

Article

Analysis of Agrometeorological Hazard Based on Knowledge Graph

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Abstract: Agrometeorological hazards significantly impact agricultural production and rural economic development. The interdisciplinary nature of studying these hazards poses challenges such as poor data interoperability in research. This paper proposes a method for analyzing agrometeorological hazards using knowledge graphs to understand occurrence patterns and devise response strategies. The study involves classifying agricultural and meteorological knowledge and designing a hazard entity model based on the characteristics and influencing factors of agrometeorological hazards. Data mining and extraction techniques are used to extract relevant information from multiple sources, and a knowledge graph for knowledge fusion and storage is built. The retrieval and inference capabilities of the knowledge graphs are used to intelligently analyze agrometeorological hazards. Results indicate that analyzing agrometeorological hazards using knowledge graphs is an innovative method that offers new perspectives and ideas for agricultural meteorological hazard research, thereby promoting the sustainable development of agricultural production and the stable growth of the rural economy.

Keywords: knowledge graph; agriculture; meteorological hazards; hazard analysis



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1. Background

Agriculture is highly vulnerable to the effects of climate change. Suitable meteorological conditions, such as temperature, light, precipitation, humidity, and wind speed are essential for the healthy growth of crops. Agricultural meteorological hazards are adverse weather and climate anomalies that significantly reduce crop yields during agriculture production processes. These hazards are becoming more frequent due to global climate change, leading to substantial economic losses. In China, agricultural meteorological hazards account for about 70% of all agricultural natural hazards [1,2]. Research on agrometeorological hazards has been conducted extensively worldwide, focusing on various aspects such as crop growth, the rural economy, and social stability [3].

Currently, research mainly focuses on the following aspects:

(1) Classification and definition of hazards. Agrometeorological hazards have been classified and defined, including drought, flood, rainstorm, typhoon, and frost [2]. Researchers have explored the occurrence mechanisms, frequency, and impact ranges of these different hazard types. Furthermore, they provide technical support for agricultural hazard monitoring and early warning systems [4,5].

(2) Impact of hazards on crops. The impacts of meteorological hazards on crop growth, development, and yield have been analyzed through field observation, simulation experiments, and remote sensing technology [6,7]. Researchers seek to understand the impact mechanisms of meteorological factors such as temperature, precipitation, and sunlight on crop quality and yield [8,9]. They also propose corresponding adaptive agricultural measures.

(3) Prevention and risk assessment of hazards. Researchers have used statistical methods, remote sensing technology, and numerical simulation tools to assess the risk of meteorological hazards and to develop early warning systems [10]. These efforts aim to reduce the impact of meteorological hazards on agriculture through technical means and management strategies, ultimately enhancing the sustainability and resilience of agricultural production [11].

The analysis of agrometeorological hazards typically relies on methods such as statistical and empirical models. However, traditional methods often suffer from issues such as low accuracy, inefficient analysis, subjective factors, and an inability to thoroughly consider multiple factors. This is a problem because agrometeorological hazards have a significant environmental context and are closely linked to agricultural production conditions [12]. In recent years, artificial intelligence technology has been employed to analyze agricultural hazards, leveraging improved data collection and processing capabilities [13]. Researchers have started using information technology and methods to conduct extensive research on vast agricultural basic data, aiming to achieve more accurate and comprehensive hazard analysis [14,15].

The concept of knowledge graphs involves integrating knowledge from various fields and establishing comprehensive correlation relationships, which are then organized and represented visually [16]. This approach is primarily used in specific areas such as intelligent question answering, pest and disease research, and analysis of research trends in agricultural production [17–21]. Currently, knowledge graphs are not widely used in meteorological hazard analysis. However, the integration of various factors (such as crops, production, and meteorology) into a single model using an agricultural knowledge graph could enhance the accuracy and reliability of hazard analysis [22].

An in-depth and precise agricultural knowledge graph, built through thorough mining and analysis of agricultural data, can enhance people's understanding of and ability to predict the development of hazards. It can also offer guidance for agricultural production decisions, ultimately reducing the impact of various meteorological hazards on agricultural production and supporting the sustainable development of agriculture.

Henan is a significant wheat producer in China, ranking first in both wheat yield and planting area. However, being located in the transitional zone from tropical to warm temperate climate, it experiences distinct continental monsoon characteristics. This results in various agrometeorological hazards like drought, water logging, wind, hail, and frost, all of which greatly impact the high and stable yield of wheat [23].

The article proposes an agricultural meteorological hazard analysis method based on a knowledge graph. It uses agricultural production information and meteorological data from Henan Province as examples. The method utilizes the text structure association features of agricultural hazards and related meteorological data to propose an ontology model of agricultural meteorological hazards. Knowledge graphs for meteorological hazard analysis are constructed through knowledge modeling and text extraction techniques. The method analyzes agrometeorological hazards intelligently using the retrieval and inference capabilities of the knowledge graphs. The method offers the following advantages:

- (1) It can extract and fuse information related to meteorological hazards from multiple data sources, improving the efficiency and accuracy of data processing and analysis.
- (2) By establishing a knowledge graph, dispersed knowledge elements can be organically linked to better analyze the essence and laws of meteorological hazards.
- (3) Automated data mining and information injection could be achieved by knowledge graphs, lowering the threshold for artificial intelligence and professional technology, and improving the repeatability and scalability of the research.

