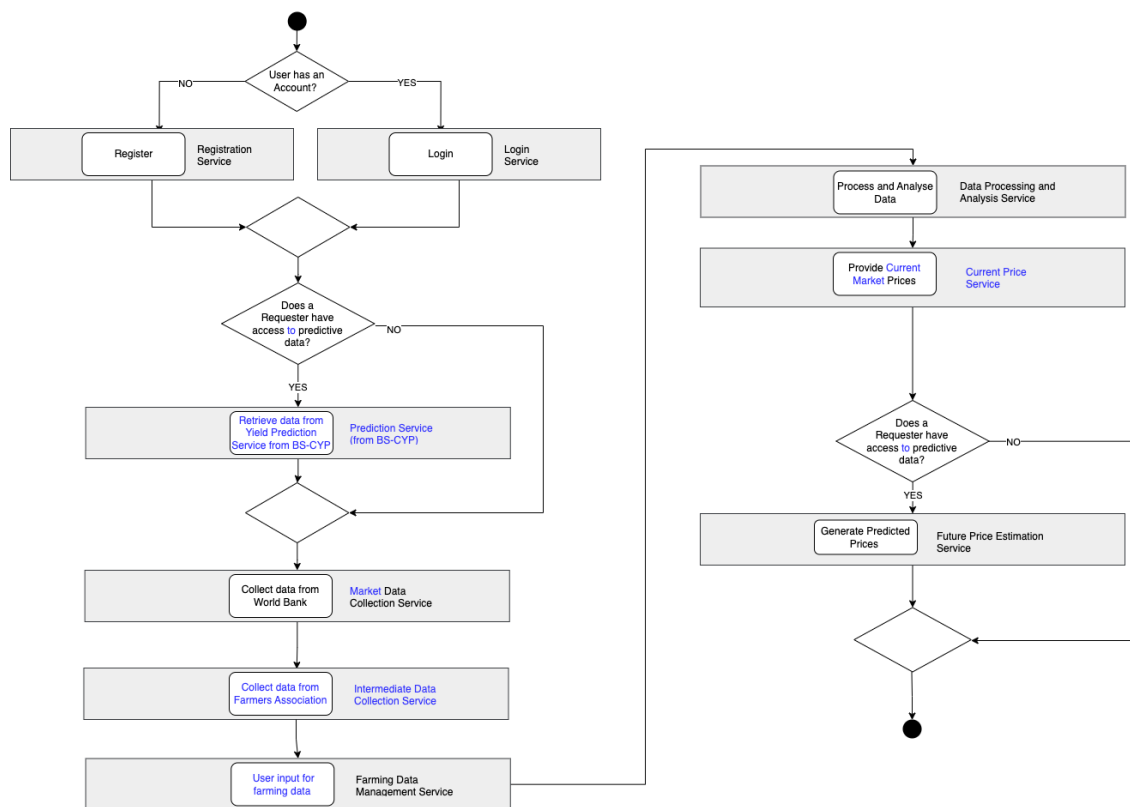
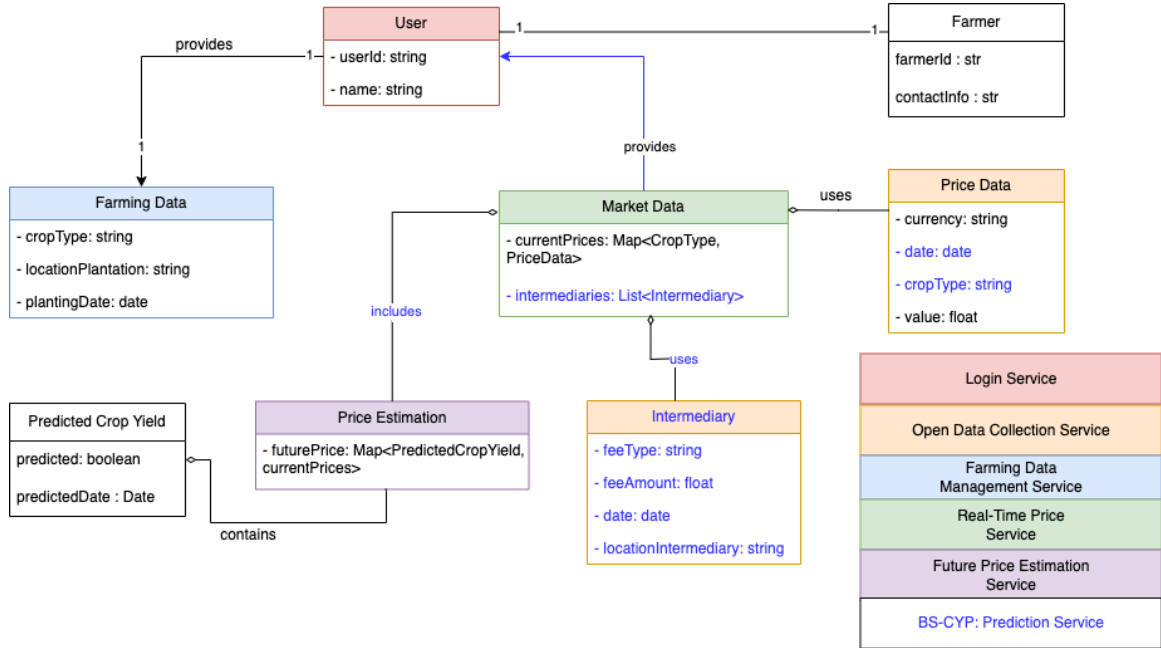Figure 5: BS-FPA Activity diagram

Figure 6: BS-FPA Use Case diagram

Figure 7: BS-FPA Class Diagram

- plantingDate: This attribute represents the date when the crop was planted or will be planted.

Price Data Class:

- *currency:* Represents the currency in which the price value is denominated.

- *date*: This attribute holds the date of the value of the price.

- *value:* This attribute holds the numeric value of the price.

Market Data Class:

- *currentPrices*: This attribute is represented as a mapping (Map) from CropType which is coming from the Farming Data class and the PriceData from the Price Data class.

- *intermediaries*: List of Intermidiate channels and their information.

Intermediary Class:

feeType: Represents the type of fee charged by the intermediary and how they work with farmers. *feeAmount*: Represents amount of money that considered as payment for the distribution channels. *date*: Represents the date when the information was last updated by a Farmers Association. *locationIntermediary*: Represents a location where a distribution channel is located.

Price Estimation Class:

- *futurePrice:* This attribute is represented as a mapping (Map) from PredictedCropYield, external class from BS-CYP, representing the predicted crop yield and PriceData which contains

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market price. This mapping associates each predicted crop yield with its corresponding current price data.

Predicted Crop Yield is an outside class from the BS-CYP which allows access to predicted crop data. As well as out-coming Farmer class, which indicates if a user is authorised to the BS-CYP service.

4.3 International Agriculture Investment Dataspace Service

Unique ID: BS-IAI
Short Name: International Agriculture Investment Dataspace Service
Involved Participants:
Users :

- Farmers : In this service the user 'farmer' will be called landowners/land tenant, as the service stands on the viewpoint of the ownership of land property.

- Companies : Investment companies that need information to make investment decisions for the farmers.

Stakeholders:

- Governments: Collaborates to provide information regarding international regulations of data-sharing.

4.3.1 Detailed Operational Description

The International Agriculture Investment Dataspace Service is a business service designed to help foreign investors make informed decisions about their agriculture investments. The service does this by providing real-time and historical data on plantations across the globe. It gives a prediction of the future yield and analytic data about the land quality as well.

The data sharing will be standardized to ensure the service can be used by investors from any country on any plantation globally. Moreover, the service will adhere to the regulations of each country about which data is allowed to be shared.

As a result, foreign companies will have a clear image of their investment, which will give them more confidence in their investment. Raising funds will allow farmers to access modern technologies that can increase the harvest yield. For tenant farmers, foreign funds will raise their possibility of owning their own land by co-owning the land they planted with the foreign investors.

The BS-IAI collaborates with another business service, BS-CYP (Crop Yield Prediction Service), to provide real-time and future analytic data from plantations. However, there is no authorized checking of BS-CYP, either by land-owning cooperation status or by national regulations.

However, it's important to note that BS-FPA can operate independently if a user chooses not to utilize the Price Prediction Service. In such cases, users can still benefit from other features of BS-FPA, such as real-time pricing and distribution channel insights, even if they opt not to access future price estimates through BS-CYP. BS-IAI maintains and strengthens the collaboration between local farmers and foreign investors, which in the long term will build a protected dataspace environment.

Key Features:

- Access and Authentication:

  - Implement robust authentication and authorization mechanisms based on international Memorandums of Understanding (MOUs).
  - Define user roles (e.g., investors, auditors, administrators) with varying levels of access to data and functionality.

- Data Security and Encryption:

- Encrypt data transmission and storage to protect sensitive information to be transferred internationally.
- Implement security best practices to safeguard against unauthorized access or data breaches.

- Audit Trail:

  - Maintain a comprehensive audit trail of all user interactions and data modifications within the system for auditing purposes.
  - Log and timestamp all access and data changes for accountability.

- Notifications: Notification alerts to investors and auditors for critical events or significant changes in plantation conditions, such as extreme weather events or disease outbreaks.

- Integration with External Systems: Allow integration with external systems, such as ERP (Enterprise Resource Planning) or financial systems, to support investment tracking and financial analysis.

The Activity diagram in Figure. 8 illustrates the behaviour of the International Agriculture Investment Dataspace business service. It begins by checking whether the requester has authorisation to access the data. If the user has an account, the service proceeds to the data retrievals, otherwise it directly ends the process

Following the authorisation, the service proceeds to accept fields for data filtering in "Requester Field Acceptance Service". The requested fields list are received from requester, and national law and regulations are retrieved by "Law and Regulation Service".

On the next step, plantation data will be acquired. The International Agriculture Investment Dataspace Service will check whether there was the same request before. If there is the same request, "Historical Record Retrieval Service" will retrieve the historical data. Otherwise, the "Crop Yield Data Retrieval Service" will retract the data from the BS-CYP (Crop Yield Prediction Service). In the event of retraction, retracted data will be saved on the database for logging and reusability purposes by "Historical Record Saving Service".

After that, acquired plantation data will be filtered for only leaving data that have been requested by the user and allowed by laws and regulations, by "Data Filtration Service". The data will be secured by encryption for privacy purposes, by "Data Secured Service". Finally, the secured data will be returned to the requester, by the "Returning ROI Service".

This comprehensive flow ensures that investment companies are with the necessary data to make informed decisions regarding their investment plan.

4.3.2 Service Behaviour

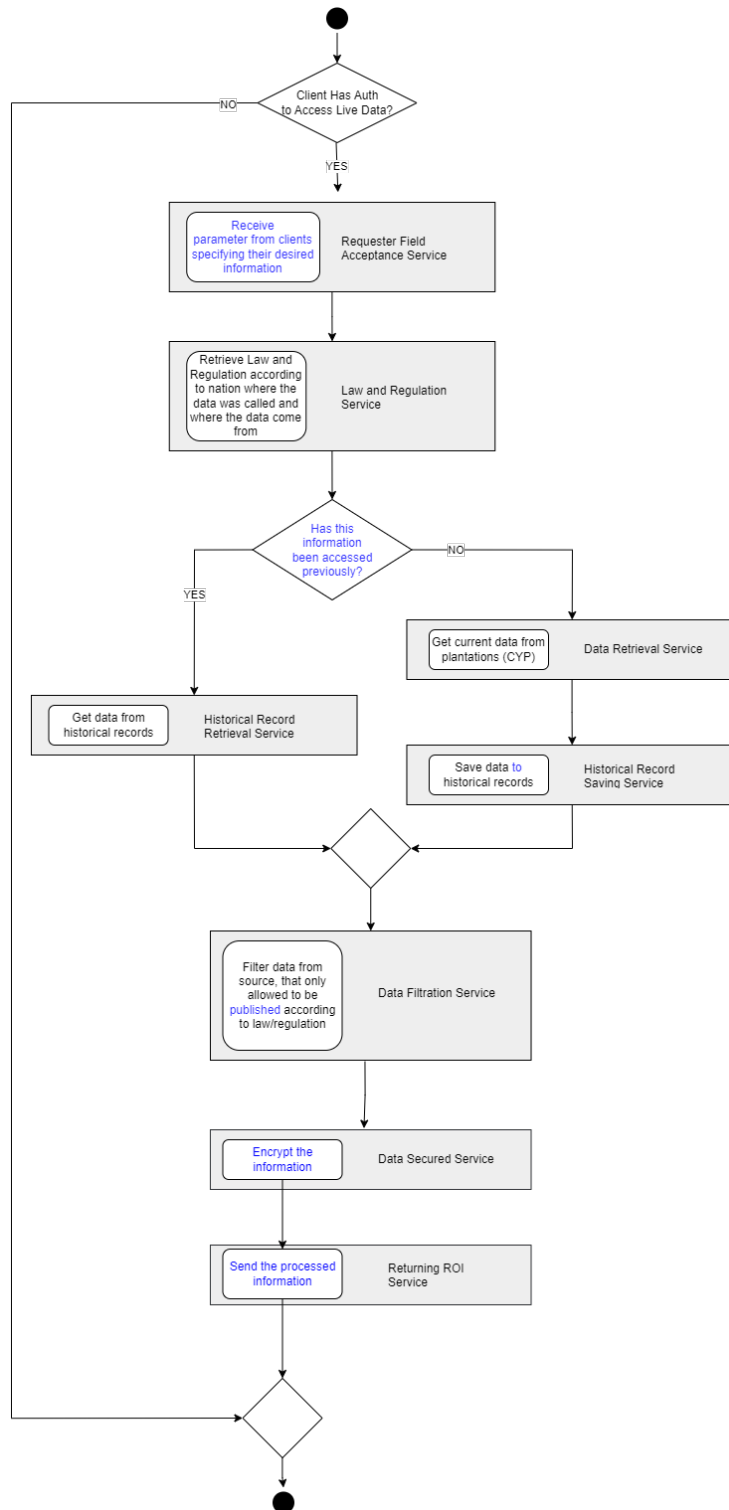BS-IAI behaviour is illustrated in Fig 8

Figure 8: BS-IAI Activity diagram

4.3.3 Service Candidates Decomposition

Figure 9: BS-IAI Use Case Diagram

In the Fig.9 are illustrated 8 software services of the "International Agriculture Investment Dataspace Service (BS-IAI)" business service. It includes: Requester Field Acceptance Service, Law and Regulation Service, Historical Record Retrieval Service, Crop Yield Data Retrieval Service, Historical Record Saving Service, Data Filtration Service, Data Secured Service, and Returning ROI Service.

