

## WP23\_25: Global Vegetation Pest and Disease Dynamic Remote Sensing Monitoring and Forecasting

1312,260

### Basic Information

#### Full title of the Initiative

Global Vegetation Pest and Disease Dynamic Remote Sensing Monitoring and Forecasting

#### Short Title or Acronym

GEO-PDRS

#### Current category in the 2020-2022 GWP

Community Activity

#### Proposed category in the 2023-2025 GWP

GEO Initiative

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### Purpose

#### Objective

The initiative aims to bring together and produce cutting edge research to provide vegetation pests and diseases habitat monitoring and early forecasting information, integrating multi-source (Earth Observation-EO, meteorological, entomological and plant pathological, etc.) to support decision making in sustainable management of pests and diseases. Taking advantages of our research groups with mutual complementary expertise in remote sensing and plant protection, and our past achievements of GEO activities, this initiative firstly study remote sensing mechanisms for vegetation pests and diseases monitoring and forecasting at multiple spatial levels to develop and optimize the coupling of spectral and spreading mechanism models. Subsequently, the new optimized models of pests and diseases that rely on satellite images were established to produce habitat monitoring and disaster early forecasting products to our multi-level actual and intended users. And then, decision making serving will deliver to our users, and we will get the feedback of evaluate habitat of pests and diseases, and forecasting of pests and diseases for time series information updating and service providing. Finally, these scientific datasets, products and services of vegetation pests and diseases would be published with function modules and software. The outcomes of the project would not only promote efficacy of pests and diseases management and prevention by improving the accuracy of monitoring and forecasting, but

also help to reduce the amount of chemical pesticides, which could thus guarantee the food security and sustainable development of agriculture in globe.

## **Please provide a short description of the Initiative**

In recent years, global climate change has led to an increase in the severity of vegetation pests and diseases. To achieve international food security and maintain ecological sustainability at a large scale, there is an urgent need to develop timely and accurate remote sensing-based monitoring and early forecasting programmes. This initiative is built upon the previous two GEO community projects CROP PEST MONITORING 2017-2019 and 2020-2022. This initiative aims to develop and optimize remote sensing habitat monitoring and risk forecasting models for major migratory and epidemic vegetation pests and diseases (fall armyworm, locust, rust, pine wilt disease, etc.); construct comprehensive products to meet the needs of multi-level users (governments, extension departments, commercial companies, farmers, etc.); deliver services to actual and intended users to issue warnings and conduct plant protection activities. This initiative will promote our users to achieve maximized benefit and further to help them recover loss, save money, conserving biodiversity, etc. We build a community of stakeholders to improve our capacity to support the SDG2 & SDG13 of UN's 2030 Agenda, and disaster prevention and reduction objects of Sendai Framework. Ultimately promoting global cooperation in vegetation pests and diseases control to help ensure global food security and sustainable development of ecosystem.

## **Why is this Initiative needed?**

This initiative aims at addressing SDGs and DRR priorities that are relevant for global remote sensing monitoring and forecasting of major vegetation pest and disease through multilateral cooperation. At present, there is a rapid increase in the area and frequency of vegetation pest and disease around the world, which is detrimental to the vegetation growth and poses a serious threat to global food security and ecological stability. According to statistics, more than 10% of annual food production losses are caused by pest and disease, and may exceed 30% in some areas. The untimely information of pest and disease monitoring and forecasting leads to the later prevention, which increases the use of chemical pesticides, causing significant damage to the ecosystem. At the same time, the ability of vegetation to sink and emit carbon can be affected by pest and disease, which in turn disrupts ecosystem cycles. To ensure global food security and ecological sustainability, there is an urgent need for multilateral cooperation to achieve multi-scale remote sensing monitoring and forecasting of major vegetation pest and disease. Meanwhile, it is necessary to provide spatial information services for some international organizations (such as, GEO, GBIF, CABI, departments in Somalia, Eritrea and Ethiopia, etc.), countries suffer from pest and disease (such as Pakistan, Ghana, Kenya, etc.) and pest and disease control companies, etc., to help them apply the suitable prevention measures and strategy to ensure food production, reduce chemical pesticide use, and thereby protect the environment, promote the sustainable development of global agriculture and ecosystems.