2. Research Methods

2.1. Knowledge Graph Construction

The construction of knowledge graphs involves several steps: data acquisition, data classification, data processing, and graph storage [24]. Data acquisition is the source

of knowledge graph data, which comprises structured data, semi-structured data, and unstructured data. Structured data refers to data stored in a clearly defined pattern. Semi-structured data refers to data with a certain structure but no clearly defined pattern. And unstructured data refers to data without a predefined structure. Data classification involves organizing raw data, identifying entities and relationships, and determining their nodes and relationships in the knowledge graph. Data processing includes cleaning, processing, and transforming acquired data, such as data deduplication, data standardization, text analysis, entity recognition, and relationship extraction. This step ensures data consistency and quality. Graph storage is the process of storing processed data in the form of graphs, which is implemented using graph database tools and frameworks. Graph storage requires designing appropriate data models to support the querying and reasoning of knowledge graphs. The process of constructing a knowledge graph in this article is shown in Figure 1.

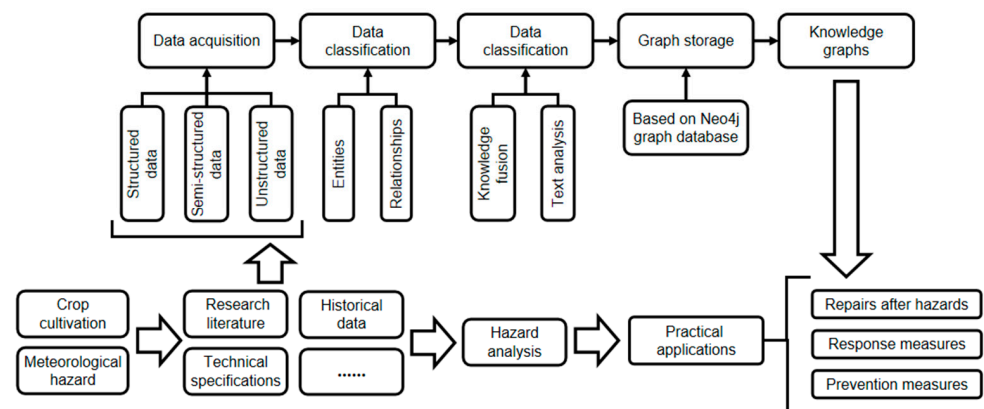


Figure 1. The steps for constructing a knowledge graph in this study.

2.2. Text Recognition

The primary role of text recognition in constructing knowledge graphs is to extract knowledge from unstructured or semi-structured text data. This involves transforming the data into entities, attributes, and relationships within the knowledge graph [25]. Entity extraction for agrometeorological hazards involves identifying and extracting named entities from text, such as crop names, meteorological states, hazard types, and so on. These identified entities are then matched with entities in the knowledge graph and added to the graph as entity nodes. Relationships between entities are then established. Relationship extraction involves identifying association relationships between entities in the text, such as the conditions required for crop growth, the stages involved in crop production, and potential scenarios for crops following meteorological hazards. The extracted relationships are then added to the knowledge graph to establish connection points. Attribute extraction involves identifying entity attribute information from the text, such as temperature, humidity, and lighting. These attributes are added to the corresponding entity nodes within the knowledge graph. Finally, the text is associated with entities, concepts, or categories in the knowledge graph, providing richer semantic information and improving the effectiveness of text classification and annotation.

2.3. Knowledge Verification

In knowledge graphs, there are numerous entities, relationships, attributes, and other elements. Building a knowledge graph is an ongoing process that involves continuous data updates, knowledge expansion, feedback, and verification. Once a knowledge graph is constructed, it is important to verify and correct its content to remove errors or inconsistent information. The accuracy and completeness of knowledge should be checked, compared, and verified. The primary methods for adjusting and correcting knowledge include manual verification, knowledge alignment, and audit mechanisms.

3. Construction of Knowledge Graph for Agricultural Meteorological Hazard Analysis

The majority of agricultural meteorological data is unstructured or semi-structured, with a low level of informatization and poor correlation of knowledge information, making it difficult to retrieve relevant information about a specific entity. To address these challenges, this study aims to build a domain knowledge graph of agrometeorological hazards, integrate relevant content, and improve the relevance and comprehensibility of knowledge information.

3.1. Hazard Ontology Modeling

Ontology modeling can help integrate and give meaning to agricultural meteorological data, making knowledge expression and retrieval more accurate and reliable. In knowledge graph ontology modeling, entities, attributes, and relationships within the knowledge graphs are defined and described. Entities in knowledge graphs represent specific things or concepts in the real world, such as characters, places, events, and products. Each entity has a unique label or name identified in the knowledge graphs, along with its associated attributes and relationships. Ontology serves as a formal representation for defining concepts, entities, and their relationships within a domain. When modeling ontology, it is necessary to determine the domain, clarify the scope of the domain covered by the knowledge graphs, and establish the goals and application scenarios for constructing knowledge graphs. Ontology modeling formally represents entities, attributes, and relationships within the knowledge graphs, offering a unified framework and shared semantic foundation to support knowledge organization, query, and inference.

