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Agriculture damage data collection: A model for reconstructing comprehensive damage dynamics

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ABSTRACT

Natural disasters may disrupt and affect negatively agricultural development and production. Extreme events that strongly threaten the Agriculture Sector are predominantly those related to weather and climate, which are likely to become always more frequent and severe due to Climate Change effects (FAO, 2018; Sivakumar, 2005; PESETA III). In such a context, accurate sector-specific disaster losses and damage data are a crucial indication for policy-making and for evaluating progress in reducing disaster risk. A better understanding of the mechanisms impacting the Agriculture Sector is needed. This paper responds to the necessity of improved damage and loss data collection for the Agriculture sector, proposing a comprehensive conceptual model to support damage assessment. On the one hand, the proposed conceptual model has been designed to be compliant to the Sendai Framework requirements while enforcing the assessment of damages in agriculture with a multi-temporal dimension. Considering a multi-step assessment of damages is one of the main results that are implemented in the model. On the other hand, the Agriculture damage data stored in the proposed relational database would allow tracking the damage evolution enabling the understanding of damage dynamics. Another key factor is related to how the database has been conceived. The process starts with the analysis of international policies and guidelines. Then a practical solution is proposed based on the investigation of existing damage assessment forms. This exploratory approach allowed to create a model that represents not only the immediate, direct and physical impact of an event, but also the indirect and systemic consequences related to the inter- and intra-dependencies of the different elements constituting the Agriculture sector.

1. Introduction

Extreme events that strongly threaten the Agriculture Sector are predominantly those related to weather and climate. This includes drought, floods, excessive rainfall, frost, hail, tropical cyclones, storms; alongside with forest and bush fires. Such events are likely to become always more frequent and severe due to Climate Change effects ([14,28]; PESETA III). The level of impact, on both development and production, depends on different factors such as the ones related to the production itself as the season of occurrence, the growth stage of the cultivation; the exposure and vulnerability of structures, equipment; and, the overall level of mitigation and preparedness of the exposed system.

Accurate sector-specific disaster losses and damage data are a crucial indication for policy-making and for evaluating progress in reducing disaster risk since they provide evidence-based knowledge. A better understanding of the mechanisms impacting the Agriculture Sector in case of natural disasters is needed. On the one hand, records of damage and losses occurred due to past disastrous events are not always available. Rarely countries have procedures and databases to collect and store damage and loss data; in many countries there are no organizations in charge of collecting data and open global datasets often have different resolution of data [5,21,25]. On the other hand, in spite of the high influence of disasters on agriculture, the impacts are rarely quantified or analyzed in their complexity. Therefore, the real impact of disasters on the agriculture sector is not properly understood [14]. This is because the data available for analysis are collected with a fragmented approach and they are not systematically stored in databases, which would have allowed to retrieve comprehensive information if properly recorded.

1.1. Disaster damage data collection and assessments and loss evaluation experiences for agriculture sector

An increased interest in the enhancement of methods and tools to collect damage and loss data has been witnessed in the last decades. In the 1970s, in Australia, the Centre for Disaster Studies was established with the aim of carrying out rapid response assessments to examine the impact of a hazard immediately after the event; King [20] proposes new areas for research and examines methodologies used in those post disaster studies illustrating the importance of standardized and replicable methodology. In 2002, loss assessment guidelines have developed in Queensland [9,17] to

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overcome previous existing limitations of the data collection process, however challenges faced in their application highlighted the issue of the quality and availability of existing data [18]. European and international risk reduction programs such as the Floods and INSPIRE Directive or Sendai Framework have become an incentive for the improvement of damage data collection in European countries [21].

According to the literature, the agricultural sector has been less investigated with respect to other sectors and mostly the focus has been directed on flood damage modelling for loss estimation. The proposed models are based on simplified schemes focusing mainly on crop damage and neglecting other significant components of the agriculture sector, consequently they present some limitations given the few parameters considered. As highlighted by several authors one reason for the little interest stems also from the little available data [1,15,22,23]. Generally analysis concerning agriculture and rural communities affected by natural disasters are carried out using data and information obtained from surveys and interviews delineated in function of the specific needs; such as in Kapuku et al. [19] where a questionnaire survey has been delineated and revised with experts in order to examine traits and problems in existing emergency management systems across rural regions in Central Florida; or, in Posthumus et al. [26] where in order to evaluate the economic impacts of the summer 2007 flood events in rural areas in England, a survey has been proposed to ensure that the characteristics of rural communities that make them vulnerable to increasing flood risk are properly taken into account.

However, in such a context, characterized by an increased interest in the enhancement of methods and tools to collect damage and loss data and an evident scarcity of occurred damage data for the Agriculture Sector Thieken et al. [30] propose a set of standards for the collection of damage data for different sectors including agriculture to allow a multi-purpose use of flood loss data.