4.3.4 Data Model
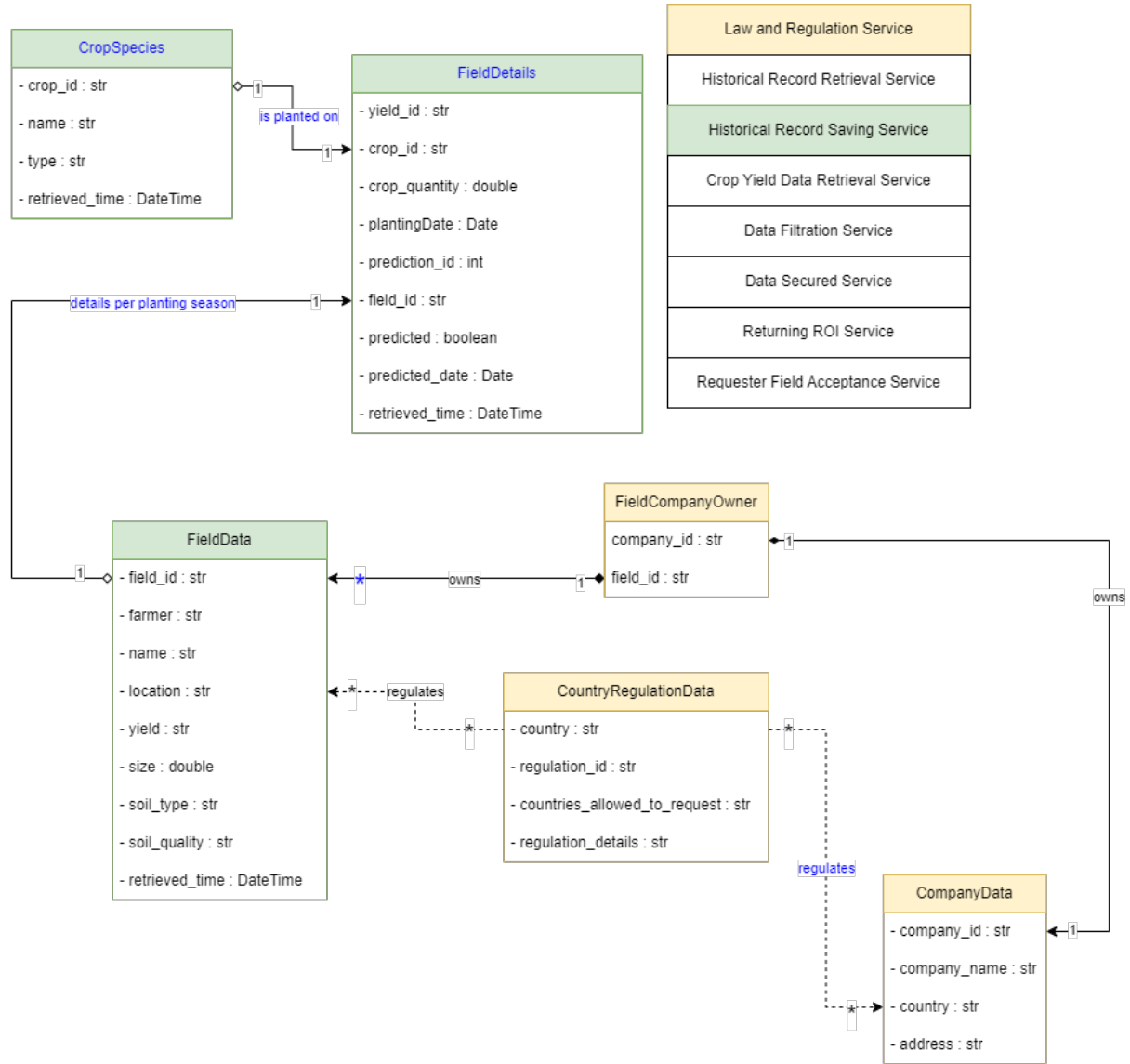
Figure 10: BS-IAI Class Diagram

The class diagram in Fig.10 illustrates the data interaction of all 8 software services.

The International Agriculture Investment Dataspace Service's data model is represented by six classes (entities) in the class diagram. These six classes (entities) are used to model the BS-IAI software services.

The data for CropSpecies, CropDetails, and FieldData are taken from the Crop Yield Prediction Business Services, which work to provide the raw data of the land quality and the forecasting analysts of the amount of crop yields by the end of the season.

The CropDetails class stores details about the crops planted in each field every season. The data includes information about planting time, soil quality, crop quantity, and the species planted in that area. The names of crop species adhere to a standard that is saved in CropSpecies in order to minimize misunderstandings between companies and farmers.

The FieldData Class stores information on plantations such as size, land quality, location, and the identity of the landowner or tenant (recorded as an attribute labeled "farmer"). The field is jointly owned by the investing companies and the landowner or tenant. In order to determine whether the firm has the authorization to access the field data, the FieldCompanyOwner Class maps the authorization.

The countries where the fields and companies are situated have laws controlling foreign data access and land ownership treaties in addition to property ownership. These regulations, stored in the CountryRegulationData entity, play a role in deciding data sharing rights.

4.4   Context Diagram
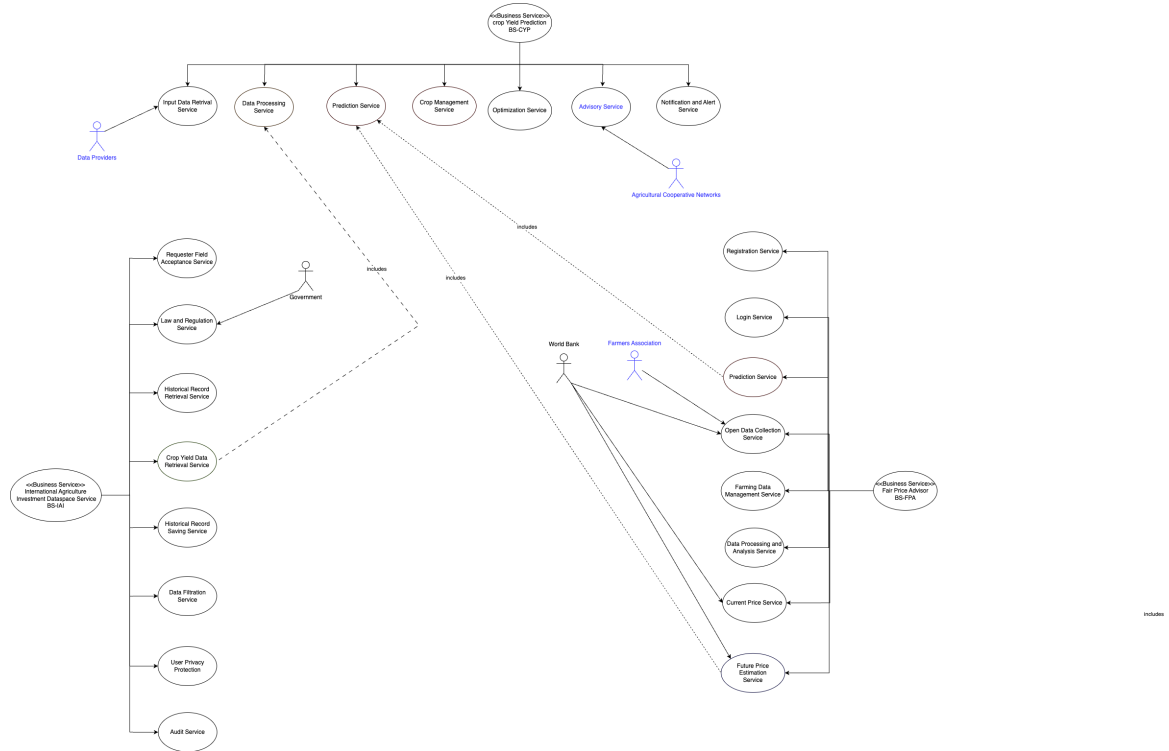
Figure 11: Context Model Diagram

In this section, we describe the context of our four business services, including the relationships between stakeholders and other business services, to provide a more holistic solution. To recap, we have the following four business services:

- Crop Yield Prediction Service

- Fair Price Advisor Service

- International Agriculture Investment Dataspace Service

In this section, we describe the relationship between the stakeholders of our business services and how they provide services in each of our three business services.
Data Retrieval Service will be provided by the Data Providers which will be external to our business services. Staying in the Crop Yield Prediction service, Agricultural Cooperative Networks will also be providing the Advisory Service as seen in the figure above. Two of the software services in the Crop Yield Prediction Service also provide data to the software services in BS-IAI and BS-FPA.
The government stakeholder for our business service is involved in several software services of our business services.
The Ministry of Foreign Affairs and the Ministry of Economy are the main government bodies responsible for providing laws and regulations regarding investment policies and strategies that foreign

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companies need to adhere to. Since different countries have different laws regarding investment, this stakeholder provides vital input to the law and regulation service of the International Agriculture Investment Dataspace Service.

As East African farmers may not have the economic means to afford services and goods, government intervention, mainly by the Ministry of Agriculture, is important in this regard. This government body can contribute to this service by providing subsidies so that farmers in this region can afford services without being hindered by economic constraints.

The World Bank plays a crucial role as a stakeholder in specific software services aimed at providing essential information. It is used in three key service areas: 'Open Data Collection Service' 'Real-Time Price Service' and 'Future Price Estimation Service'

The World Bank supplies current market prices, and this data is also used to project future price estimates for agricultural crops. Additionally, it offers insights into distribution channels, aiding farmers in making informed decisions about selling their commodities.

Farmers are the primary users of these services, as they are designed to provide vital information for their decision-making processes. The forecasting of future prices relies on the correlation between real-time prices and predictions generated by the Crop Yield Prediction Service.

5 Design Space

[This Design Decision is related to a business service that is no longer within the domain.]
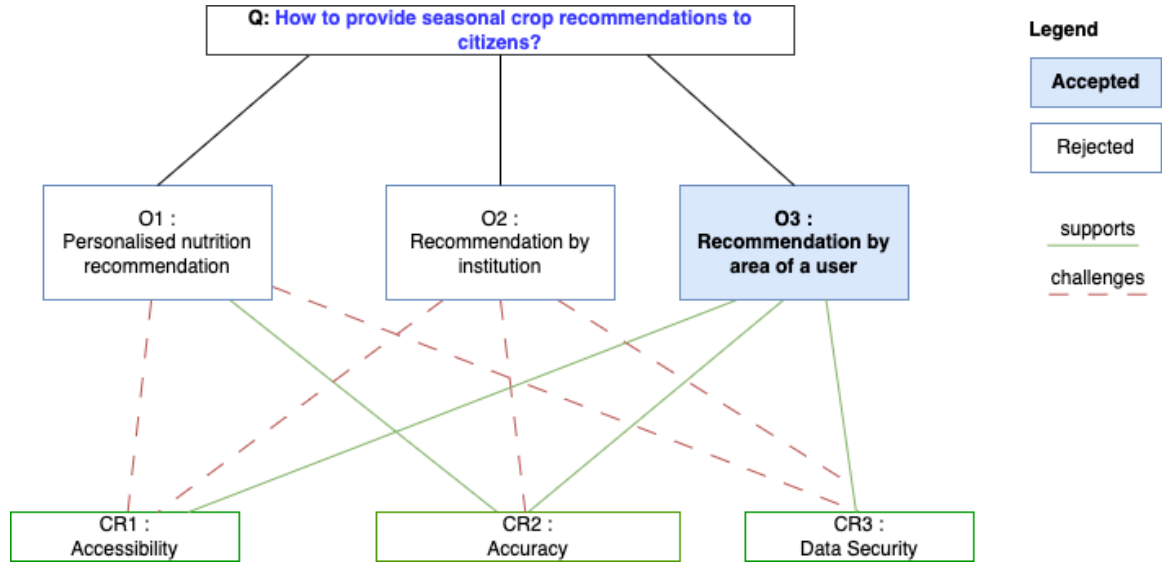
Figure 12: Graphical Representation of the Design Decision

Concern (Identifier: Description)		Con#1: *How to provide seasonal crop recommendations to citizens?*
Ranking criteria (Identifier: Name)		Cr#1:Accessibility Cr#2:Accuracy Cr#3:Data Security
Options	**Identifier: Name**	**Con#1-Opt#1: Personalised nutrition recommendation**
	Description	Provide personalized nutrition recommendations to individuals based on their individual dietary preferences, health goals, and dietary restrictions.
	Status	This option is REJECTED.
	Relationship(s)	None
	Evaluation	Cr#1: Accessibility may be limited for individuals who are unable to provide their personal information. Cr#2: Personalized recommendations can be highly accurate, considering the individual's specific dietary needs. Cr#3: The service would require access to extensive personal data, including allergies and dietary preferences, which could raise privacy and security concerns.
	Rationale of decision	This option is rejected due to concerns related to data security and limited accessibility for users without the ability to input their personal information.
	Identifier: Name	**Con#1-Opt#2: Recommendation by institution**
	Description	Partnering with schools, hospitals, and other institutions to provide recommendations on seasonal food to their students, patients, or staff. Allow cafetarias of that institutions may provide customised food for their members.
	Status	This option is REJECTED.
	Relationship(s)	It's continuing the idea of Con#1-Opt#1 with a control of an institution.
	Evaluation	Cr#1: Access to the service is restricted to individuals affiliated with specific institutions, limiting its availability. Cr#2: Personalized recommendations can be highly accurate, considering the individual's specific dietary needs. However, in this case institution representative may manually input personalized dietary information, which could introduce errors or inaccuracies. Cr#3: Personal data, including allergies, is owned and managed by institutions.
	Rationale of decision	This option is rejected due to concerns regarding accessibility. Only people in certain institutions have access to the service.
	Identifier: Name	Con#1-Opt#3: Recommendation by area of a user
	Description	A Recipe Recommendation Service that offers recommendations based on the seasonal availability of ingredients in the region of a user.
	Status	This option is ACCEPTED.
	Relationship(s)	None
	Evaluation	Cr#1: Information about seasonal food is freely accessible to everyone, promoting inclusivity regardless of income, location, or other factors. Cr#2: Prediction data comes from reliable Crop Yield Prediction service Cr#3: Users are not required to share extensive personal data, except for their location, reducing privacy concerns.
	Rationale of decision	This option is accepted because it shows promise in terms of all criteria. This option is accurate, accessible, and beneficial for citizens in terms of nutrition.