This study utilized industry standards and agriculture and meteorology literature as the data source. It also incorporated industry background and research practices to design a hazard entity model. The agricultural meteorological hazard ontology model is depicted in Figure 2.

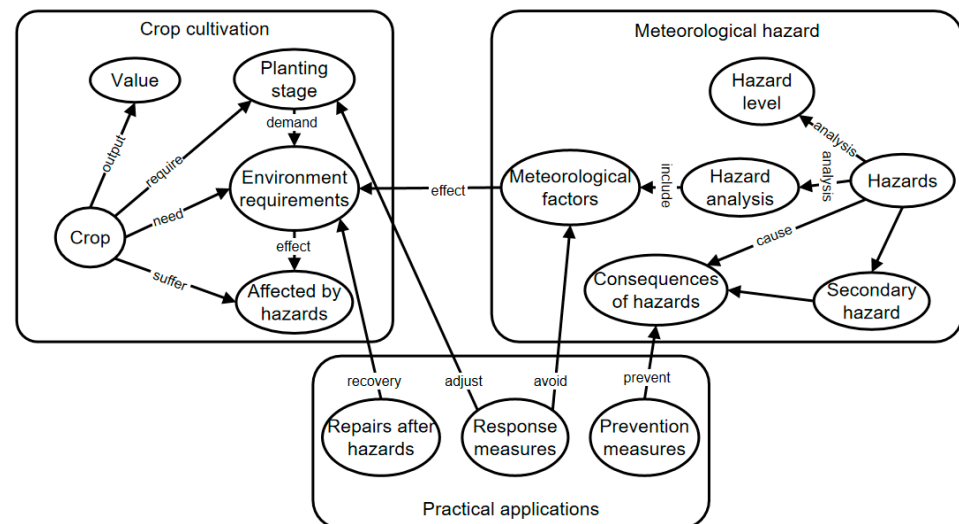


Figure 2. Ontology model of agrometeorological hazards.

3.1.1. Model Definition

After understanding the scope of the modeling domain, it is important to define top-level categories or concepts as the starting point for the ontology model. A category is the classification or categorization of entities. In a knowledge graph, an entity can belong to one or more categories. These categories can help the system understand the relationships and attributes between entities. The model used in this study is defined as the nodes and relationships between nodes in the construction of a knowledge graph. This includes entities, attributes, and relationships. The specific definition process is as follows:

(1) Define entities and categories. Identify different entities and categories. Provide definitions and descriptions for each. In this study, entities refer to crops, meteorological indicators, etc., and their characteristics and attributes are explained.

(2) Define relationships. Establish the connections between entities and provide definitions and descriptions for each relationship. Relationships can be one-way or two-way, and attributes are used to express these connections between entities.

(3) Define attributes. Identify the entity's characteristics and provide definitions and descriptions for each attribute. Attributes can be numerical, textual, or enumerated, and they are used to describe different aspects of an entity.

3.1.2. Instantiation

After completing the design of the model definition, it is important to create an ontology instance based on the defined ontology and fill in the relevant information. During the application process, it is also crucial to review and iterate the ontology to meet different needs and scenarios. The specific instantiation process involved in this study includes standardization, formalization, review, and iteration. Standardization and formalization involve standardizing and formalizing ontologies based on specific representation languages or tools so that computers can understand and process them. Review and iteration involve checking and verifying the constructed ontology to ensure its accuracy and consistency. In practical applications, it is necessary to iterate and modify the ontology according to specific requirements.

3.2. Knowledge Extraction

This article utilizes technical specifications, research literature, and historical data from crop cultivation and meteorology in Henan Province to identify agricultural meteorological hazards. The content of agricultural hazards is extracted by using keywords related to crop growth and planting hazards, and then searching for corresponding meteorological data.

Different methods of knowledge extraction are used to extract domain knowledge content due to the varying contents and forms of agricultural production information and meteorological data.

3.2.1. Agricultural Production Data Extraction

The agricultural meteorological conditions studied here mainly involve the weather conditions that impact crop growth, development, yield formation, and agricultural production processes. This kind of data is mostly unstructured, but it contains detailed descriptions of specific content and associated information about agricultural production [26]. We use keyword retrieval to extract entities and their related attribute information.

3.2.2. Meteorological Hazard Data Extraction

Meteorological hazard data has diverse, real-time, and spatial characteristics, with a large volume of heterogeneous data. Meteorological conditions are based on the values of detected and predicted atmospheric states, with statistical data primarily in the form of attribute values, mostly semi-structured. This study utilized methods such as manual extraction combined with templates to extract relevant content.