More recently, relevant standardized methods and procedures for reporting damage and economic losses have been developed [6] such as the DaLA (Damage and Loss Assessment) and the PDNA (Post-Disaster Needs Assessment). These methodologies require to perform assessments of impacts for different economic sectors, including agriculture. FAO (Food and Agricultural Organization of the United Nations) encourages countries to collect and report relevant data on the immediate physical damage caused by disasters on agricultural assets, as well as on the cascading negative effects of disasters on the agricultural production. The PDNA tool is considered as a solution to these concerns as it follows a harmonized and coordinated approach, providing comprehensive assessment of the post disaster damages, losses and recovery needs. In order to effectively use the PDNA methodology, the European Commission, the United Nations Development Group and the World Bank designed specific guidelines concerning the data collection, validation, consolidation and analysis should be followed [12]. Furthermore, FAO designed step-by-step guidelines to support the damage and loss assessment for pacific Islands Countries following disasters affecting the agriculture sector. The forms define requirements and necessary steps in undertaking post-disaster damage, loss and needs assessment in all of the sub-sectors of agriculture considering that a disastrous event can impact different farm sections, such as flows which coincide with seasonal crops and stocks or assets (perennial plant material, buildings, machinery), with different level of severity. The guidelines invite to collect numerous information concerning the social and economic profile of the farmers, the planting to harvest season, investment costs in crops by stage of growth, production and prices, assets, irrigation system, livestock, damages to permanent crops, seasonal crops, fisheries etc. Moreover, in this context resides the Sendai Framework for Disaster Risk Reduction (2015-2030) guidance. As a main guiding instrument for Disaster Risk Management it explicitly recognizes the significance of collecting and analyzing damage and loss data at all relevant scales and regarding the compound of impacted sectors. The Sendai Framework focuses on threats of both natural and man-made origin, fundamental when the agriculture and food security sectors are considered, since these risks are crucial for the mechanisms regulating the agriculture sector (contamination of foods, degradation of natural resources etc.). Additionally, the Sendai Framework emphasizes the relevance to consider also small-scale and slow- evolution disasters which affect communities given their frequent recurrence. This indication is highly appropriate for the agriculture sector, since it allows to properly cover the impacts of meteorological, hydrological, biological and geophysical/geological slow onset events, that every year affect agriculture causing a high percentage of losses. Between all the described important aspects of the Sendai Framework regarding agriculture, another relevant feature is the importance that is attached to the local level, in terms of expertise development and empowerment of the institutions at a local level and of communities; of the appreciation of ancestral knowledge and technology transfer; of the involvement of the population in the assessment of needs, strategies and plans. Local farmers and producers are those who are involved, in first place, in the effective transformation of their agricultural practices towards resilient productive systems. This approach will provide sectoral line with a clearly defined vision, priorities and strategic actions to reduce risks within the agriculture sector, facilitating the planning and delivery of the goals of the framework for mainstreaming Disaster Risk Reduction into agriculture.

2. Research line

This research begins from the analysis of the previously described international policies for damage data collection for the agriculture sector with specific regard to the Sendai Framework for Disaster Risk Reduction guidelines. Afterwards, existing practices (four case-studies) for loss and damage data collection for the agriculture sector are investigated in order to determine their level of compliance with previously analyzed international policies and guidelines.

Following the analysis of the international policies and guidelines, relevant examples of designed damage and loss assessments forms have been investigated. The research revealed that several States in collaboration with academia or other organizations have been working on the design of forms which provide a standardized method to collect data in order to determine the extent of damages and losses to the Agriculture Sector. Forms and procedures designed in different countries, such as: i) Pennsylvania State University Agriculture Damage Assessment Forms; ii) South Carolina Department of Agriculture and Clemson University Damage Assessment Forms; iii) Online Agricultural Damage Assessment Form designed by C3L Associates' Agriculture Emergency Response Service Support in collaboration with University Drive of Maryville; and, iv) Agricultural Damage Assessment Form of the Slovenian Department of Agriculture, Fisheries and Food; have been investigated to evaluate the current state of the art of damage and losses collection process worldwide. The Damage Assessment Forms provide a structured format and instructions to more accurately collect information, assess the damage, and determine an accurate estimation of economic losses. In addition, two specific events for which the previously described assessment methods have been implemented were taken into consideration: the agriculture damage, losses and needs assessment for Tropical Storm and Floods in Yemen and the rapid agriculture needs assessment in response to “El-Niño” in Tanzania [2–4,11,13,16,29,32]. These procedures consent to obtain a good prospective of the impacts, however, damage dynamics cannot be reconstructed since the systemic characteristics of the sector and its related damage data cannot be retrieved following such procedures. Agriculture is a dynamic system and its intra- and interdependencies need to be taken into account and documented to effectively assess the impact of hazardous events.

In such a context this paper responds to the need of an improved damage and loss data collection to account for the damage dynamics so that an accurate complete event scenario can be reconstructed to further support a variety of actions aimed at reducing disaster risks. A comprehensive conceptual model supporting damage assessment for the agriculture sector is proposed.

The line of this research has been pursued based on the personal understanding of the agriculture sector, since from generations my family has conducted agricultural activities. Nonetheless, the model has been conceived as a discretization of the reality once the conceptual gaps between

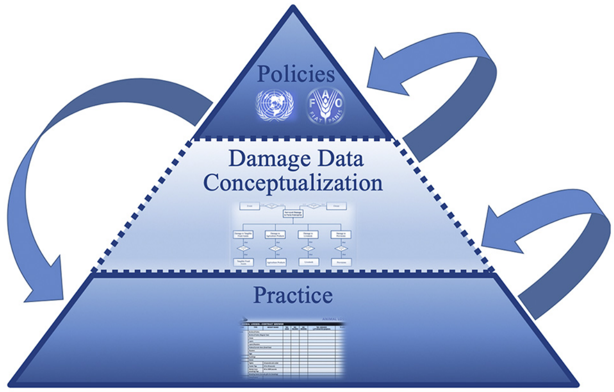

Fig. 1. Dynamic of the analysis performed.

policies and practices have been identified. Firstly, the conceptualization of the database starts from the investigation of the agriculture sector damage dynamics and the related policies, followed by the analysis of existing procedures (practice) and their disaggregation, till the understanding of the missing elements in the process of the agriculture damage data collection (Fig. 1).