It is clear from the challenges in addressing the SDGs and DRR that a comprehensive, objective means of informing risk reduction is required at a global level. EO has the potential to provide such information. In particular, this initiative aims to achieve efficient and accurate monitoring and forecasting of vegetation pests and diseases, and deliver EO-based vegetation pest and disease monitoring and forecasting products and services to multi-scale wider users. We will be engaged in the research of Fall Armyworm, Locust and Wheat Rust, and to meet the requirements for efficient and accurate monitoring and forecasting of epidemic and migratory pest and disease globally, and will propose methods for dynamic spatio-temporal pest and disease monitoring and forecasting at global scale, regional scale, subregional scale, national scale and local scale.

EO has a compelling role to play in bringing UN 2030 Agenda and Sendai Framework objectives into reality. However, the barriers to accurately extracting information from satellite data and serving for vegetation pest and disease monitoring and forecasting are enormous. This initiative proposes an effective method for global vegetation pest and disease monitoring and forecasting by interpreting the link between EO data and the occurrence of vegetation pests and diseases. Provide products and services to decision makers, extension department staffs, commercial company technicians, investigators in the field and farmers. In this initiative, global pest and disease monitoring and forecasting will integrate methods and models into the GEO platform and Knowledge Hub, and circulate the products and services in GEO summits, workshops, weeks, etc. to improve the impact of results in GEO community. With the support of this initiative EO-based products and services, objections in SDGs and DRR related to agricultural disaster reduction will be better to achieve.

## **What evidence is there to support this need?**

According to SDG2 "End hunger, achieve food security and improved nutrition and promote sustainable agriculture", and Sendai Framework for DRR 2015-2030, vegetation pest and disease monitoring and

forecasting can improve disaster prevention and control ability, thus guarantee food security and promote sustainable development, and it will promote GEO play more important role in global SDGs and DRR decision making support.

**Is this Initiative open to participation by representatives of any GEO Member, Participating Organization, and GEO Associate?**

Yes

**Are you aware of other projects or initiatives at a global or regional scale (both in GEO and externally) that provide similar products or services?**

No

**Please identify the most important actual and/or intended outputs (products, services, etc.) produced by the Initiative, along with their intended and/or actual users. This list does not need to be comprehensive but should identify the outputs which are most used and are expected to have the greatest potential impact.**

Output	Status	Users	Additional info
Metadata	In development	Actual users? FAO, CABI, GBIF, NATESC, NFGA; Intended users: UN-SPIDER, AOGEO, GEO Knowledge Hub, PMAS Arid Agriculture University, Pakistan Academy of Sciences;	One of the outputs of this initiative is the metadata of the results of remote sensing monitoring and forecasting of vegetation pests and diseases, which adheres to the 'FAIR Guiding Principles for scientific data management and stewardship' in terms of data organisation and labelling. We upload the produced metadata to users' own platforms to make pest and disease information available to a wider community. A success case is our uploading of metadata to FAO Hand-in-Hand Geospatial Platform. FAO issued warnings to high-risk countries such as Somalia, Ethiopia and Kenya to guide crop protection, and these countries found the pest in our forecast areas and achieved timely control of pest.
API	Regularly updated	Actual users? FAO, GBIF, MMU, University of Technology Sydney, NATESC, NFGA; Intended users: UN-SPIDER, CABI, GEO	Another output of this initiative is APIs for remote sensing monitoring and forecasting models of vegetation pests and

		<p>Knowledge Hub, CNR-IMAA, King's College London, PMAS Arid Agriculture University, Pakistan Academy of Sciences, Agriculture and Agri-Food Canada, CBCGDF;</p>	<p>diseases, which are developed in the unified way. Users who integrate the APIs into the platform can directly call the models we have developed. These products enable users to monitor and forecast pests and diseases directly in their area of interest. A success case is that GBIF used APIs further to reveal environmental disturb factors and protect biodiversity. Besides, GBIF produced the Desert Locust dataset using our APIs, and GBIF secretariat Tim Hirsch said that this dataset is the first 'Remote Sensing Dataset' in GBIF for global circulation to support ecology sustainable development.</p>
Map	In development	<p>Actual users? FAO, GBIF, CABI, PMAS Arid Agriculture University, Pakistan Academy of Sciences, CNR-IMAA, King's College London, Ethiopian Space Science and Technology Institute, Agricultural Extension Department of Eritrea, Iraqi Ministry of Agriculture, Welthungerhilfe in Somalia, UN-SPIDER, CBCGDF, NATESC, NFGA, Assimila Ltd., Tekever Ltd., Anyang Quanfeng Aviation Plant Protection Technology Co., Ltd., Hangzhou Waobot Technology Co., Ltd; Intended users: AOGEO, GEO Knowledge Hub, GEO community, MMU, University of Technology Sydney, Agriculture and Agri-Food Canada;</p>	<p>Another output of this initiative is thematic maps for vegetation pests and diseases monitoring and forecasting, which contain information on the spatial distribution and severity of pests and diseases. Based on these thematic maps, users can carry out diversified application, such as the development of control strategies, estimation of crop yield, adjustment of market strategies, etc. Pakistan technicians and prevention staffs have used pests and diseases map to conduct precision control. Pakistani Ambassador to China Moin ul Haque mentioned "Chinese scientists led by Wenjiang Huang are helping Pakistan enhance the country's food security through sharing data of monitoring and assessment of desert locust".</p>