3.3. Knowledge Fusion

Knowledge fusion involves integrating knowledge from different data sources, domains, or structures to create a comprehensive and coherent knowledge graph that is understandable by machines. The goal is to enhance the accuracy, completeness, and consistency of the knowledge graph. In agricultural data, a single entity can have multiple names. Therefore, when constructing a knowledge graph, it is important to provide a standardized and unified description of these entities. This is typically achieved through methods such as manual proofreading, entity alignment, relationship reasoning, and knowl-

edge mining. Considerations for data quality, semantic consistency, and structural matching are essential in this process [27].

3.4. Knowledge Storage

The term “knowledge storage” refers to the organized storage of different entities, relationships, and attributes in a structured form within a knowledge graph. This facilitates easy access, querying, and inference. To effectively understand and analyze the data stored in knowledge graphs, it needs to be organized in specific structures, such as triplets and graphs. The storage method must meet the requirement for efficient querying and retrieval operations of the knowledge graphs. Query performance can be enhanced by creating indexes beforehand and optimizing the query method. Storage provides the data foundation for inference engines in knowledge graphs, which support inference operations based on rules, logic, and semantics, allowing new knowledge to be automatically discovered and derived.

In building a knowledge graph, information can be stored using methods like triplet storage, graph databases, RDF storage, document databases, distributed storage systems, and more. The data scale involved in this study is relatively small, and the analysis of agrometeorological hazards demands a strong ability to express relationships. In comparison to relational databases, graph databases offer higher traversal efficiency and stronger relational expression capabilities [28]. Therefore, this study utilizes Neo4j graph databases for storing data.

4. Analysis Template for Agrometeorological Hazards

The core of agricultural meteorological hazard analysis lies in organizing and applying knowledge about agrometeorological hazards. By creating a knowledge graph of entities and relationships related to these hazards, integrating dispersed knowledge into a unified framework, and making the connections and attributes between different entities clear, we can improve the comprehensibility, discoverability, and usability of data and knowledge. This study aims to create a hazard analysis template based on agricultural and meteorological hazard knowledge, match hazard entities with the content stored in the knowledge graphs, and generate a hazard analysis report using retrieval technology to access the associated content of the knowledge graphs.

4.1. Identification of Hazard Related Entities

In the fields of agriculture and meteorology, there are intersections of knowledge, but the specific knowledge for each discipline is relatively limited. Agricultural workers have a limited understanding of meteorological information, while meteorological service personnel lack targeted information on agricultural production. This leads to differences in how the same concept is described between the two fields, with the presence of multiple meanings and synonyms. Therefore, it is important to identify and understand key elements in the text and connect them with existing knowledge bases to establish relationships between different components. This will help in revising the elements based on specific needs and obtaining more comprehensive hazard analysis results.

4.2. Hazard Analysis Template

The hazard analysis template is divided into four parts: introduction to crops, introduction to hazard, hazard impact, and response measures.

The crop overview includes:

- Crop types;
- Environmental requirements;
- Planting stage;
- Affected by hazards.

Hazard overview includes:

- Hazard types;

- Hazard level. Agrometeorological hazards are usually classified into different levels according to their impact on crop growth and agricultural production, including minor hazards, general hazards, and major hazards;
- Types of crops affected;
- Production conditions affected.

Hazard analysis includes:

- Meteorological factors;
- Related hazard events;
- Hazard consequences;
- Secondary hazards. These are indirect impacts or chain reactions caused by direct losses to agricultural production caused by meteorological hazards, but not directly caused by the hazards themselves.

Response measures include:

- Hazard response and prevention;
- Hazard phenomenon prevention;
- Production cycle adjustment;
- Post-hazard assessment and recovery.

In practical applications, comprehensive hazard analysis reports are generated by combining crop production and hazard situations with knowledge graphs and related information retrieval. The specific structural relationship of the hazard analysis template is shown in Figure 3.

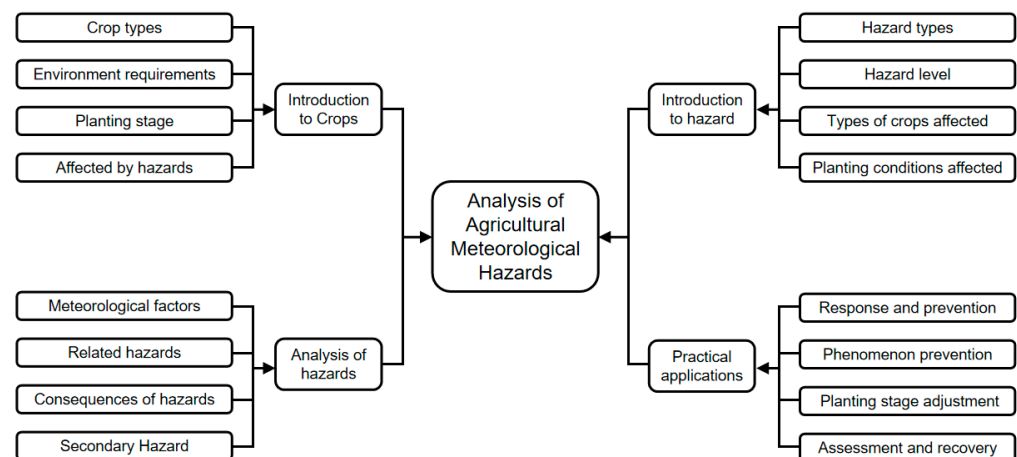


Figure 3. Analysis template for agrometeorological hazards.