The rationalized damage data model is conceptualized in order to be implemented in a common database which considers the agriculture sector as both an ecosystem and an economic system. Coherently, agriculture is considered in all its dynamism and its intra- and interdependencies are taken into account to effectively assess the impact of hazardous events. Since the model has been developed following an accurate analysis of the international policies and guidelines, included the FAO guidelines proposed to support damage and loss assessment for Pacific Islands Countries following a disaster affecting the agriculture sector, it contains an elaboration and integration of several crucial factors and indicators of different agricultural economic systems. The proposed approach can be adopted in countries with different social and economic profiles for Subsistence Farmers, Commercial Farmers and Enterprise Farmers once baseline information regarding the farmer's profile are properly collected. The conceptual model of the database has been designed so as to comply with the Sendai Framework requirements while enforcing the assessment of damages in agriculture with a multi-temporal dimension. Indeed, the damages affecting agriculture may evolve in time, as primary physical damages usually cause systemic induced damages. Considering a multi-step assessment of damages is one of the main results that are implemented in the proposed conceptual model. Agriculture damage data stored in the relational database would allow tracking the damage evolution enabling the damage dynamics reconstruction.

3. Proposed methodological approach

Given the objectives of an improved damage and loss data collection for a better understanding of the damage disfunction process, the design of a relational database as comprehensive conceptual model supporting damage assessment for the agriculture sector is proposed. A relational database consists in a collection of tables that store interrelated data. By designing a relational database, knowing all variables and data to be collected according to the needs which have been, in this case, explored along the research path, it is possible to create a structure that eliminates redundancy and inconsistency. A relational database management system allows to store and retrieve data represented in tables through different types of queries elaborated in advance to support a range of different purposes.

The proposed approach steps forward the actual situation. Considering that most of the damage assessments are carried out manually filling paperforms with data that lose their interrelation, a relational database anticipates the use of data for multiple objectives such as the development of curate risk assessments and the understanding of damage mechanism to create real and robust trends. A relational database would allow to create a comprehensive inventory of information, by storing large amount of data permitting efficient search performance through a wide range of prefigurated queries. The use of a well-designed database would enhance the understanding of the impacts through timely availability and large-scale accessibility of the information. Moreover, the collection of the data through an ICT (Information and Communications Technology) application user-interface would allow to insert the data directly into the database reducing the time of the operations which are generally carried out filling first the forms manually and then inserting the data into the archive. An additional advantage of such a system is that it allows a more accurate filling by simple-usable and efficient user-interaction enhancing the coordination procedures of the damage assessments.

The relational database and its physical model (relational model) designed in the proposed research comprises specific characteristics derived from the accurate study of the different impacting mechanisms that affect the agriculture sector in case of natural hazards. The temporal and spatial characteristics of the damage become crucial for the development of a comprehensive and effective model. The temporal contextualization of the damage itself and its exact location are a main aspect considered in the model. Damages do not happen simultaneously to the event, and they need to be analyzed considering their exact time of occurrence and their evolution till the time of the assessment. The model proposes a methodology that allows the historical damage dynamics reconstruction through the multi-step assessment of damages allowing to represent not only the immediate, direct, physical impact of an event, but also the indirect and systemic consequences related to the inter- and intra-dependencies of the different elements constituting the Agriculture sector.

The development of such an IT (Information Technology) tool would support the whole process from data collection to analysis, bringing numerous advantages. However, it has to be stated that the proposed relational database is not a solution, but represents a tool that can improve the traditional approaches facilitating the data management from input to output, supporting both reporting and analysis for different purposes with accurate interrelated evidence-based data.

4. Development of the database

Considering a multi-step assessment of damages is one of the main results that are implemented in the conceptual model. Agriculture damage data stored in the proposed relational database would allow tracking the damage evolution enabling the reconstruction of the damage dynamics; moreover, those data can be further used to construct the damage-dysfunction matrices, a methodology which can be adapted to evaluate the potential dysfunctions and damage of the agriculture sector in case of hazardous events [7].

4.1. Conceptual design of the database

The model consists is a relational database composed by an Entity Relationship Diagram (ERD) - i.e. conceptual design, and Relational model - i.e. physical design. The basic elements of an ERD are called entities (represented as rectangles), each entity is described through relative attributes. From a graphical point of view, entities are generally related to each other through rhombus (Chen's notation). Relationships among two entities have cardinality ratios which specify the maximum number of relationship instances that an entity can participate in [8].

During the damage data conceptualization, a comprehensive set of entities that represent the agriculture sector has been created according to the analysis performed on existing international policies and practices. Each entity is characterized by the so called attributes, which have been selected in accordance to the knowledge acquired through the analysis of the hazardous events affecting agriculture and of the existing procedures to collect agriculture damage data. Relationships have been designed considering the interactions between the sector's elements.