Table 5: Design Decision

6 Sustainability Strategies

Field	Description
Unique ID	SUS-RRS-1
Short Name	Enhanced Food Access through Supply Chain Efficiency
Description	The overarching goal is to elevate food accessibility by streamlining resource efficiency throughout the agricultural supply chain. In pursuit of this goal, our green strategy revolves around enhancing the accessibility of food for citizens. By addressing the entire supply chain, we aim to fortify the link between producers and consumers, ultimately benefiting the entire community.
Type of Strategy	Process awareness, for decreasing hunger by supporting the whole agriculture supply chain, consisting of supporting the agriculture industry, raising crop yield, and decreasing food waste.
Relevance to Malnutrition	This strategy is relevant to combating malnutrition in Ethiopia. By optimizing food access and bolstering resource efficiency in the agricultural supply chain, it directly addresses the urgent need to ensure a stable and abundant food supply. With a focus on protecting farmers, enhancing funding opportunities, and improving crop yields, this strategy contributes significantly to alleviating malnutrition in a country where agriculture plays a vital role in sustaining the population.
Diagram	Fig. 13: Sustainability Strategy

Table 6: Sustainability Strategies

Fig. 14 illustrates sustainability strategy map.

Option 1 - Reducing Harvest Failures: To boost crop yield and minimize food shortages, we implement early prediction systems to identify and mitigate potential threats from external factors. By proactively addressing adverse conditions, such as unfavorable weather patterns or pest outbreaks, we aim to safeguard food production and accessibility.

Option 2 - Empowering Farmers: Our strategy aims to protect farmers from exploitation by intermediaries in the distribution channels. By ensuring fair and transparent pricing, we strive to enhance the financial well-being of farmers and ensure a consistent supply of food to consumers.

Option 3 - Enhancing Funding Opportunities: We recognize the pivotal role of farming equipment in ensuring higher crop yields and food accessibility. To this end, we work to increase funding opportunities for farmers, enabling them to acquire higher-quality equipment and resources. By doing so, we bolster their capacity to meet the demand for food in a sustainable manner.

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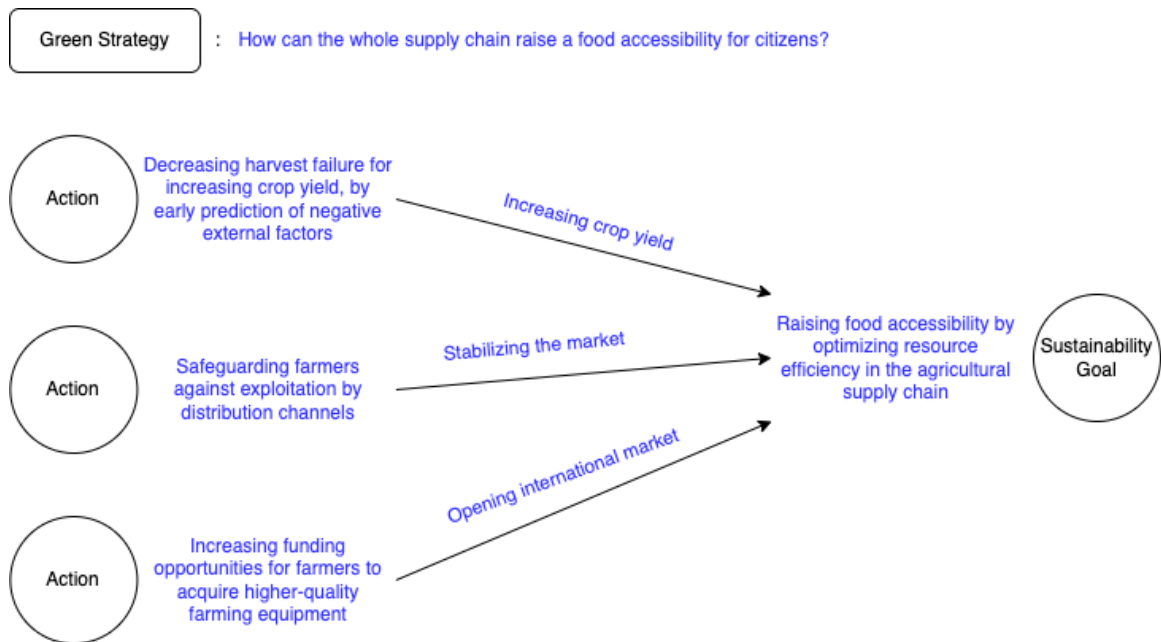
Figure 13: Sustainability Strategy
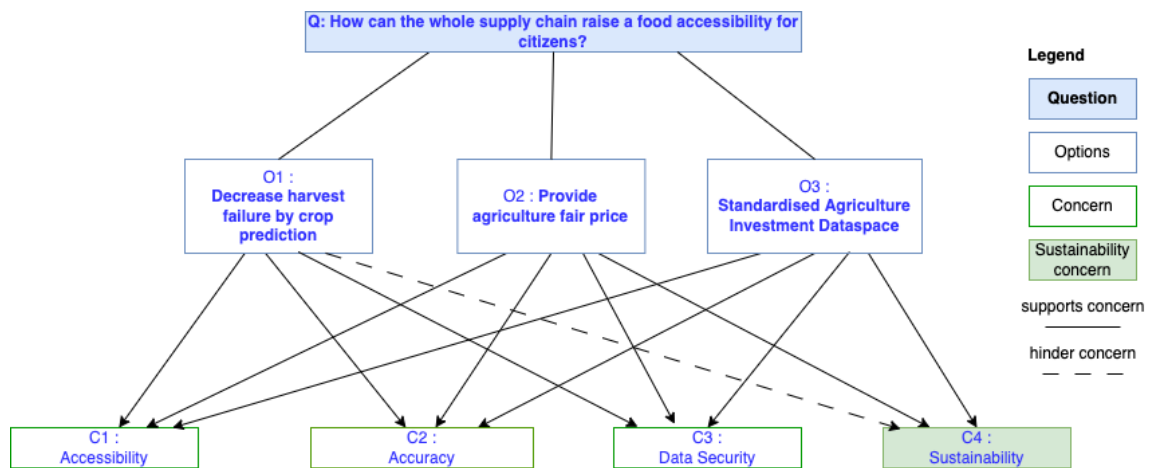
Figure 14: Mapping of Sustainability Strategy

Part 2. Assignment 2: Solution Space

7 Software decomposition of business services

7.1 BS-CYP software decomposition

Field	Description
ID	BS-CYP
Name	Crop Yield Prediction Service
Business Service Behavior	Figure 2: BS-CYP Activity diagram
Software Service Candidates	Data Retrieval Service (ss1-01-DataRetrievalService), Data Processing Service (ss1-02-DataProcessingService), Yield Prediction Service (from BS-CYP))(ss1-03-YieldPredictionService), Crop Management Service (ss1-04-CropManagementService), Optimization Service (ss1-05-OptimizationService), Advisory Service (ss1-06-AdvisoryService), Notification Service (ss1-07-NotificationService).
Diagram	Figure 15 : BS-CYP Mapping

Table 7: BS-CYP Definition
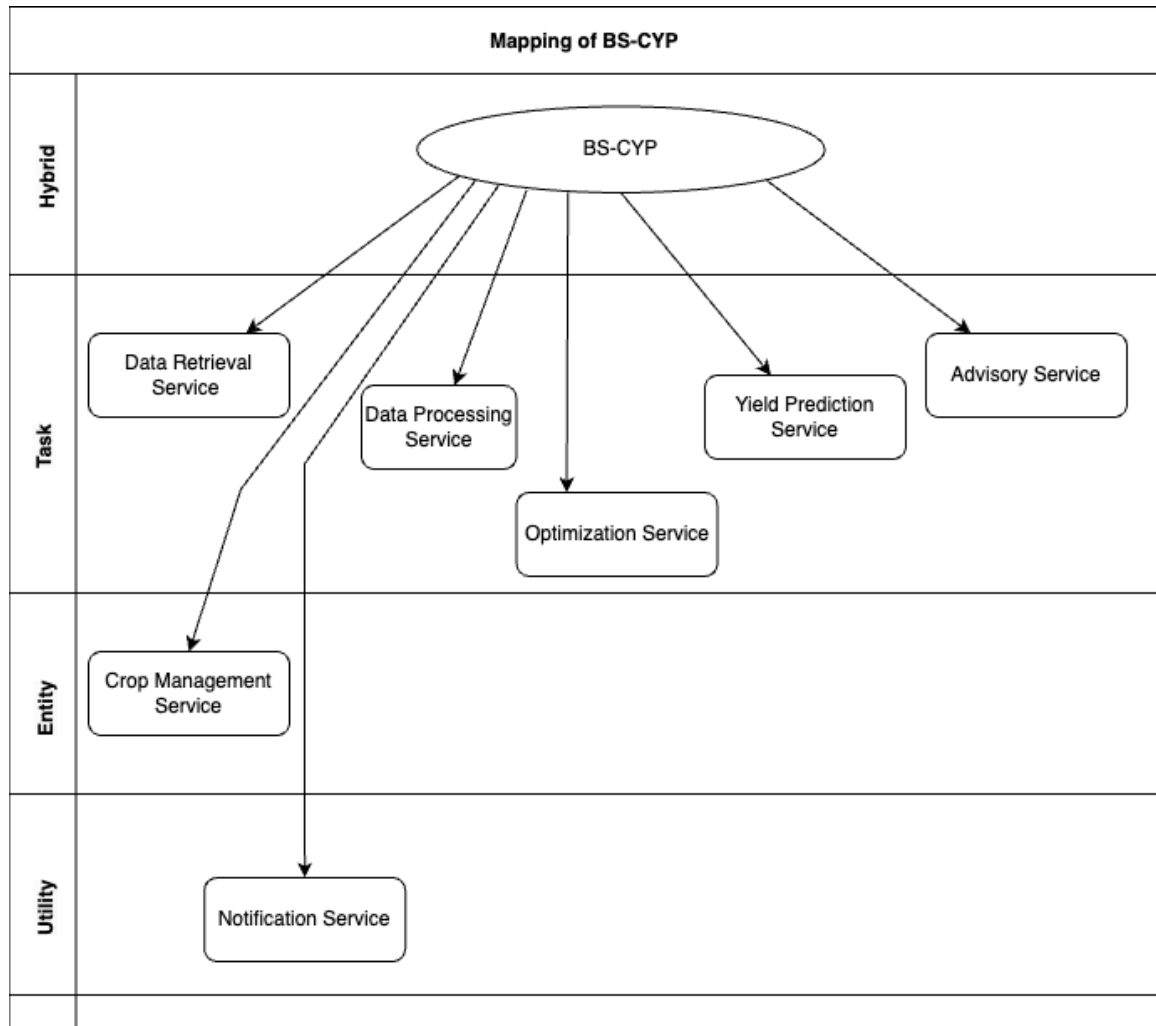
Figure 15: Mapping of BS-CYP

7.2 BS-FPA software decomposition

Field	Description
ID	BS-FPA
Name	Fair Price Advisor Service
Business Service Behavior	Figure 5: BS-FPA Activity diagram
Software Service Candidates	Registration (ss2-01-Registration), Login (ss2-02-Login), Prediction Service (from BS-CYP))(ss2-03-PredictionService), Market Data Collection (ss2-04-MarketDataCollection), Intermediate Data Collection (ss2-05-IntermediateDataCollection), Farming Data Management (ss2-06-FarmingDataManagement), Data Processing and Analysis (ss2-07-DataProcessingAnalysis), Current Price (ss2-08-CurrentPrice), Future Price Estimation (ss2-09-FuturePrice).
Diagram	Figure 16 : BS-FPA Mapping

Table 8: BS-FPA Definition
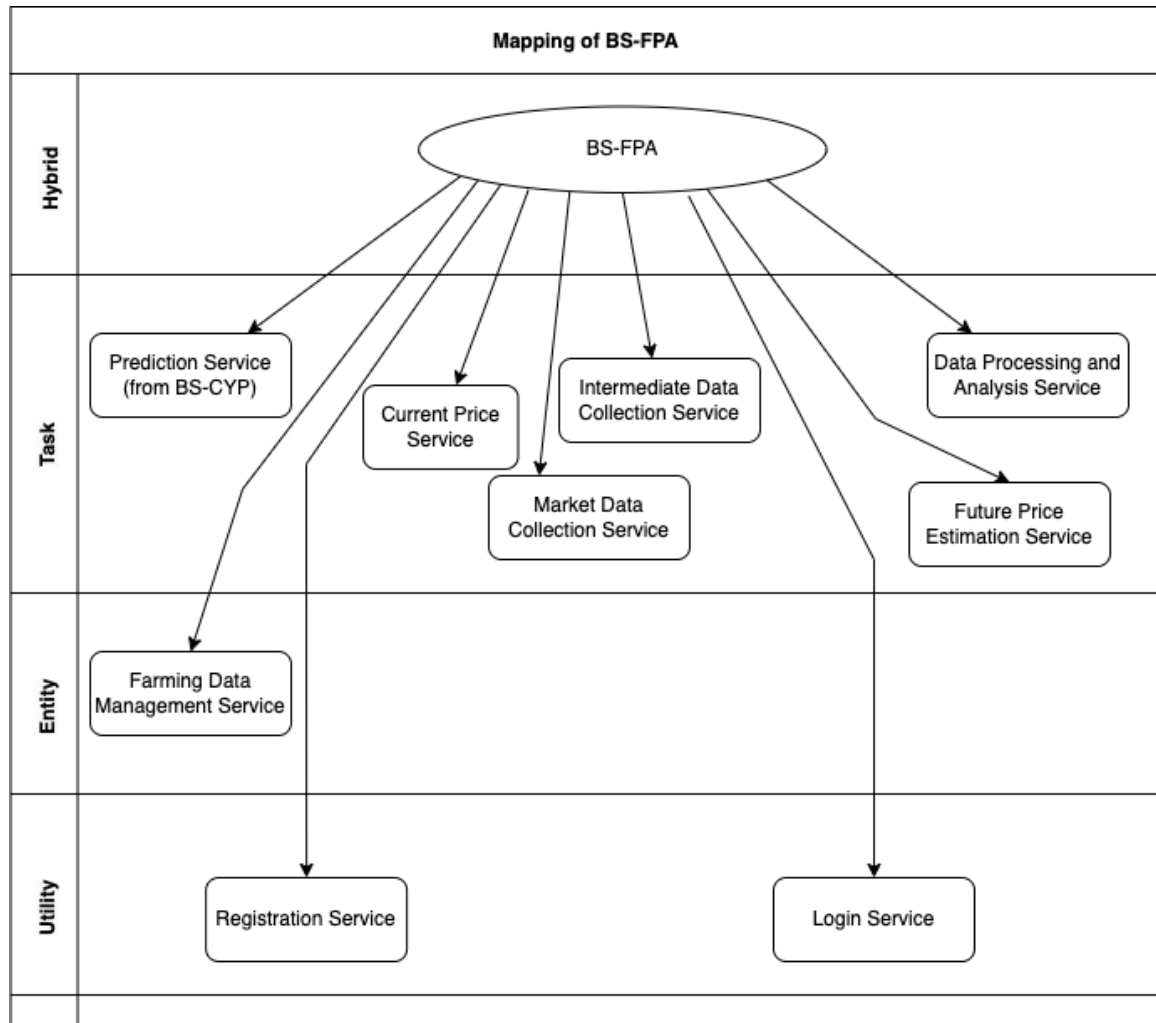
Figure 16: Mapping of BS-FPA