5. Result Analysis

The experimental running environment for this study includes the following: Operating system: Windows 10. CPU: Intel I7-7700. GPU: NVIDIA GT 1660. Python version: 3.8. Operating platform: PyCharm Community Edition 2022.1. CUDA version: 11.6.1. Database: Neo4j Community 4.4.19.

5.1. Graph Construction

5.1.1. Knowledge Graph Entity Relationships

Based on the technical specifications for crop planting and agricultural meteorological services in Henan Province, along with related reference materials, we identified 10 entities, including crop types, production conditions, production cycles, types of meteorological hazards, and meteorological hazard factors (Table 1). We also uncovered 24 relationships, including agricultural production factors, analysis of meteorological hazard factors and impact of meteorological hazards (Table 2).

Table 1. Entity Statistics.

Entity	Quantity	Entity	Quantity
Crop types	12	Hazard types	33
Utilization pathways	37	Meteorological factors	15
Planting conditions	424	Hazard level	18
Planting stage	127	Secondary Hazard	25
Affected by hazards	68	Practical applications	68

Table 2. Relationship / Attribute Statistics.

Entity 1	Relationship or Attribute	Entity 2 or Attribute Value	Quantity
Crop types	The conditions needed for crop production.	Planting conditions	424
Crop types	Crop production consists of planting stages.	Planting stage	127
Crop types	The value of crop production output.	Utilization pathways	37
Crop types	Possible situations that may occur after crop hazards.	Affected by hazards	68
Planting stage	Meteorological requirements during the crop stage.	Planting conditions	416
Affected by hazards	Growing conditions that cause crop problems.	Planting conditions	68
Planting conditions	Crops grow at the right temperature.	Temperature	229
Planting conditions	Suitable humidity for growing crops.	Humidness	103
Planting conditions	The appropriate amount of light for crop planting.	Light amount	65
Planting conditions	Crops are planted at suitable wind speeds.	Wind speed	19
Hazard types	Describe the numerical values of dimensions.	Hazard level	142
Hazard types	The consequences of meteorological hazards.	Affected by hazards	68
Hazard types	Secondary hazards caused by meteorological hazards.	Secondary Hazard	25
Hazard types	Meteorological factors affecting crop cultivation caused by hazards.	Meteorological factors	33
Hazard types	The crops affected by meteorological hazards.	Crop types	33
Meteorological factors	The planting conditions affected by meteorological hazards.	Planting conditions	362
Meteorological factors	The temperature value of meteorological hazards.	Temperature	75
Meteorological factors	The humidity value of meteorological hazards.	Humidness	41
Meteorological factors	The amount of light in meteorological hazards.	Light amount	26
Meteorological factors	The wind speed of meteorological hazards.	Wind speed	10
Repairs after hazards	The method of restoring to the pre-hazard state after a hazard occurs.	Planting conditions	67
Response measures	The situation to avoid in the event of a hazard.	Meteorological conditions	65
Response measures	The planting stage that needs to be adjusted after a hazard occurs.	Planting stage	57
Prevention measures	Methods for early defense before hazards occur.	Affected by hazards	74

5.1.2. Results of Knowledge Graph

Due to the numerous relationships between entities in the agricultural meteorological hazard knowledge graphs, this paper only presents a partial depiction of the relationships between designed model entities, as shown in Figure 4. The information depicted in the graphs includes the following: the crop is wheat, and its production cycle consists of the following stages: seedling stage, pre-winter seedling stage, wintering stage, resume growth boot stage, heading and flowering stage, filling and mature stage, and harvest stage. Its production conditions include suitable temperature, soil moisture, precipitation, light exposure, etc.

Meteorological hazards include drought, flood, continuous rain, cold damage, frost damage, heat damage, dry hot wind, high temperature, and more. Secondary hazards include plant diseases, insect pests, and soil erosion, corresponding to different types of hazards. Various meteorological conditions such as wind, temperature, humidity, and light are associated with these hazards, as shown in Figure 5.