The entities are organized in:

I. Set of primary entities
II. Set of entities representing the farm components
III. Set of damage entities

4.1.1. Set of primary entities

The model allows to collect primarily data concerning the occurred event, the survey, the specific farm enterprise surveyed and its owner as shown in Fig. 2. Those entities serve to contextualize the survey. The baseline information can be restructured or integrated with further information for different agricultural economic systems. The model would allow to carry damage assessments for distinct farmer's profiles such as Subsistence Farmers, Commercial Farmers and Enterprise Farmers. The proposed ERD starts from the event since disaster damage and loss data are collected worldwide by event, facilitating forthcoming comparisons among events and the potential integration with already existing databases. Relevant is the feature that allows to give a temporal contextualization to the data collected, the Assessment Survey is characterized by a date and a time, since often events are followed by after-shocks which can occur, even after a very short time from the main event. Therefore, such a detail can allow to report in the database more detailed information concerning the damage dynamics.

4.1.2. Set of entities representing the farm components

Farm enterprise's components are structured into four main entities: Tangible fixed asset, Agriculture Product; Livestock; Provisions.

As shown in Fig. 3 for tangible fixed assets all the elements belonging to the owner of the farm enterprise are represented, such as structures, infrastructures, machinery, lands and all agriculture related materials (fuel, fertilizers etc.). Concerning the agriculture products, raw materials and transformed goods are considered separately in order to be able to take into account the potential effects both on agriculture production and transformation. Raw materials are all the unprocessed or minimally processed materials, which are in their natural form such as eggs, milk or seeds. On the other side, transformed goods are processed agricultural commodities such as dairy products, gastronomic products, textile goods etc. Livestock includes all breeding animals such as sheep, cattle, poultry, pigs and fisheries. For Provisions it is intended the amount set aside for probable economic obligations of an enterprise, in order to cover a future liability.

Concerning the Crop sub-classes, data such as Type, Growth Stage, Average Invested Costs are collected, however in this regard a specific generalization has been conceived. Crop entity is a sub-class of the Raw Material generalization, which in turn is a superclass of the On-Land Crop and Stored crop sub-classes (Fig. 4). This generalization is important since damage occurring on the two different states of the crops has different meaning in terms of cascading effects.

4.1.3. Set of damage entities

Damages that can affect the farm enterprise are structured in four main entities subsequent the Farm enterprise's components: Damage to Tangible Fixed Asset; Damage to Agriculture Product (which is a generalization of Damage to Raw Material and Damage to Transformed Good); Damage to Livestock; and Damage to Provision. As reference Fig. 5 illustrates the Damage to provisions entity and the related attributes.

4.2. The entity relationship diagram

Once all the entities of representing the Agriculture Sector have been delineated, the relationships have been carefully generated. The entities representing the elements of the farm enterprise have been related to the respective damage as indicated in Fig. 6.

One of the most relevant features of the model lies in the embraced concept that damages are inter-connected (i.e. if a damage occurs on a tangible fixed asset such as a rural infrastructure, provisions will be consequently affected due to the repair costs), and intra-connected (a damage occurred on agriculture products can happen due to the intra-connection of the damage between raw materials and transformed goods, i.e. if a damage occurs on a raw material, such as milk, transformed goods will be therefore affected due to the shortage of this raw material needed to produce dairy products). Fig. 7 clearly denotes the intra- and inter-connections between the different agricultural elements, therefore the dynamics and cascading effects of potential damage.

As aforementioned, agriculture damage data stored in the proposed relational database can be further used to construct the damage-dysfunction matrices, a methodology developed by Eleutério et al. [7] for evaluating potential network infrastructure dysfunctions and damage in cases of flooding. The proposed methodology can be easily revised and adapted to evaluate the potential dysfunctions and damage of the agriculture sector in case of hazardous event considering the