Software	In development	Actual users? CABI, FAO, GBIF, CBCGDF, Agriculture and Agri-Food Canada, Ethiopian Space Science and Technology Institute, Agricultural Extension Department of Eritrea, Iraqi Ministry of Agriculture, Welthungerhilfe in Somalia; Intended users: AOGEO, GEO community, PMAS Arid Agriculture University, Pakistan Academy of Sciences, MMU, King's College London, CNR-IMAA, UN-SPIDER, University of Technology Sydney, Assimila Ltd., Tekever Ltd., Anyang Quanfeng Aviation Plant Protection Technology Co., Ltd., Hangzhou Waobot Technology Co., Ltd;	The software of this Initiative is a system platform containing a database, a model library and a product library. The Initiative will develop global vegetation pest and disease monitoring and forecasting systems and localise them to the specific conditions of key countries or regions, as well as providing regional customised services. Users can directly use our software to monitor and forecast hotspots and trends of pests and diseases, and then develop appropriate control strategies. CABI has used the software to forecast the risk of pests and diseases in specific areas and time to maximize biopesticide promotion. Eventually, CABI international branches in East Asia, East and South Asia, etc. reduced chemical pesticide usage and achieved cost saving.
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**If needed, please provide additional comments or explanation to accompany the outputs table**

The outputs of this initiative are divided into four categories, namely metadata, API, map and software. Metadata of the results of remote sensing monitoring and forecasting of vegetation pests and diseases can be easily uploaded to different platforms, thus using the power of the platform to serve more users. APIs for remote sensing monitoring and forecasting models of vegetation pests and diseases gives users more possibilities to use their own data for pests and diseases monitoring and forecasting. Thematic maps for vegetation pests and diseases monitoring and forecasting is mainly used to display information on the occurrence and development of pests and diseases, allowing users to easily access key information and take timely action to control them. Software is an output that is easier to use and can serve multiple levels of users. Software is a collection of data, models and products, and this type of output usually has the greatest impact and is the most accessible to users.

**What kinds of decisions are the outputs of this Initiative primarily intended to support?**

The outputs of this initiative mainly support joint multi-country pest and disease control at the global level, pest and disease control strategy development and market regulation at the national level, regional management at the regional level and pesticide spraying and yield estimation at the farm level.

**How will these decisions benefit from the outputs of this Initiative?**

We provide the UN organization (FAO, UN-SPIDER, GBIF, etc.) and countries governments (Italy, UK, Pakistan, Ghana, Kenya, Australia, Canada, China, etc. suffering serious damage by Fall Armyworm, Locust and Wheat Rust) that responsibility to carry out disaster management with pest and disease monitoring and

forecasting reports to warn officials how severe the threat is happened and development. Meanwhile, we help plant protection technology extension departments (NATESC of MARA, NFGA, CBCGDF, departments in Somalia, Eritrea and Ethiopia, CABI, etc.), commercial companies, farmers, etc. to decide if it is necessary and suitable to apply chemical fungicides/biological fungicides/ecological technologies, and when, where, how and at what dosage to prevent and control vegetation pest and disease.

**What kinds of impacts (for example, reduced loss of life, monetary savings, conservation of biodiversity, etc.) are anticipated as a result of the use of the outputs of this Initiative?**

This initiative combines remote sensing technology with traditional methods for monitoring and forecasting of major global vegetation pests and diseases, and is of great significance in achieving joint scientific prevention and control of vegetation pests and diseases in multiple countries, promoting science and technology diplomacy, and ensuring global food security and regional stability. The outputs of this initiative can make new advances in areas such as hotspot monitoring and time-series forecasting of vegetation pests and diseases, and the initiative's results have a clear advantage over similar products worldwide. In addition, the control of vegetation pests and diseases in China is mainly based on extensive manual spraying of pesticides, which is not only time-consuming and labour-intensive but also prone to excessive control and environmental pollution. The implementation of this initiative can provide information support for regional management and invasion control of vegetation pests and diseases, thus reducing unnecessary chemical pesticide applications, reducing control costs while protecting food security and biodiversity, and bringing greater social, economic and ecological benefits.