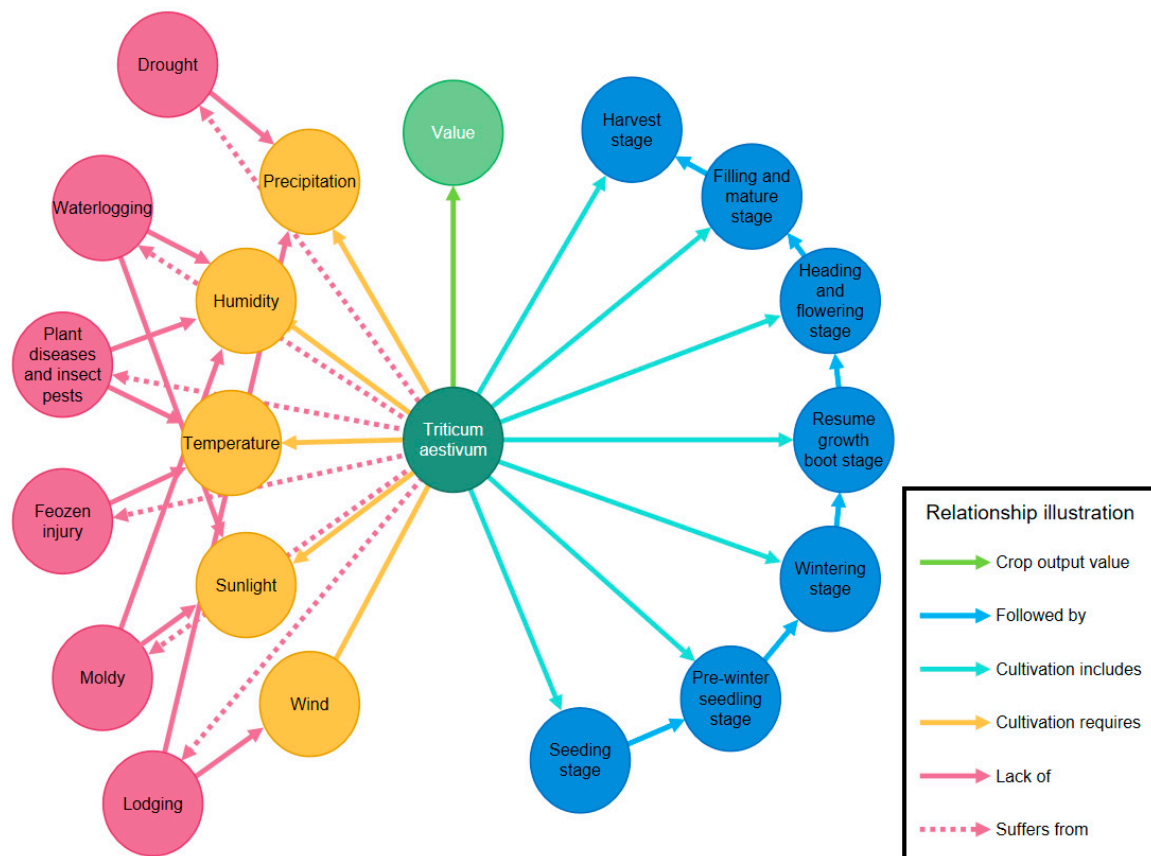


Figure 4. Physical knowledge graph of agrometeorological hazards related to wheat.

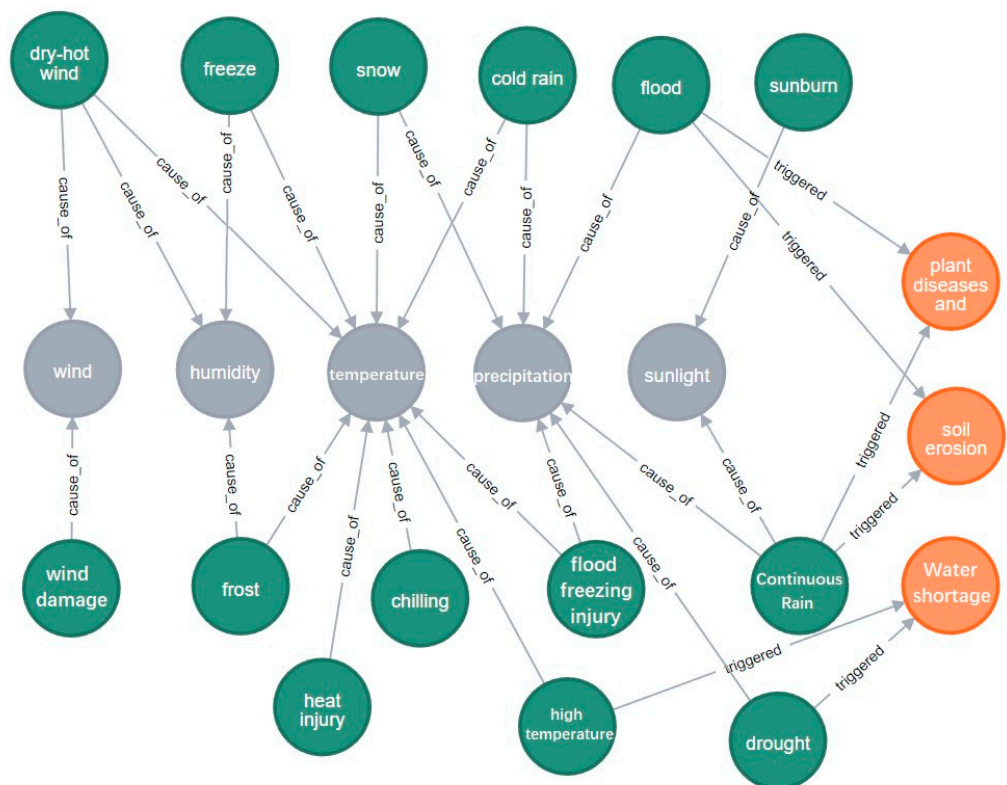


Figure 5. Meteorological Hazard Knowledge Graph.