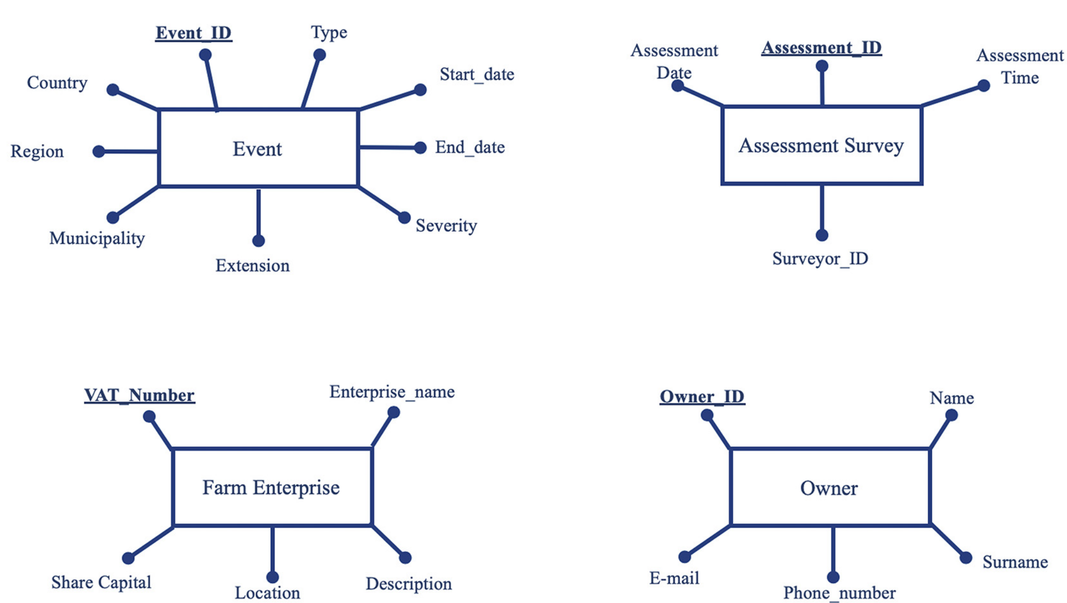

Fig. 2. Set of Primary Entities and related attributes.

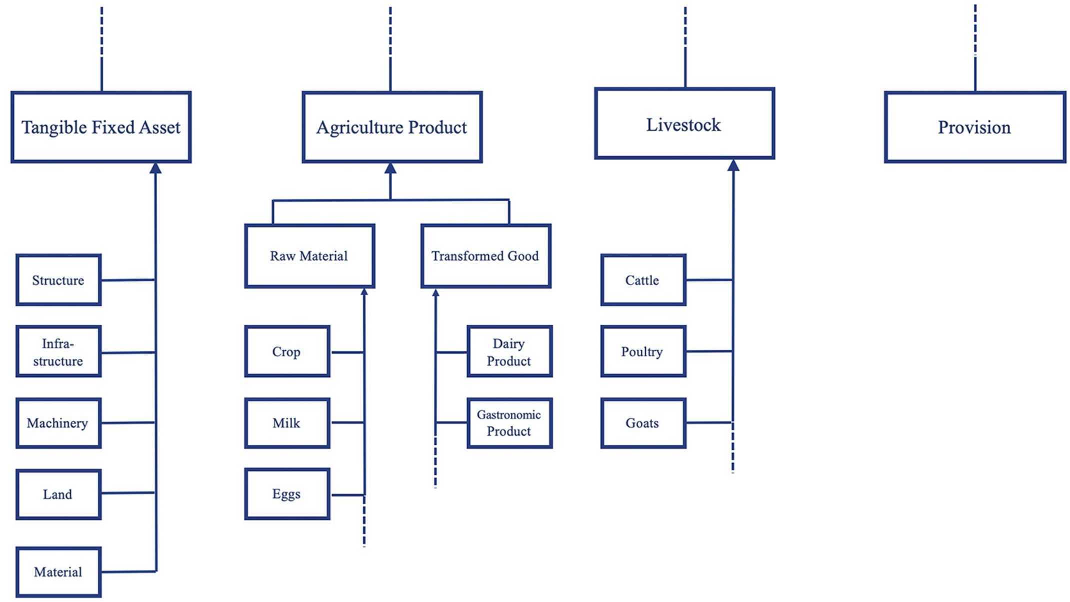

Fig. 3. Farm enterprise components.

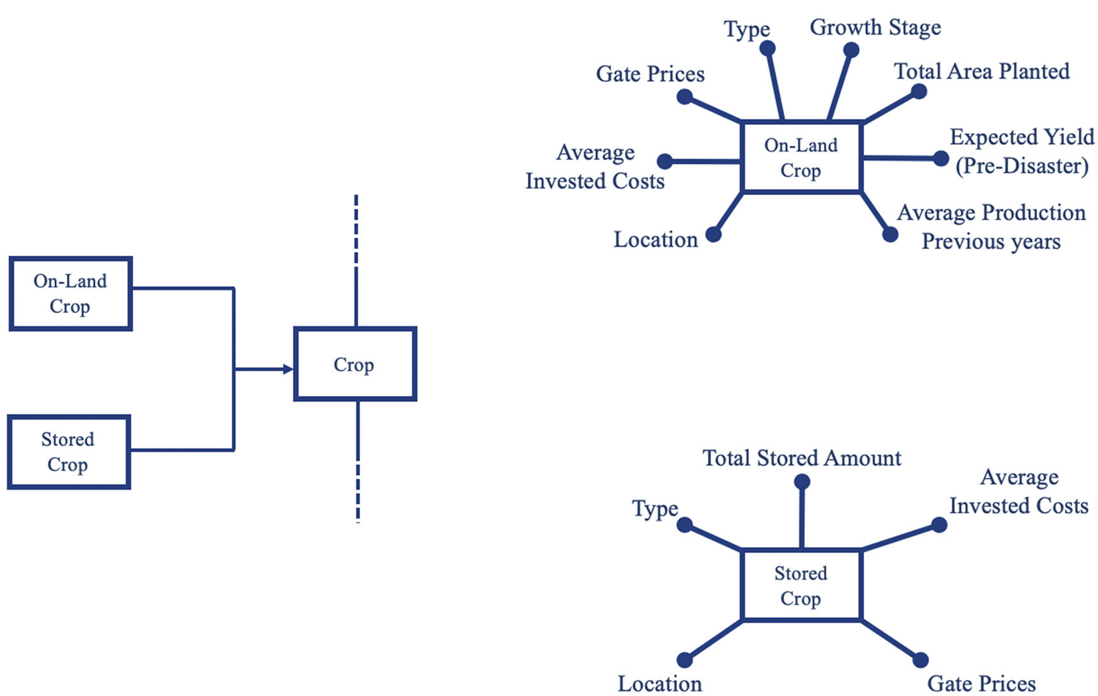

Fig. 4. Crop entity and related sub-classes' attributes.