7.3 BS-IAI software decomposition

Field	Description
ID	BS-IAI
Name	International Agriculture Investment Dataspace Service
Business Service Behavior	Figure 5: BS-IAI Activity diagram
Software Service Candidates	Requester Field Acceptance (ss3-01-RequesterFieldAcceptance), Law and Regulation (ss3-02-LawAndRegulation), Historical Record Retrieval (ss3-03-HistoricalRecordRetrieval), Crop Yield Data Retrieval (from BS-CYP) (ss3-04-CropYieldDataRetrieval), Historical Record Saving (ss3-05-HistoricalRecordSaving), Data Filtration (ss3-06-DataFiltration), Data Secured (ss3-07-DataSecured), Returning ROI (ss3-08-ReturningROI).
Diagram	Figure 17 : BS-IAI Mapping

Table 9: BS-IAI Definition
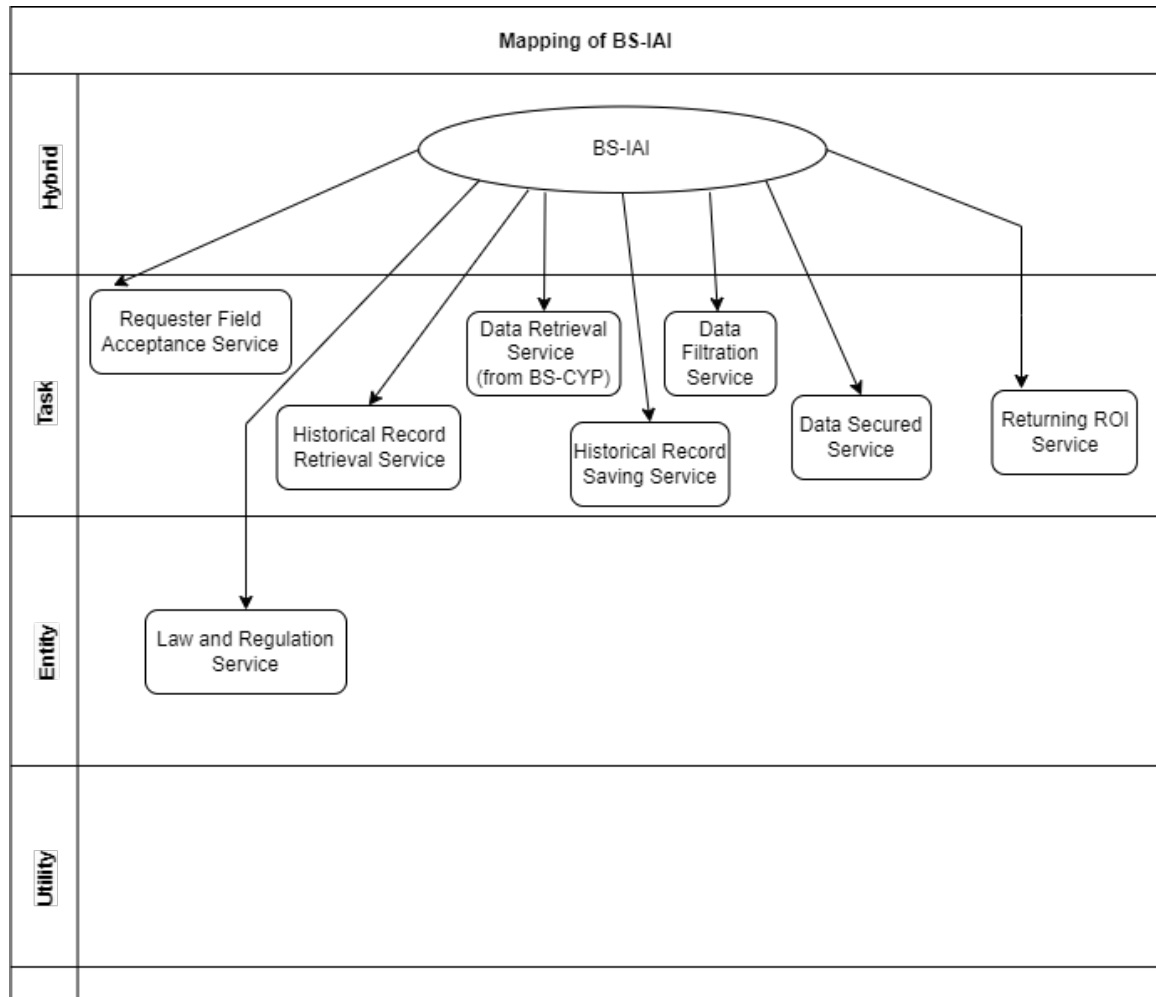
Figure 17: Mapping of BS-IAI

8 Participant service inventory identification

8.1 BS-CYP inventory identification

Field	Description
ID	inv1-01-AGRA
Name	Business Service Owner
Participant	AGRA(Alliance for a Green Revolution in Africa)
Constituent Software Service Candidates	Data Processing Service (ss1-02-DataProcessingService), Yield Prediction Service (ss1-03-YieldPredictionService), Crop Management Service (ss1-04-CropManagementService), Optimization Service (ss1-05-OptimizationService), Notification Service (ss1-07-NotificationService).
Diagram	Figure 18: Inventory of AGRA

Table 10: Inventory of AGRA
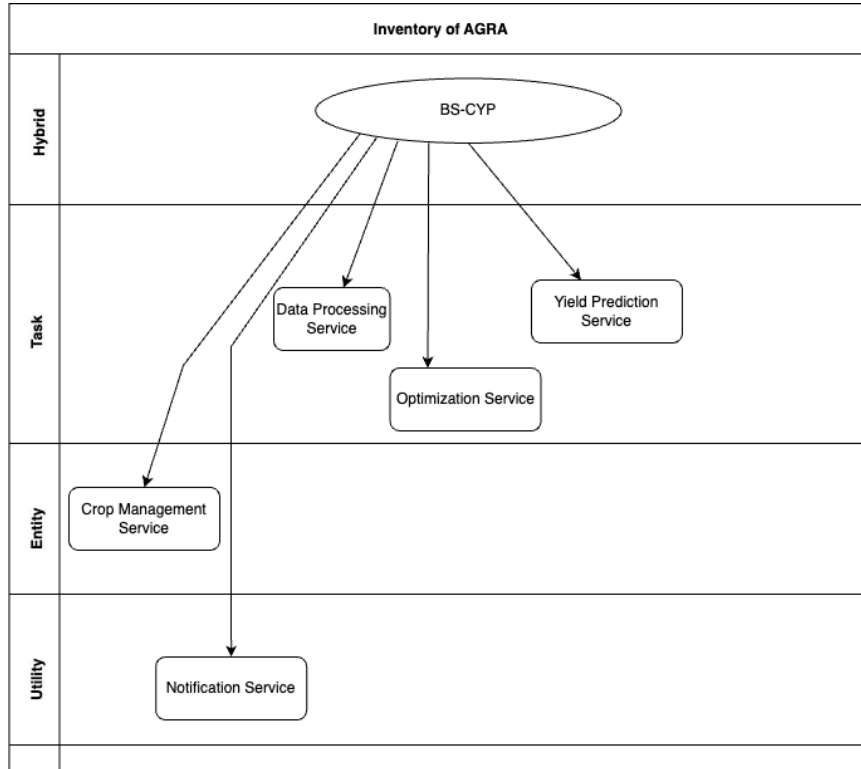
Figure 18: Inventory of AGRA

Field	Description
ID	inv1-02-DataProviders
Name	Input Data Providing
Participant	Data Providers
Constituent Software Service Candidates	Data Retrieval Service (ss1-01-DataRetrievalService)
Diagram	Figure 19 : Inventory of Data Providers

Table 11: Inventory of Data Providers
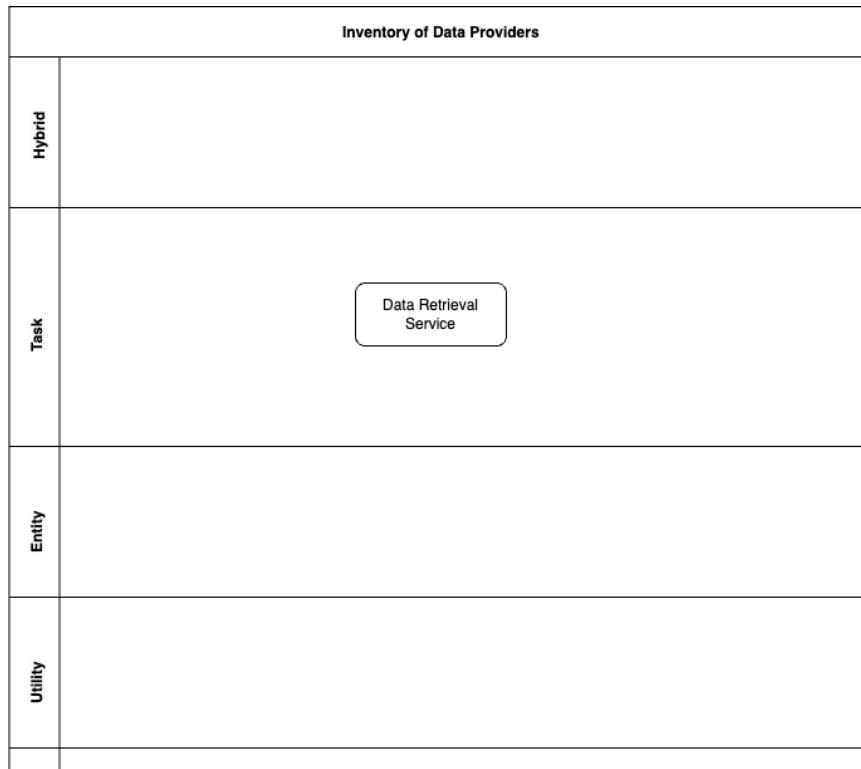
Figure 19: Inventory of Data Providers

Field	Description
ID	inv1-03-AgriculturalCooperativeNetworks
Name	Agricultural Advise
Participant	Agriculutral Cooperative Networks
Constituent Software Service Candidates	Advisory Service (ss1-06-AdvisoryService)
Diagram	Figure 20: Inventory of Agricultural Cooperative Networks

Table 12: Inventory of Agricultural Cooperative Networks
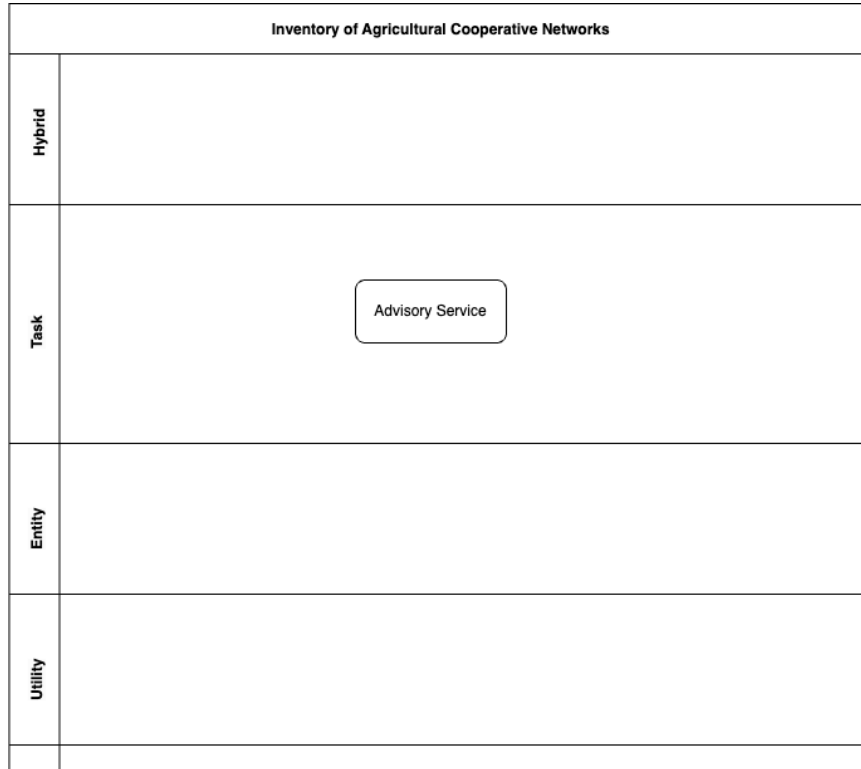
Figure 20: Inventory of Agricultural Cooperative Network

8.2 BS-FPA inventory identification

Field	Description
ID	inv2-01-SecurityServiceProvider
Name	Security Service Certifier
Participant	Security Provider
Constituent Software Service Candidates	Registration (ss2-01-Registration), Login (ss2-02-Login).
Diagram	Figure 21: Inventory of Security Provider

Table 13: Inventory of Security Provider
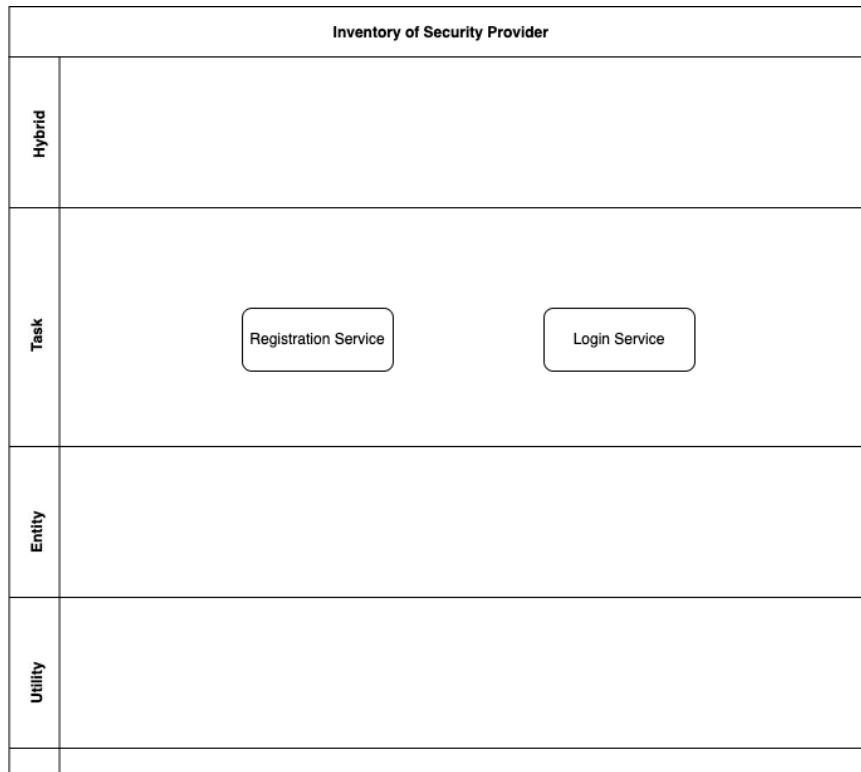
Figure 21: Inventory of Security Provider