Various hazards are associated with specific response and defense measures based on production conditions to link physical information such as crop production, meteorological hazard events, and response measures.

5.2. Hazard Ontology Modeling

The study involves recognizing various entities in the knowledge graph, including crops, production conditions, hazard events, meteorological factors, meteorological correlation conditions (related to crop production conditions), response measures, and other entities in agricultural production processes and meteorological hazard events.

The recognition training process begins with manually annotating the required entity information. Then, the data content is divided into training sets, validation sets, and testing sets based on the model design. Since the data volume is not particularly large, the division ratio is set at 60% for the training set, 20% for the validation set, and 20% for the testing set.

The results of the model training are presented in Table 3. Once the extraction of entity content is completed, the results are verified and proofread. Any incorrect and biased content information is modified. The entities are consolidated into a CSV file format and entered into the knowledge graph database.

Table 3. Statistics of Training Extraction Results.

Entity Type	Accuracy Rate/%	Entity Type	Accuracy Rate/%
Crop types	84.5	Hazard types	81.2
Utilization pathways	65.2	Meteorological factors	79.0
Planting conditions	72.0	Hazard level	85.7
Planting stage	79.3	Secondary hazard	45.8
Affected by hazards	67.5	Practical applications	51.6

5.3. Hazard Analysis Results

The agricultural meteorological hazard analysis template, along with agricultural meteorological hazard-related entities, is used to intelligently generate agricultural meteorological hazard analysis reports using knowledge reasoning and knowledge graph retrieval functions. The report includes information related to crop entities, the impact of meteorological hazards on the crop production cycle, the production conditions required for the production cycle, types of meteorological hazard phenomena, meteorological factors that cause hazards, the impact of hazards on crops, as well as response and defense measures. Additionally, the knowledge graph is utilized to display the needs of crop production and other related content.

Analysis was conducted on the meteorological hazard event of “large-scale continuous rainy weather in May, causing wheat fields to rot”. Meteorological factors such as “May” and “continuous rainy weather” were examined in the knowledge graphs, yielding the following relevant entities: wheat (crop type), harvest period (crop production cycle), sufficient sunlight/low relative humidity/moderate temperature (crop production conditions), pre-harvest sprouting/lodging/mold (affected by hazards), flooding (meteorological hazards), continuous rainfall (precipitation/meteorological factors), drainage/pest control/drying/early harvesting (response measures). The specific search results are displayed in Table 4.

Based on the current situation, relevant data for the crop “wheat” is gathered from the search results. The entity and relationship information of associated nodes are obtained through graph retrieval to conduct a comprehensive hazard analysis.

Based on knowledge graph analysis, it was determined that the crop affected by “large-scale continuous rainy weather in May, causing wheat-rotting fields” is wheat. This crop is in the harvest period of the wheat production cycle. The meteorological hazard is flooding, which may result in sprouting, lodging, and moldy growth in the wheat. To address this, drainage, drying, and early harvesting are recommended response measures. The specific search results and related entity relationships can be found in Figures 6 and 7.

Table 4. Statistics of Search Results.

Entity Type	Entity	Number of Results	Result Proportion/%
Crop types	Wheat	8	57.1
	Maize	3	21.4
	Other crops	3	21.4
Planting stage	Harvesting stage (Wheat)	5	50
	Growth stage (Maize)	2	20
	The planting stage includes other crops from May	3	30
Planting conditions	Adequate lighting/Low humidity/Moderate temperature (Wheat)	8	61.5
	Adequate lighting/Appropriate rainfall/20–25 °C (Maize)	3	23.0
	The planting conditions for other crops during the May planting phase	2	15.3
Hazard types meteorological factors	Floods/Continuous rainy	9	75
	Rain	6	75
	Pre-harvest sprouting/Lodging/Mildew (Wheat)	9	60
Affected by hazards	Plant diseases and insect pests (Maize)	3	20
	Drain the waterlogging/sunning and stoving/Advance harvesting (Wheat)	8	50
Countermeasures	Pest control/Reasonable fertilization/Maintain suitable soil humidity (Maize)	3	18.8