different vulnerabilities of each element composing the system, describing how the different components are linked to each other and how they can disrupt the operation of the whole agriculture sector if impacted by the occurrence of a hazardous event. Understanding the agriculture sector, its functioning and its operation under abnormal circumstances is fundamental for dealing with risk management. The damage-dysfunction matrices are useful evaluating tools which allow to summarize the different vulnerabilities of the sector, describing how the different elements are linked to each other and how a fault of one of those may disrupt the operation of the entire system in case a hazardous event will occur.

4.3. Data retrieval – samples of prefigured queries

The model described in the previous section is qualitatively implemented to analyze the 2012 Emilia Earthquake. The case reported is used with fictitious data to demonstrate how the database can be queried and how the information retrieved are structured showing the damage dynamics. On 20th of May 2012 an earthquake of 6.1 magnitude struck in the Emilia Romagna region (Italy). Several aftershocks occurred after the main event. Initial reports showed significant damage to factories and agricultural assets. Production of Grana Padano and Parmigiano Reggiano, which are renowned Italian cheeses, was severely affected; approximately

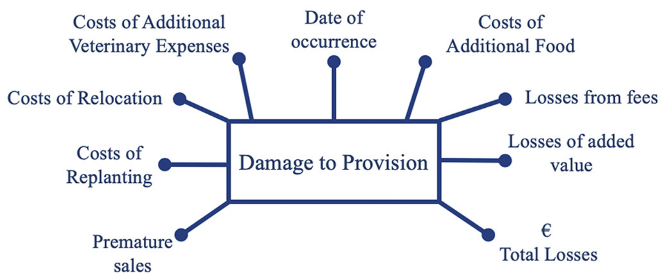

Fig. 5. Damage to Provisions entity and related attributes.

300.000 wheels of cheese where destroyed [31]. This event perfectly exhibits the intra- and inter-dependencies of the agriculture sector. On the one hand, the shock affected the quality and quantity of the milk production up to a 15% of reduced production due to the alteration of animal physiological rhythms, therefore the amount and quality of raw material for further production (Il giornale della protezione Civile, 2012). While on the other hand, all the younger cheeses aged up to six months were entirely ruined due to direct physical damage to the warehouses and shelves where cheese was stored, causing severe damages to the entire agriculture sector of the region.

In order to qualitatively show how to retrieve data from the model, two queries have been formulated. The first query shown in Table 1 allows to retrieve information concerning the direct damage occurred due to the event. According to the performed query, Table 2 shows qualitatively data that can be retrieved from the implementation of the proposed database. Qualitative data related to the collapse of the roof of assets occurred due to the 2012 Emilia Earthquake (Event_ID = ERTQ20052012 and Region = Emilia Romagna) are displayed.

The second query, shown in Table 3, allows to retrieve data related to the systemic connection of damages. Accordingly, Table 4 shows the systemic dependency of the damage can be observed from these data.

5. Discussion

Natural disasters may disrupt and affect negatively agricultural development and production in any country, impacting societal groups regardless their economic profile, from subsistence farmers considered most vulnerable once a severe disaster occurs to large scale enterprises which have a relevant influence on macroeconomic indicators. In spite of the high influence of disasters on agriculture, the real impact is still not properly understood. This is because sector-specific records of damage and losses occurred due to past disastrous events are not always available, collection procedures are fragmented and rarely data are systematically stored in databases [10]. Therefore, a rationalized conceptual model for the Agriculture damage and losses data collection, consisting in an ERD and a relational model, is proposed. The model takes into account all elements constituting different agricultural economic systems with the aim to overcome the existing gaps in the collection process.

The relational database model allows a comprehensive understanding of damage dynamics in the agricultural sector. The latter is considered in its economic dimension and as distinct and dynamic class of ecosystem. Moreover, Agriculture is intended as a system composed by elements of different nature which not only ensure the general functioning of the sector but are also dynamically correlated to each other. Furthermore, the proposed conceptualization considers damages as inter-connected (i.e. if a damage occurs on a tangible fixed asset such as a rural infrastructure, provisions will be consequently affected due to the repair costs), and intra-connected (a damage occurred on agriculture products can occur due to the intra-connection of the damage between raw materials and transformed goods - for example, if a damage occurs on a raw material, such as milk, transformed goods will be therefore affected due to the shortage of this raw material needed to produce dairy products).