Field	Description
ID	inv2-02-WorldBank
Name	Current Price Insight
Participant	World Bank
Constituent Software Service Candidates	Market Data Collection (ss2-04-MarketDataCollection)
Diagram	Figure 22 : Inventory of World Bank

Table 14: Inventory of World Bank

43
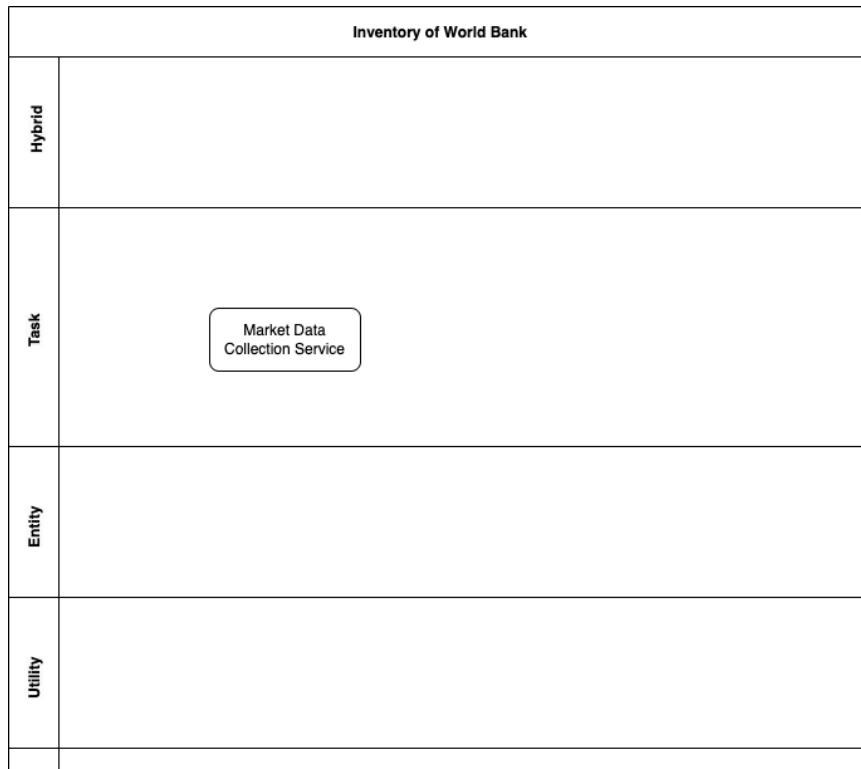
Figure 22: Inventory of World Bank

Field	Description
ID	inv2-03-FarmersAssociation
Name	Intermediate Price Insight
Participant	Farmers Association
Constituent Software Service Candidates	Intermediate Data Collection (ss2-05-IntermediateDataCollection)
Diagram	Figure 23: Inventory of Farmers Association

Table 15: Inventory of Farmers Association
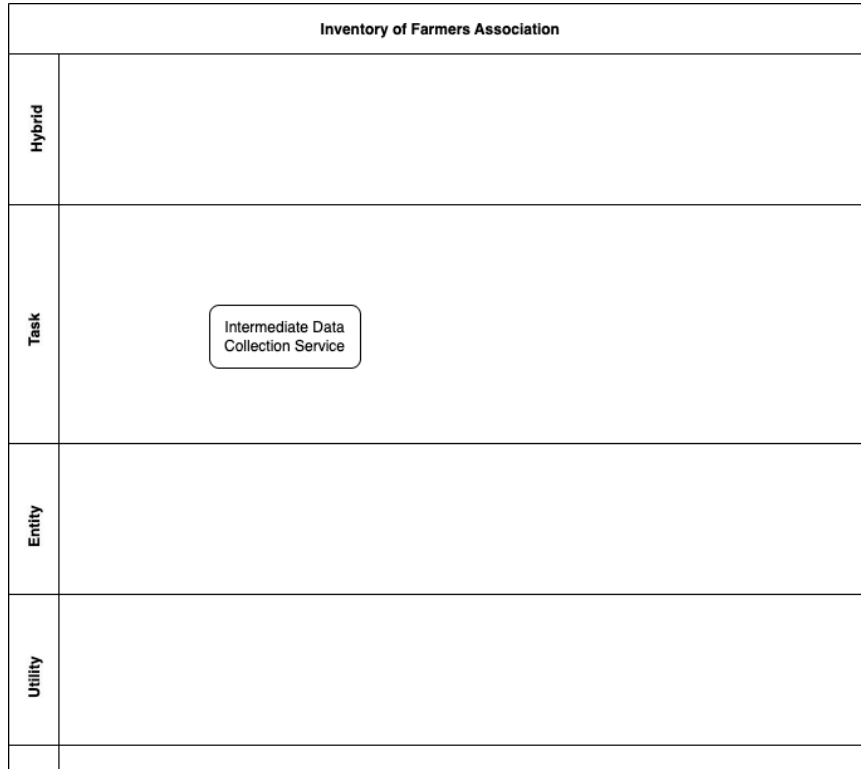
Figure 23: Inventory of Farmers Association

Field	Description
ID	inv2-04-FuturePrice
Name	Crop Yield Prediction
Participant	AGRA
Constituent Software Service Candidates	Prediction Service (from BS-CYP))(ss2-03-PredictionService)
Diagram	Figure 24: Inventory of AGRA

Table 16: Inventory of AGRA
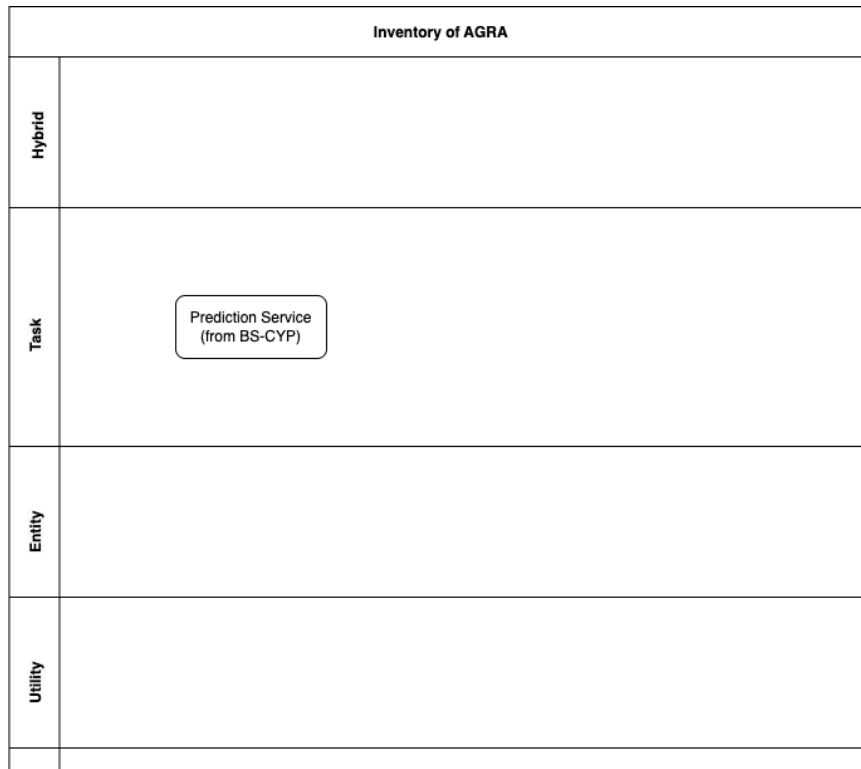
Figure 24: Inventory of AGRA

8.3 BS-IAI inventory identification

Field	Description
ID	inv3-01-MFA
Name	Law and Regulation Management
Participant	Ministry of Foreign Affairs
Constituent Software Service Candidates	Law and Regulation (ss3-02-LawAndRegulation)
Diagram	Figure 25: Inventory of Ministry of Foreign Affairs

Table 17: Inventory of Ministry of Foreign Affairs
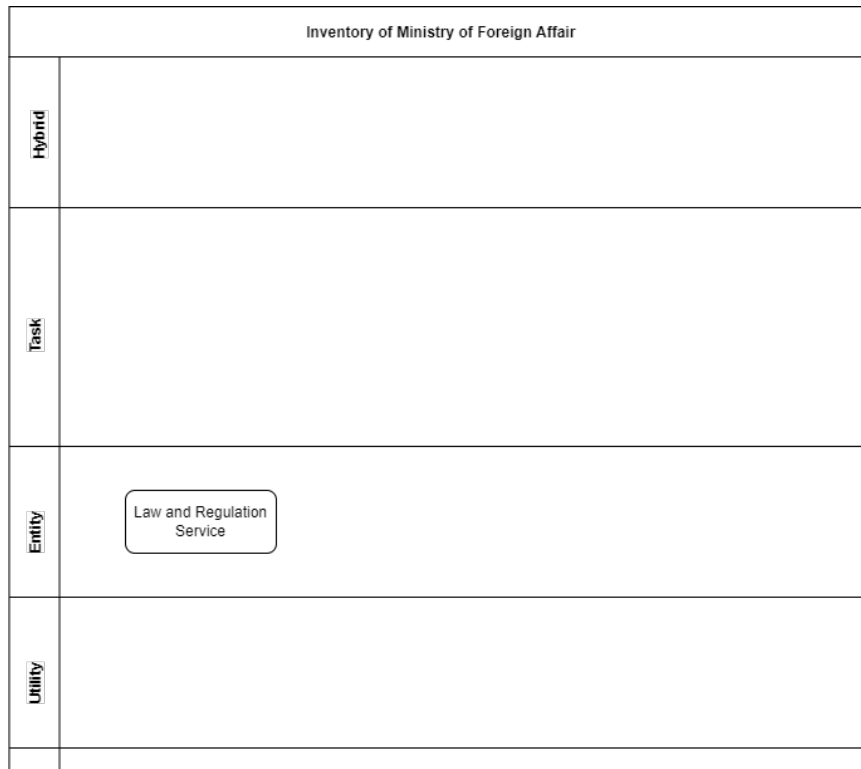
Figure 25: Inventory of Ministry of Foreign Affairs

Field	Description
ID	inv3-02-AGRA
Name	Land Information Update
Participant	AGRA
Constituent Software Service Candidates	Crop Yield Data Retrieval (from BS-CYP) (ss3-04-CropYieldDataRetrieval)
Diagram	Figure 22 : Inventory of AGRA

Table 18: Inventory of AGRA

Figure 26: Inventory of AGRA

9 Service contract identification

9.1 BS-CYP Service contract identification

Field	Description
ID	cn1-01-Recommendation
Name	Recommendation
Involved Participants	Agricultural Cooperative Networks
Service Structure diagram	Figure 27: Contract Recommendation

Table 19: Recommendation Contract
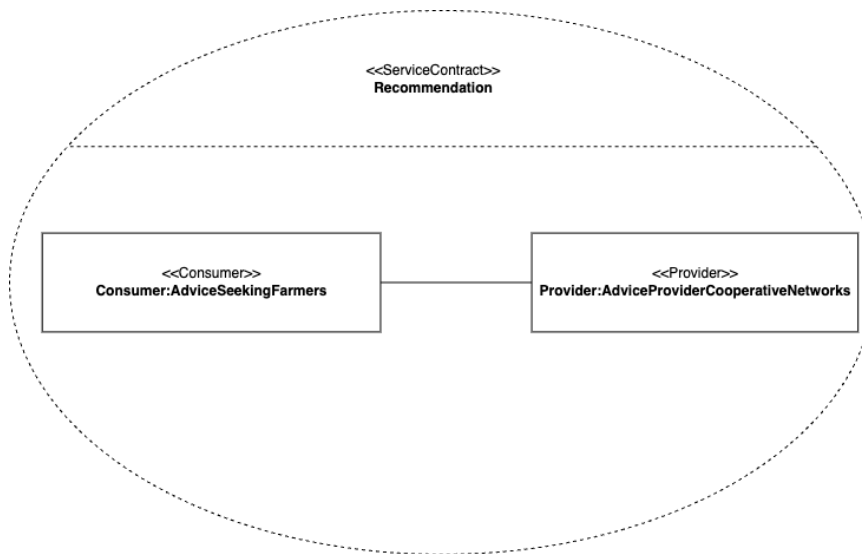
Figure 27: Contract Recommendation

Field	Description
ID	cn1-02-FarmLandInformation
Name	Farm Land Information
Involved Participants	AGRA, Data Providers
Service Structure diagram	Figure 28: Farm Land Information

Table 20: Farm Land Information
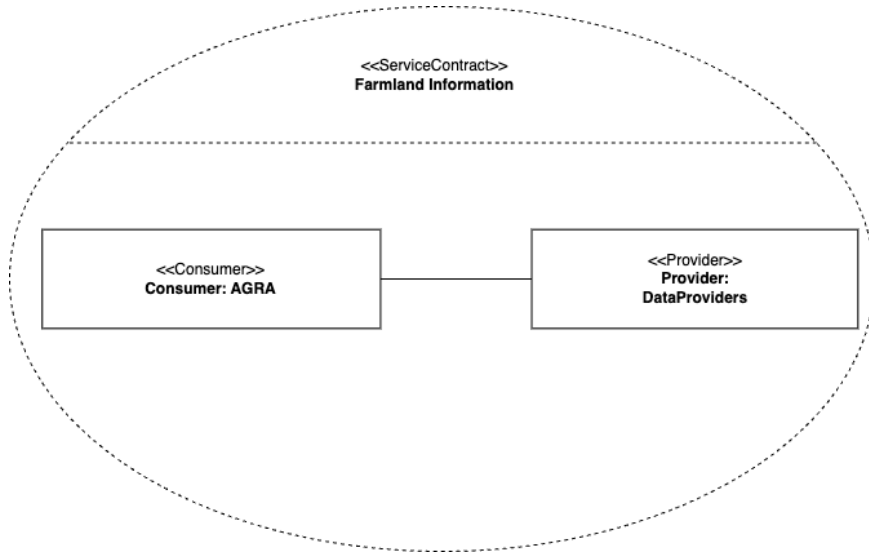
Figure 28: Farm Land Information