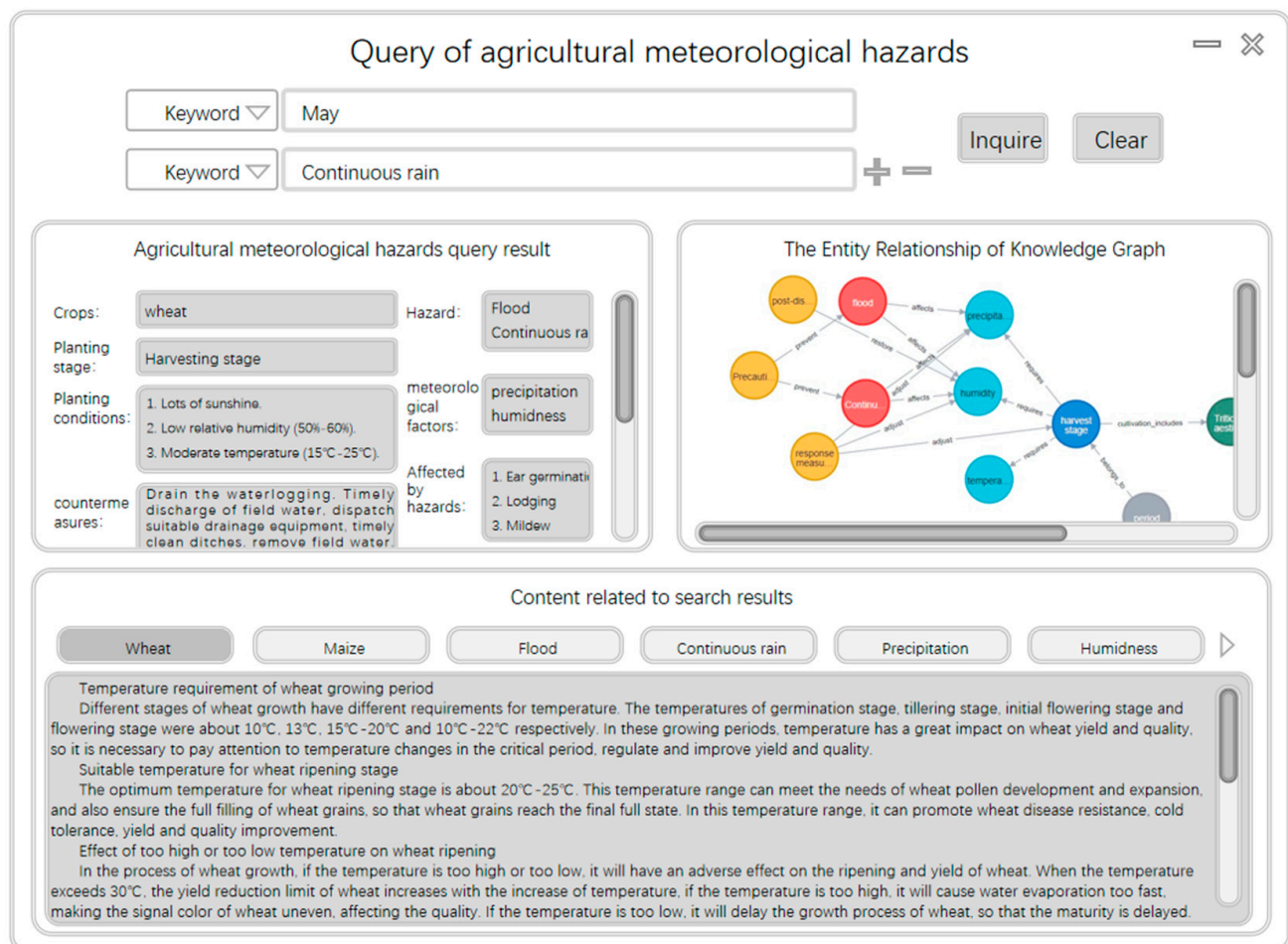


Figure 6. Hazard analysis results retrieved using keywords “May” and “continuous rainy weather”.



Figure 7. Partial Related Entity Relationships of Search Results.

6. Conclusions and Outlook

This article introduces a method based on knowledge graphs for analyzing agricultural meteorological hazards. The main points are as follows:

Analysis and compilation of agricultural meteorological hazard events was conducted based on the meteorological needs and data of agricultural production in Henan Province. An ontology model for hazards was designed, and a knowledge graph of meteorological hazard analysis was constructed using text recognition and extraction technology. This method provides a new approach to querying and retrieving agricultural meteorological hazard-related knowledge by analyzing the connection of agricultural meteorological hazard ontology-related content.

The association content of agricultural and meteorological hazard-related entities was studied using the hazard entity model designed according to the characteristics of agriculture and meteorology. This approach solved issues such as weak correlation of agricultural meteorological hazard-related data and inconvenient retrieval of research-related content.

Characteristics and response measures of agricultural meteorological hazards were studied, and agricultural meteorological hazard analysis reports were generated automatically using graph retrieval technology. The results will effectively assist agricultural production personnel defend against agricultural meteorological hazards.

Currently, this study is concentrating on agricultural production and meteorological data from Henan. The study provides effective results in analyzing regional agricultural meteorological hazards. After the research project is completed, the project methodology will be made publicly available. It will also be expanded to other regions to verify its effectiveness and applicability.

The study created a knowledge graph using text recognition technology to analyze agricultural meteorological hazards. The researchers discovered that relevant knowledge comes in various forms, including text, audio, images, and videos, but they focused solely on text data for this study. Future studies will explore creating multi-modal knowledge graphs, which will enable machines to better understand and process information from different sources. The researchers also found that meteorological data is well suited for temporal knowledge graphs, which will be used to analyze patterns, trend changes, and anomalies in the data for more accurate predictions and analysis results. This approach aims to enhance agricultural information research and application, ultimately benefiting agricultural production.

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