Considering all these crucial aspects, the model allows to systematically report data with a spatial and temporal stamp taking into consideration the intra- and inter-dependencies of the sector. Moreover, the conceptualized database has been designed with the aim to be compliant to the Sendai Framework requirements while enforcing the assessment of damages in

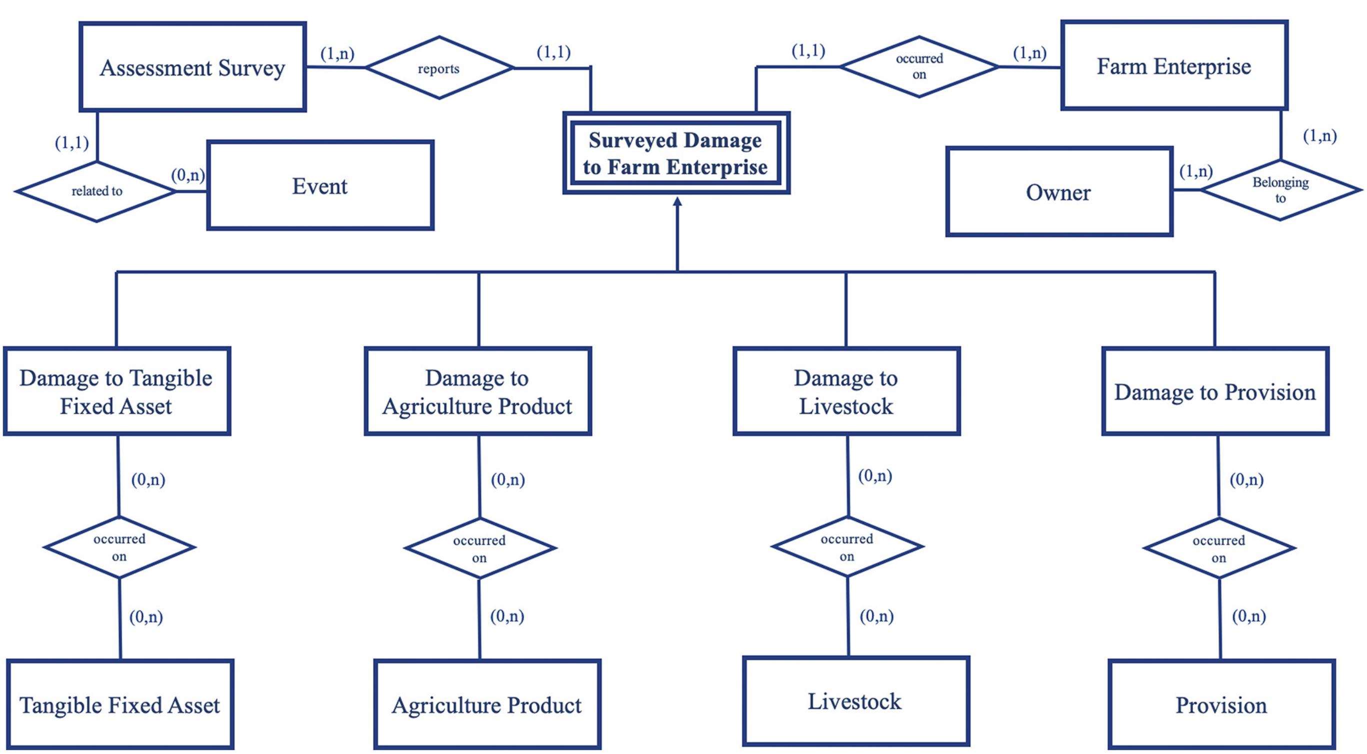

Fig. 6. ERD - Relationship between Farm Enterprise components and their respective damages entities.