9.2   BS-FPA Service contract identification

Field	Description
ID	cn2-01-Authorisation
Name	Authorisation
Involved Participants	Ministry Of Agriculture, Security Provider
Service Structure diagram	Figure 29: Contract Authorisation

Table 21: Authorisation Contract
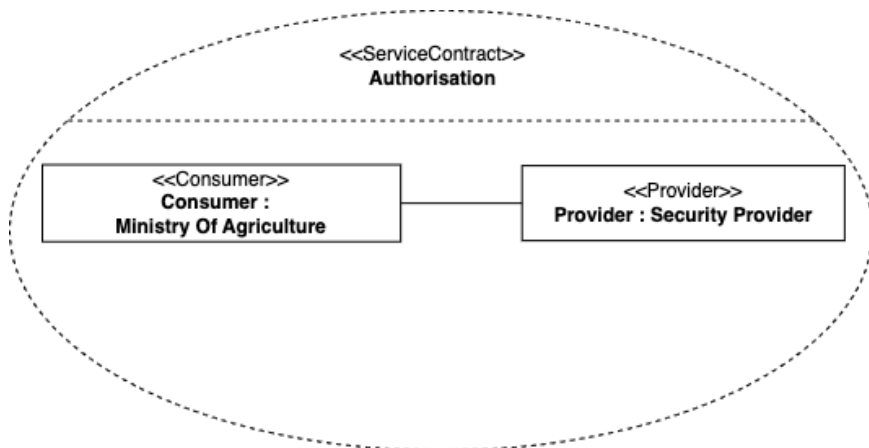
Figure 29: Contract Authorisation

Field	Description
ID	cn2-02-MarketInformation
Name	Market Information
Involved Participants	Ministry Of Agriculture, World Bank
Service Structure diagram	Figure 30: Contract Market Information

Table 22: Contract Market Information
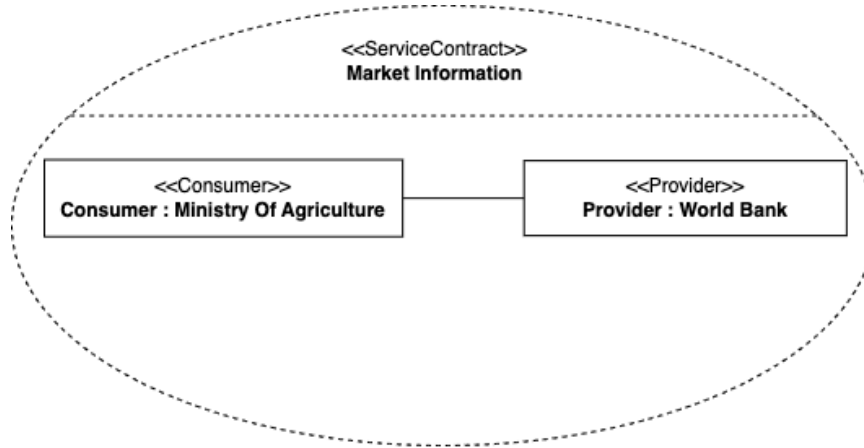
Figure 30: Contract Market Information

Field	Description
ID	cn2-03-IntermediateInformation
Name	Intermediate Information
Involved Participants	Ministry Of Agriculture, Farmers Association
Service Structure diagram	Figure 31: Contract Intermediate Information

Table 23: Contract Intermediate Information
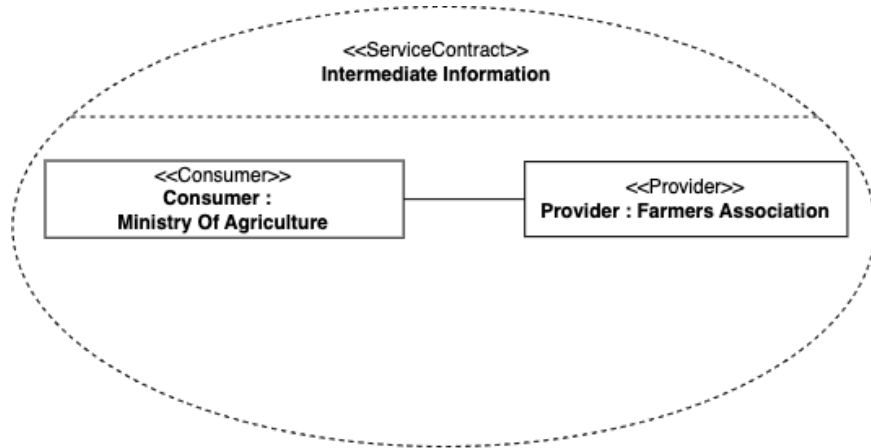
Figure 31: Contract Intermediate Information

Field	Description
ID	cn2-04-PricePrediction
Name	Price Prediction
Involved Participants	Ministry Of Agriculture, AGRA
Service Structure diagram	Figure 32: Contract Price Prediction

Table 24: Contract Price Prediction
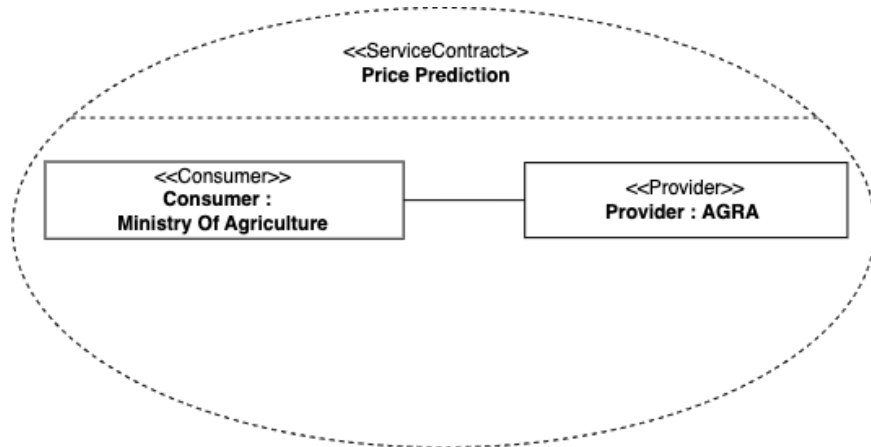
Figure 32: Contract Price Prediction

9.3 BS-IAI Service contract identification

Field	Description
ID	cn3-01-RegulationCompliance
Name	Regulation Compliance
Involved Participants	Ministry Of Finance, Ministry of Foreign Affairs
Service Structure diagram	Figure 33: Contract Regulation Compliance

Table 25: Regulation Compliance Contract
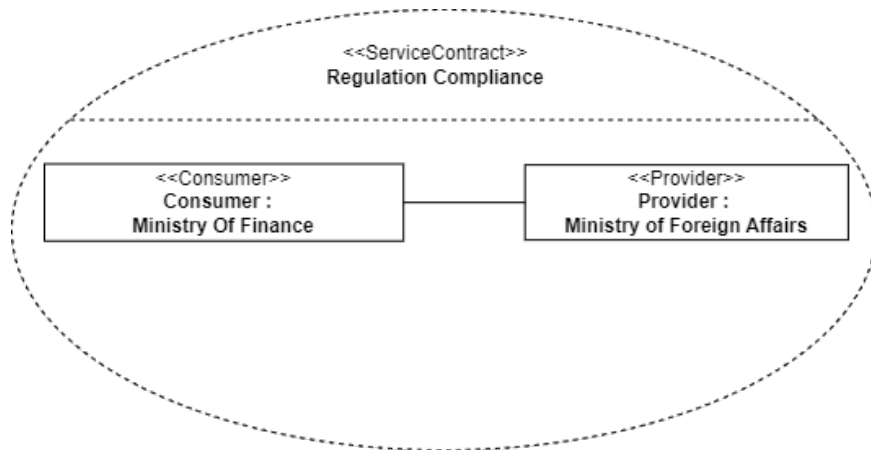
Figure 33: Contract Regulation Compliance

Field	Description
ID	cn3-02-LandConditionCheck
Name	Land Condition Check
Involved Participants	Ministry Of Finance, AGRA
Service Structure diagram	Figure 34: Contract Checking Land Condition

Table 26: Contract Checking Land Condition
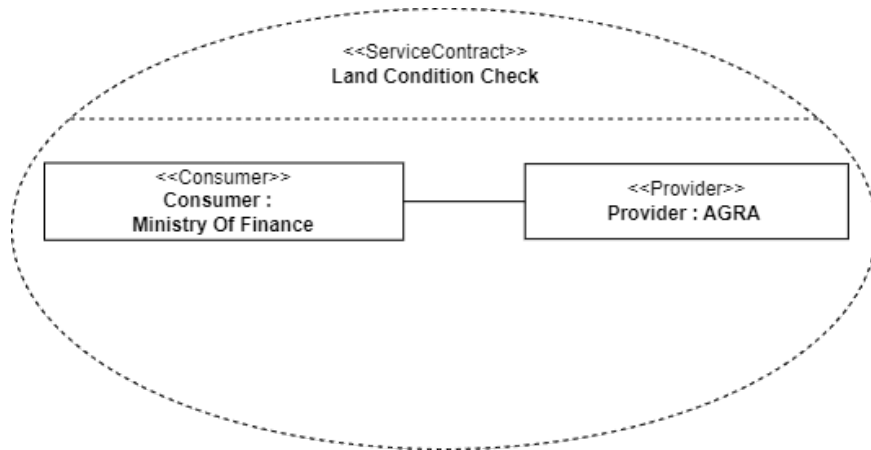
Figure 34: Contract Checking Land Condition

10 Business service network
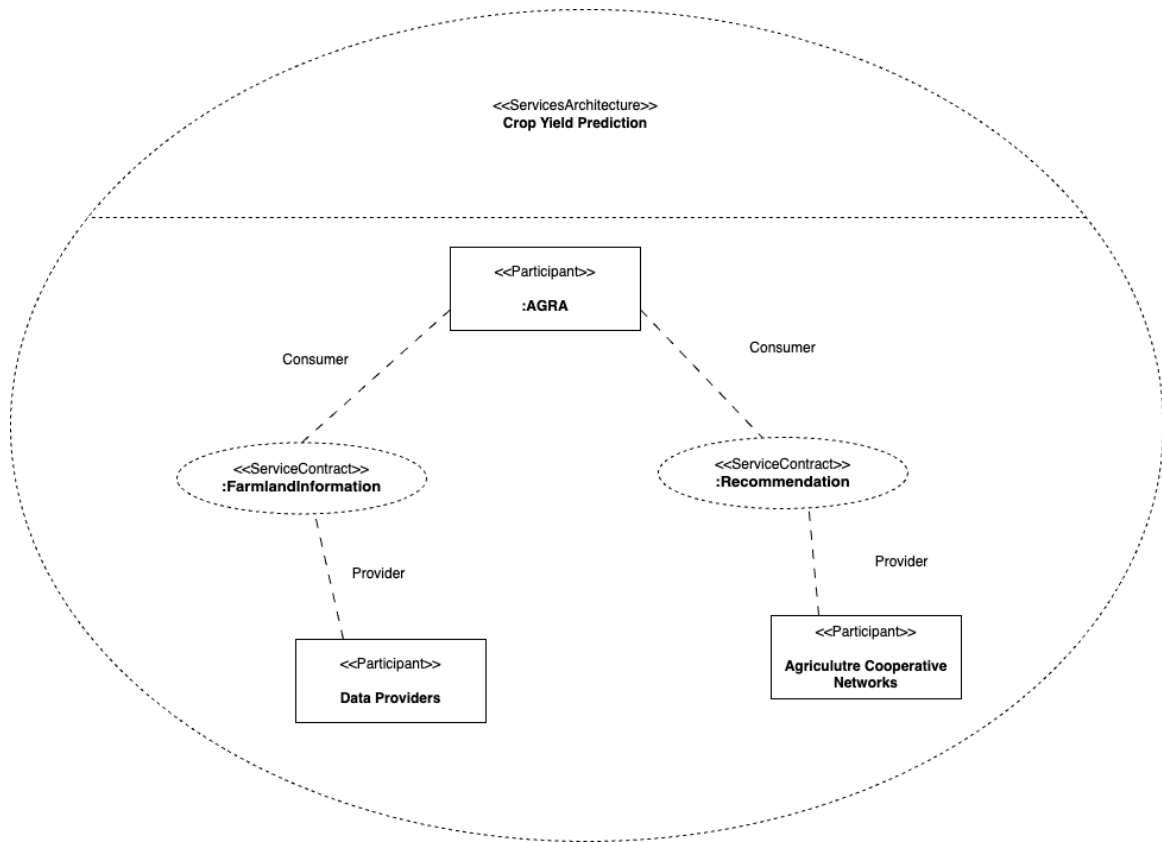
Figure 35: Crop Yield Prediction service network
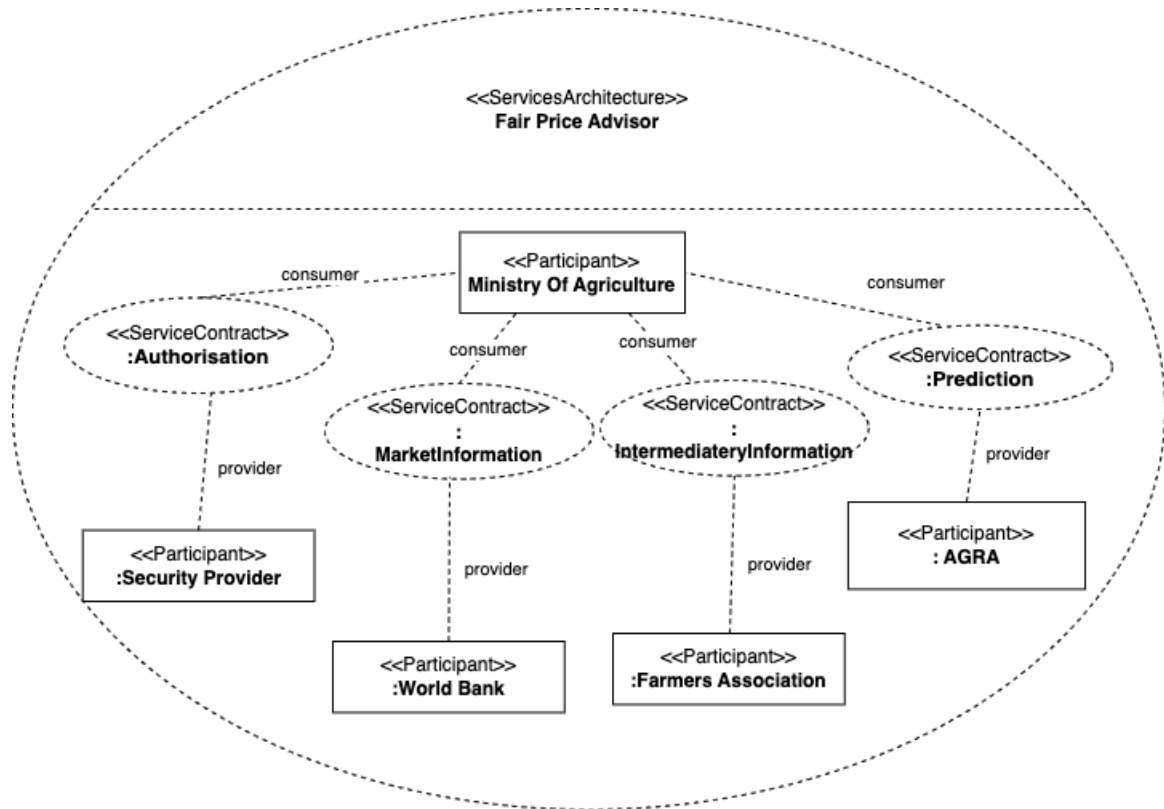
Figure 36: Fair Price Advisor service network
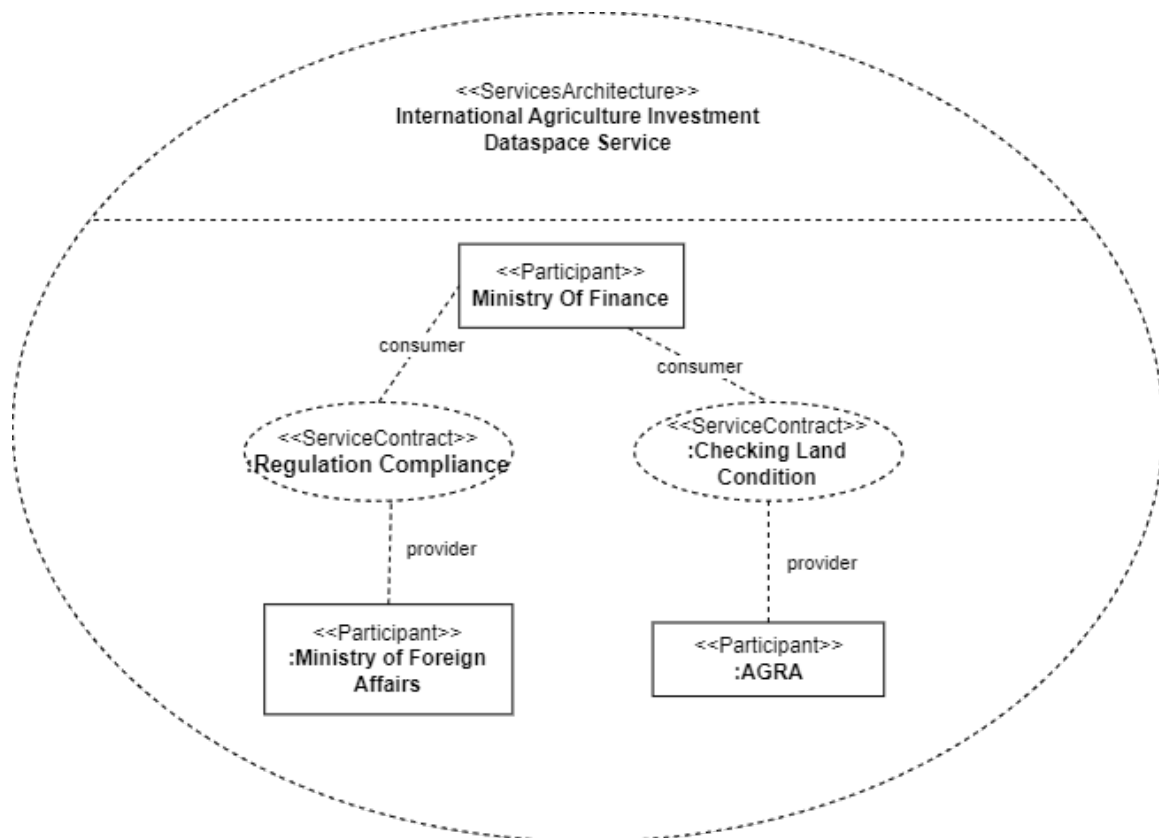
Figure 37: International Agriculture Investment Dataspace Service Network