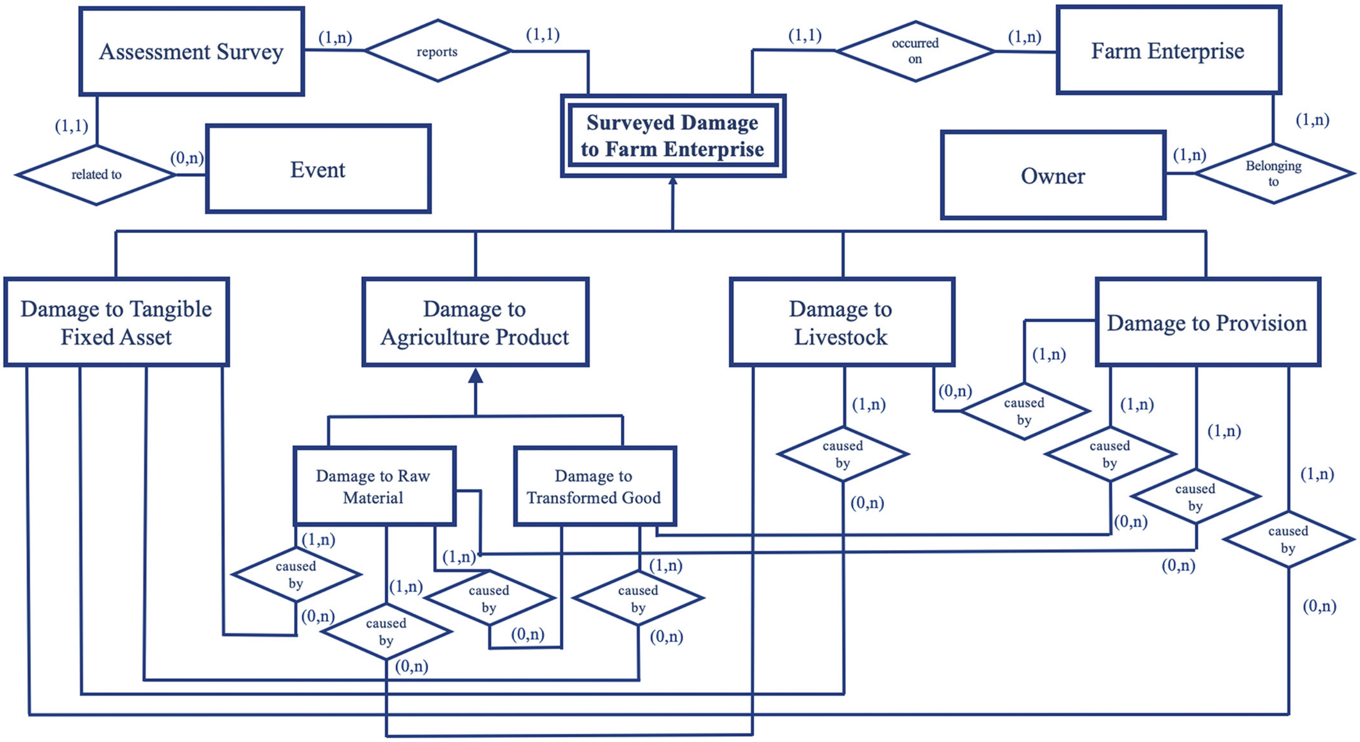

Fig. 7. ERD - Damage dynamics.

Table 1
Query to retrieve direct physical damage data.

SELECT	Event_ID, Region, Assessment_ID, Asset_category, Location, Function, Damage_description
FROM	Event, Assessment_Survey, Damage_to_Tangible_Fixed_Asset
WHERE	Event_ID = ERTQ20052012 AND Region = Emilia Romagna AND Damage_Description = Collapse of the Roof

agriculture with a multi-temporal dimension. Damages affecting agriculture may evolve in time, therefore the model allows to represent not only the immediate, direct, physical impact of an event, but also the indirect and systemic consequences related to the inter- and intra-dependencies of the different elements constituting the Agriculture sector. Considering a multi-step assessment of damages is one of the main results that are implemented in the proposed conceptual model. This allows tracking the damage evolution enabling reconstruction of the damage dynamics with a wider view on the real impact of disasters on the Agriculture since changes in agriculture production and economic flows can be properly monitored.

Finally, the implementation of the proposed model through ICT tools, rather than the classic paper-forms, would allow storing data in an integrated and coordinated manner due to the predefined relationships among data which permit consistency in data collection, storage and analysis. Rapid and more accurate documentation and sharing of big amounts of damage and loss data will be possible given the potential to facilitate fast

Table 3
Query to retrieve induced damage data.

SELECT	Event_ID, Assessment_ID, Asset_ID, Asset_category, Product_ID, Type, Damage_Description, %_Quality_Loss, VAT_Number
FROM	Assessment_Survey, Damage_to_Tangible_Fixed_Asset, Damage_to_Transformed_Good, Damage_to_Transformed_Good_caused_by_Damage_to_Tangible_FixedAsset
WHERE	Event_ID = ERTQ20052012 AND Cause_Asset_Category = Warehouse AND Type = ParmigianoReggiano

flow of information and to instantaneously connect numerous organizations across wide geographic areas.

6. Conclusion

Considering the limited information on the impact of disasters on Agriculture and its subsector, the proposed database would allow the acquisition of sector- specific damage and loss data which potential lies in the possibility to:

i. Aggregate and disaggregate information according to the needs since data are collected at the farm level;
ii. Understand the root-causes of damages and their consequences on the agriculture production and economic flows;

Table 2
Example of direct physical damage data.

Event_ID	Region	Assessment_ID	Asset_ID	Asset_category	Location	Function	Damage_description
ERTQ20052012	Emila Romagna	31052012XY	RE1960RW	Warehouse	Reggio Emila	Aging cheese warehouse	Collapse of the Roof
ERTQ20052012	Emila Romagna	31052012XZ	BO1973RW	Warehouse	Bologna	Aging cheese warehouse	Collapse of the Roof
ERTQ20052012	Emila Romagna	03062012XT	BO1990CS	Shed	Bologna	Cattle Breeding	Collapse of the Roof
ERTQ20052012	Emila Romagna	…	…	…	…	…	Collapse of the Roof

Table 4
Example of induced damage data connected to the causing damage.

CAUSE				CONSEQUENCE						
Event_ID	Assessment_ID	Asset_ID	Asset_category	Assessment_ID	Product_ID	Product_category	Type	Damage_description	% Quality Loss	VAT_NUMBER
ERTQ20052012	31052012XY	RE1960RW	Warehouse	25062012XY	PR_DOP_89,547_10012012	Cheese	ParmigianoReggiano	Fracture of cheese rounds	60%	89,547
ERTQ20052012	31052012XZ	BO1973RW	Warehouse	29062012XZ	PR_DOP_90,347_10012012	Cheese	ParmigianoReggiano	Fracture of cheese rounds	68%	90,347
…	…	…	…	…	…	…		…	…	…

iii. Recreate a compete representation of the suffered damages and their evolution in time and space.

Such a model would allow the creation of an inventory of crucial information to support a variety of actions aimed at reducing disaster risks.

Authorship statement

I certify that I meet authorship criteria, and that I have worked to take public responsibility for the content (concept, design, analysis, writing and revision of the manuscript). Furthermore, I certify that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in the Progress in Disaster Science Journal.

Uncited references

[24,27]

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