11 Service interactions and behavior

11.1 BS-CYP interactions and behavior
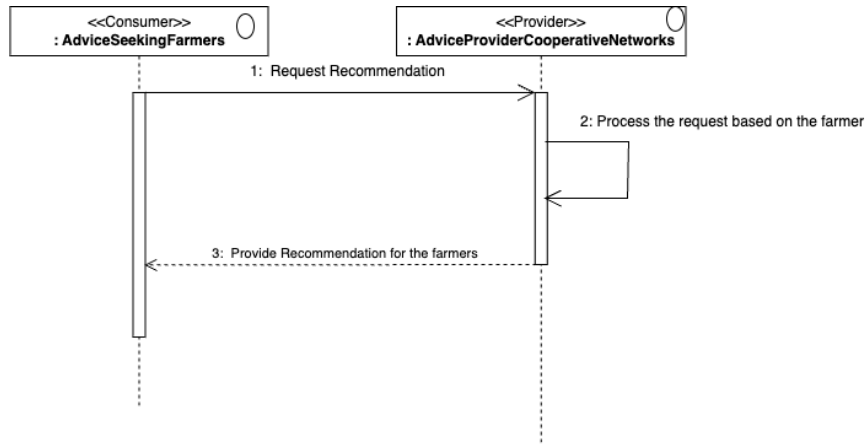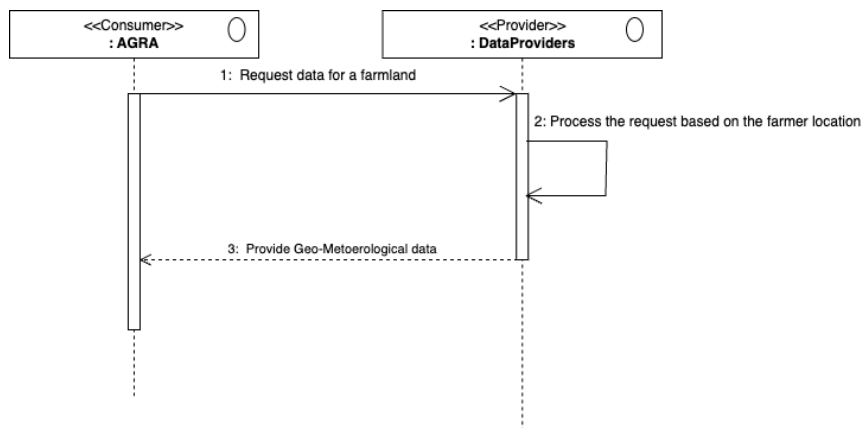

Figure 38: Advisory Sequence Diagram

Figure 39: Data Provider Sequence Diagram
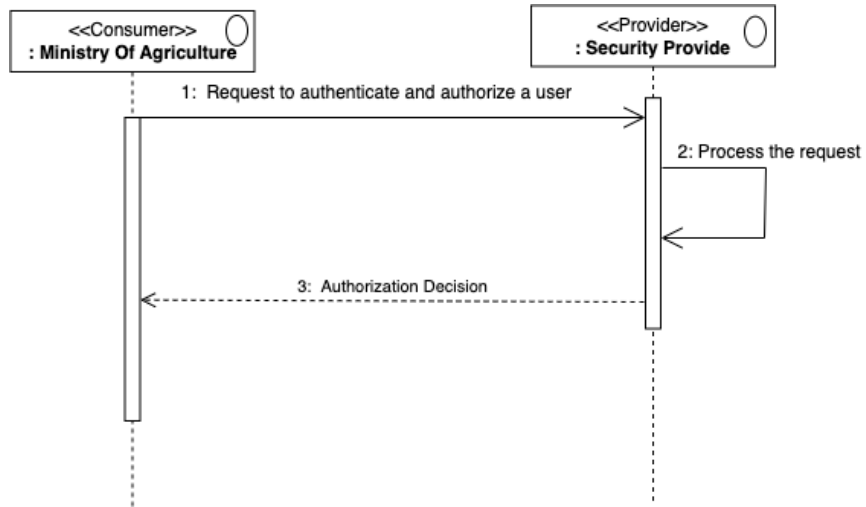
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11.2 BS-FPA interactions and behavior

Figure 40: Authorisation Sequence Diagram
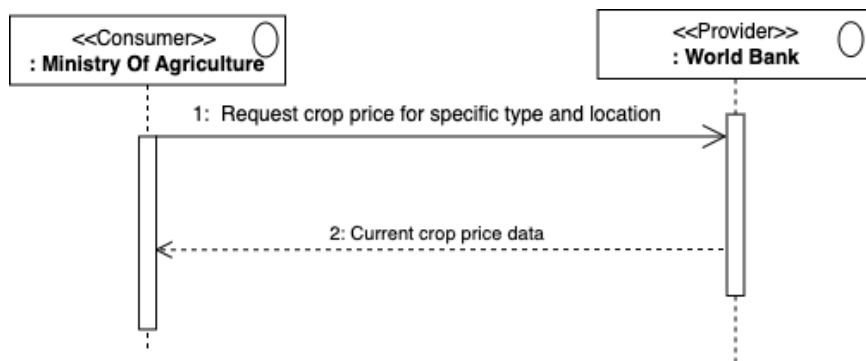
Figure 41: Market Information Sequence Diagram
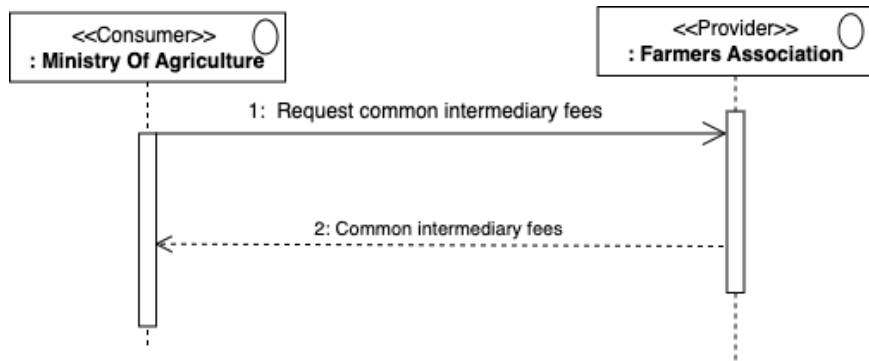
Figure 42: Intermediate Information Sequence Diagram
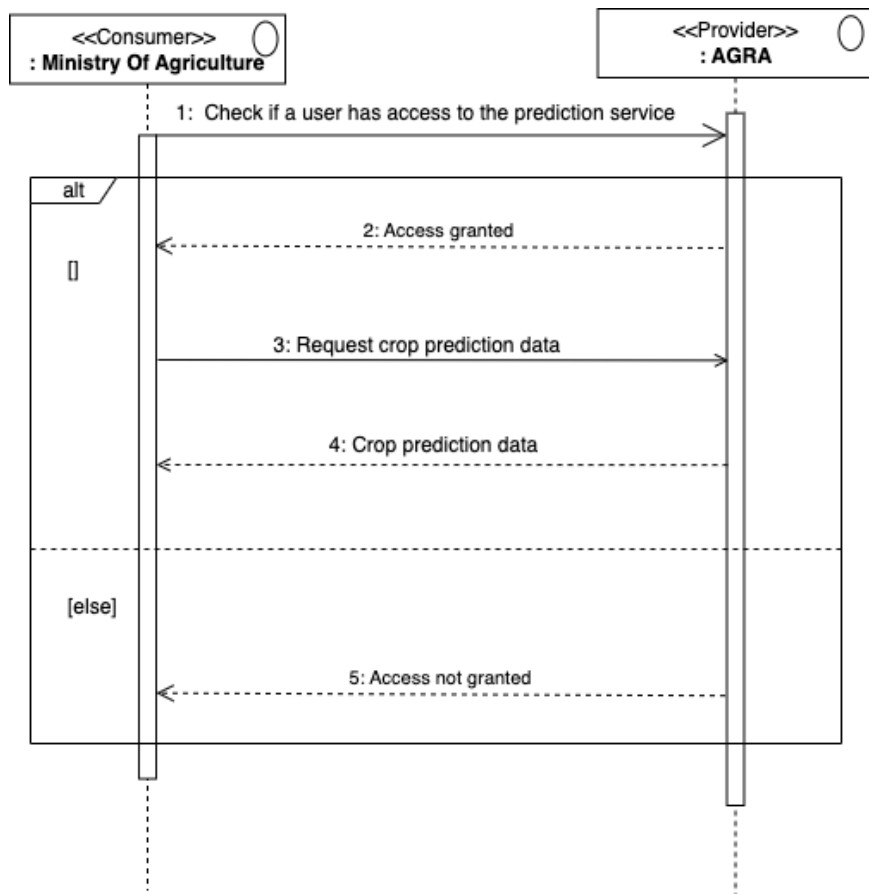

Figure 43: Price Prediction Sequence Diagram
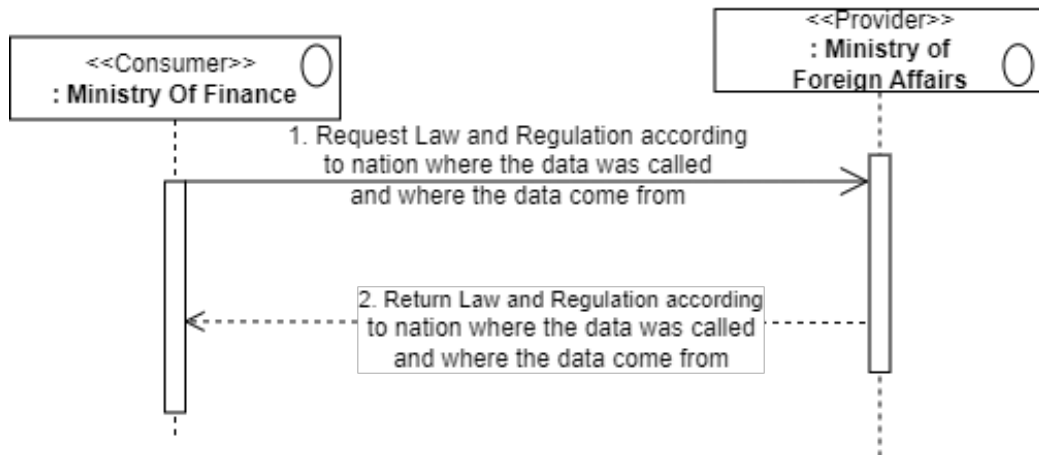
11.3 BS-IAI interactions and behavior
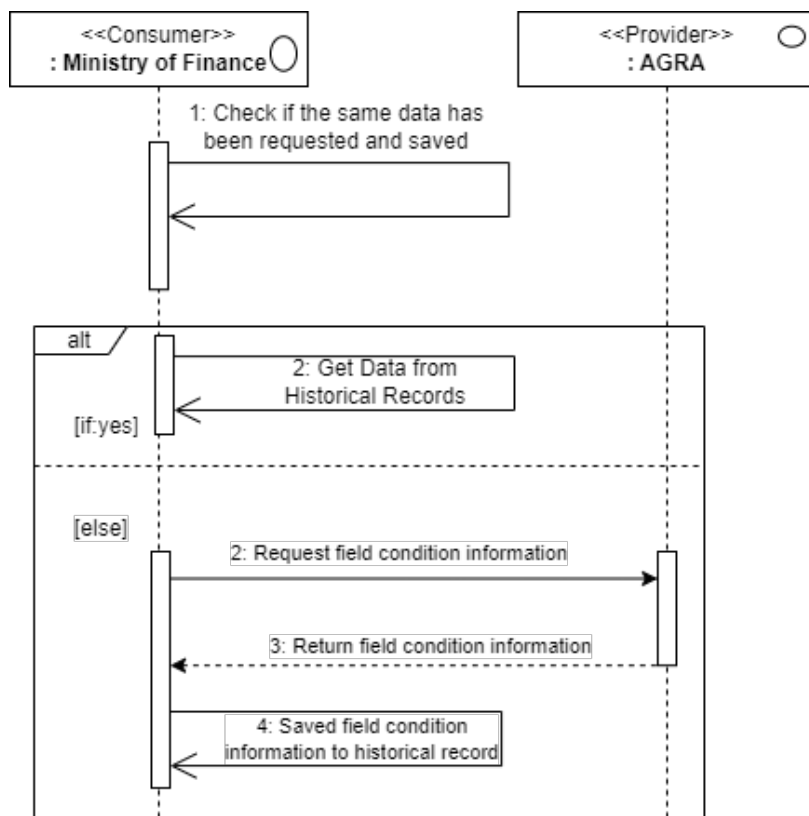

Figure 44: Law and Regulation Data Management

Figure 45: Acquiring Farm Information Sequence Diagram

12 Design view

Field	Description
Design Concern	What data can be passed for international user communication?
Decision	Receive the list of data requested by the requester and share only the data fields permitted by the laws and regulations of the respective nations.
Diagram Links	Fig. 8: BS-IAI Activity diagram
Description	Certain data fields, sourced from BS-CYP or historical data, will be transmitted to the data recipient in compliance with the regulations of the respective country. Data security is ensured, as only authorized data fields will be shared with the user. Additionally, data transmission will be efficient, as only the data required by the requester will be provided.

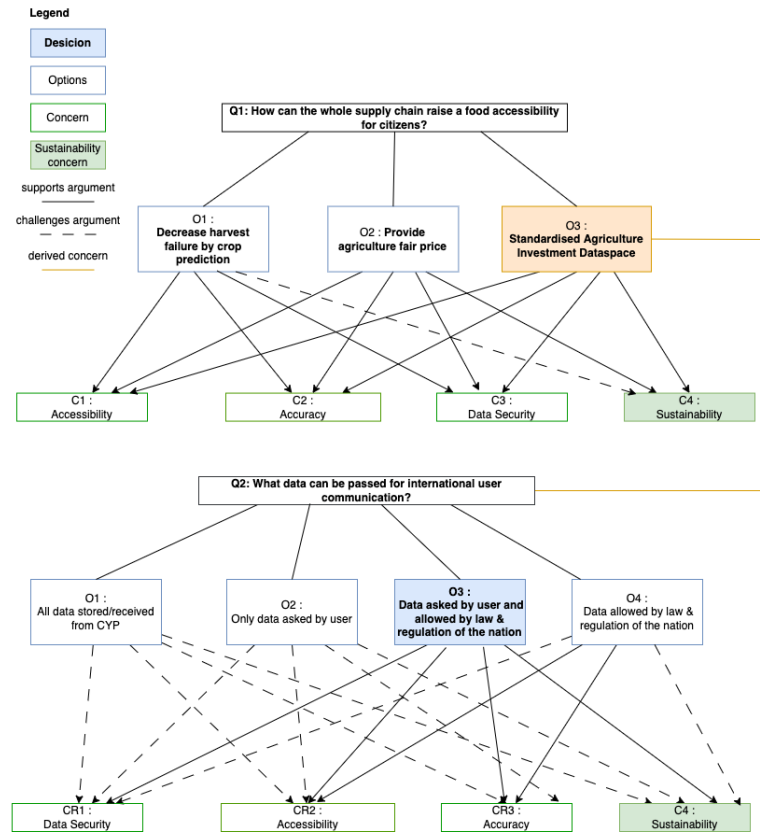Table 27: Design decision overview

Figure 46: Design decision overview

To reduce malnutrition in Ethiopia, we are enhancing the efficiency of existing supply chain (Fig.14). The enhancement is done by several actions :

- Increasing food stock, by decreasing harvest failure.

- Raising farmer livelihood and common people food buying power, by promoting price transparency.

- Secure funding for farmers by building trust with foreign investors.

However, sharing plantation data with foreign investors entails potential legal complexities. As such, a meticulous evaluation is imperative when determining which data to be disclosed. Following a comprehensive assessment, we have opted to share only the information explicitly requested by the client, thereby reducing the data transfer load. Additionally, we will exclusively transmit data that aligns with national regulations to ensure legal compliance. (Fig.46)

To describe in details of the steps (Fig.47), an abroad investment company which have intention to fund an agriculture project in Global South may request comprehensive land quality data to align with their business contract's premises.

The "Historical Record Retrieval Service" via "Requester Field Acceptance Service" receives this request and retrieves the complete land quality data. Subsequently, the "Data Filtration Service" comes into play, meticulously filtering the data. It retains only the information explicitly requested by the company while ensuring strict adherence to national regulations. The "Law and Regulation Service" contributes to this process by providing access to relevant regulations from the Ministry of Foreign Affairs and securing permissions from the farmers.

Once the data has been thoroughly filtered, the "Returning ROI Service" takes charge, conducting a comprehensive analysis and subsequently transmitting the cleaned data. This approach strikes a balance between resource efficiency and legal compliance.

This process (Fig.47) is vital for instilling trust and facilitating efficient international investments, ensuring that the venture remains within legal boundaries.
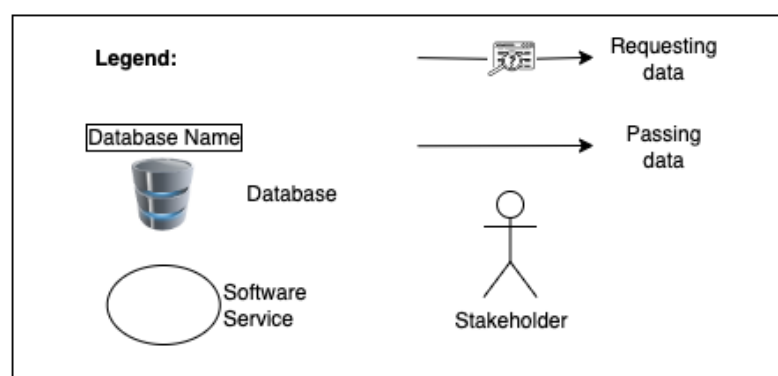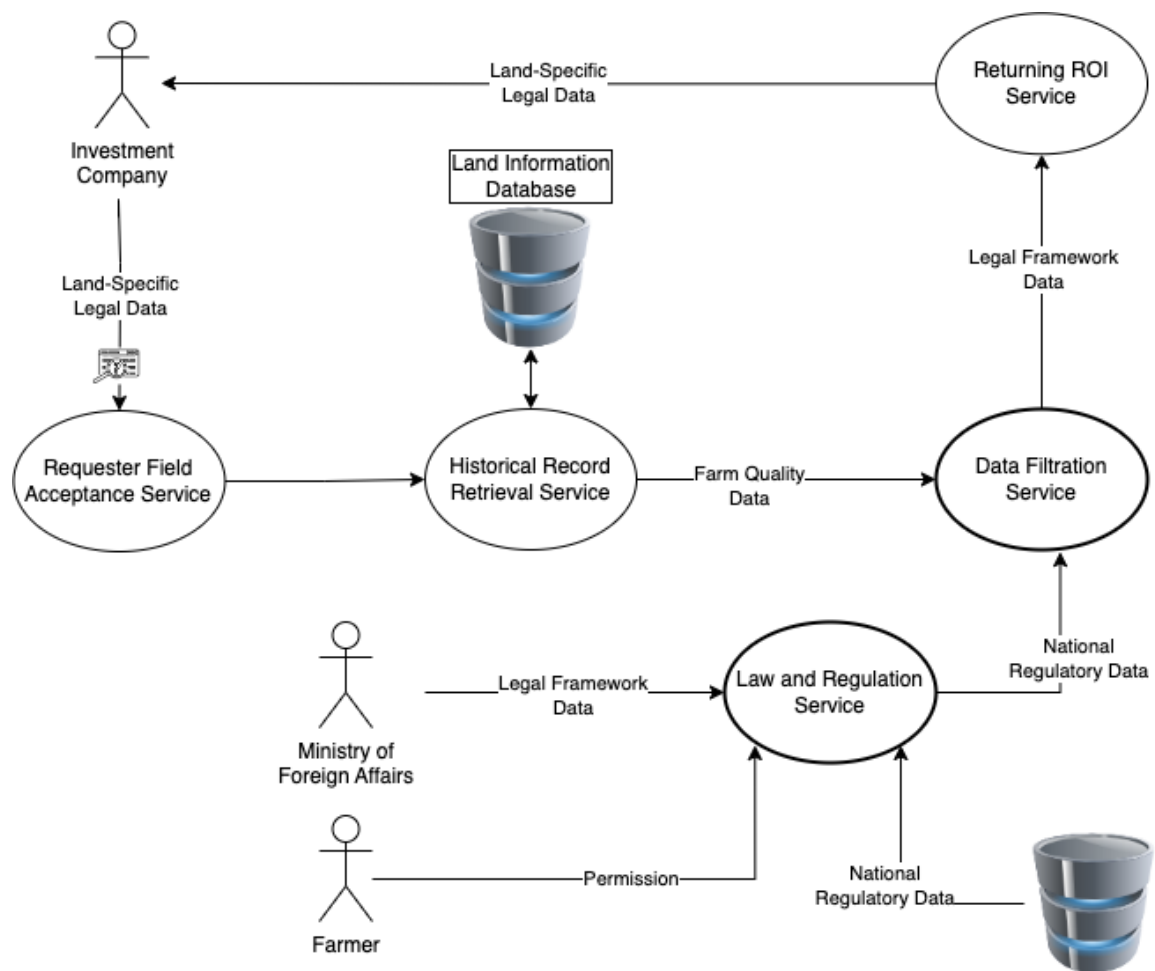
Figure 47: Data Flow View

Viewpoint Name	Legal Framework Data Sharing Viewpoint
Viewpoint Description	The Viewpoint is focused on the process of sharing legal information and regulations from the Ministry of Foreign Affairs. This viewpoint aims to address the legal complexities, compliance requirements, and considerations associated with sharing data while adhering to national legal constraints.
Concerns	- Investment Companies: Concerned with accessing data as complete as possible, while still conforming to the legal framework that governs the international information sharing. - Ministry of Foreign Affairs: Concerned with protecting the security and interest of the citizen, while allowing enough access for building trust of foreign investors. - Farmers: Concerned with data privacy and protection regulations to protect their privacy security, while still promoting themselves to foreign investors.
Meta-model	- Legal Data Sharing Process Model: Captures the step-by-step process of sharing legal framework data, with specific attention to the restrictions on sharing phone numbers. - Data Selection Criteria: Includes specific criteria to identify and exclude phone number data from international sharing.
Conforming Notation	Utilize visual representations that clearly indicate which data is restricted and cannot be shared internationally.

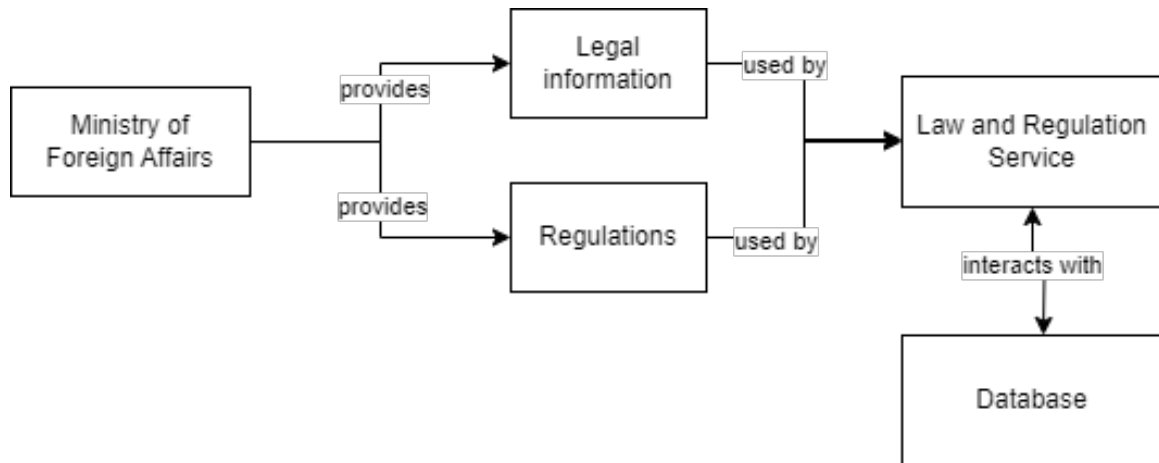Table 28: Legal Framework Data Sharing Viewpoint

Figure 48: Legal Framework Data Sharing Viewpoint Meta-Model

References

[1] Vallence Ngabo Maniragaba, Leonard K. Atuhaire, and Pierre Claver Rutayisire. Undernutrition among the children below five years of age in uganda: a spatial analysis approach. *BMC Public Health*, 23(1):390, Feb 2023.