**Has this Initiative been asked to provide specific information (for example, reports, data, services) on an ongoing basis to an international convention, organization, or other multilateral body?**

No

## **Technical Synopsis**

**Please provide a brief description of the methods used by the Initiative to produce its (actual or planned) outputs.**

Our GEO initiative targets globally significant plant pests and diseases, such as the fall armyworm, locust, and wheat rust. We combine multi-sourced biological data to establish the spatio-temporal developmental mechanisms of pests and diseases. These are combined with multi-level mechanistic models to create convolutional networks. Partial differential equations are used to dynamically update the model parameters and enhance the spatio-temporal generality of the model. We integrate spatio-temporal big data and cutting-edge technologies to meet the demands of user applications in food security and ensure ecological stability. In addition, we fill use EO-based monitoring and forecasting products and services to maximize plant protection and control.

WP1: The WP develops and optimizes remote sensing monitoring and forecasting models for vegetation pests and diseases. Remote sensing will be combined with multi-scale meteorological, agronomic, ecological, and plant protection-related data, along with other spatio-temporal data. Based on this, we intend to develop intelligent identification techniques and methods for the rapid and dynamic extraction of information related to disease hotspots. This information will include data regarding the core breeding areas of plant pests, key areas in which they cause damage, and disease characteristics under multi-scale complex geological scenarios. By coupling the radiative transfer model, habitat suitability model, and models for the spread process of pests and diseases, we can determine the spatio-temporal patterns of pest and disease expansion. This would allow the dynamic monitoring and forecasting of pests and diseases at multiple scales.

WP2: This WP develops comprehensive products to meet the needs of multi-level users. We will dynamically estimate the occurrence and spread of pests and diseases at global and national scales. These data can be used to warn the UN and governments of various countries regarding the status and future risk of pest and disease occurrence. Extension departments related to plant protection technologies will be provided with reports and thematic maps detailing the dynamic spatial distribution of pests and diseases, which would assist the development of effective control strategies. Commercial companies and farmers will be provided with local

disaster assessment data and precision pesticide application plans, which would allow them to adopt necessary and suitable management strategies.

WP3: This WP delivers services based on the above-mentioned methods and products for valuable capacity development. We will integrate these methods and models into the GEO Knowledge Hub with API, XML and LIB, and will provide GEO members and participating organizations with efficient cloud computation services for the monitoring and forecasting of pests and diseases. We will offer scientific prevention and control strategies and intelligent linkage information services to expand our scope at the global, regional, subregional, national, and local scales, thus maximizing the application value. We will build a closer cooperative relationship with our end users and provide charitable and commercial services to extension departments, commercial companies (e.g., companies that provide unmanned aerial vehicles (UAV), pesticides, and insurance), and farmers. With these services, we will facilitate the industrial application of our data and help achieve the SDG and DRR objectives.

**If you would like to provide further details on the technical methods, you may upload one or more documents here.**

- the\_contents\_of\_the\_three\_work\_packages\_and\_their\_relationship.jpg ([link](#))

**Are there any significant scientific or technical challenges that need to be resolved by the Initiative during the 2023-2025 period?**

Yes

**Please describe these challenges and the steps being taken to solve them.**

C1: There are several scientific challenges associated with the high-precision and comprehensive modelling of pest and disease occurrence, dynamically updating the models at multiple spatio-temporal scales, and ensuring the reliability of models under complex geological scenarios.

Solutions: In terms of model construction, this initiative will effectively link models that describe the development biology of pests and diseases with those that describe the process of atmospheric spread. These will be further combined with the radiative transfer model and an analysis of habitat suitability to achieve the dynamic monitoring and forecasting of pests and diseases. To facilitate the spatio-temporal expansion of the model, we will input the initial and spread states of the forecast indicators into the transfer learning framework. This will help realize online model training, allow the updating of parameters under complex geographic scenarios, and output multi-scale and multi-level monitoring and forecasting products. Sufficient in situ data can help improve the accuracy and usability of the product. This initiative includes multiple types of in situ data, including historical records, data obtained through international ground observation experiments, data obtained from the global observatories of CABI in the UK and FAO in the UN, and data obtained from the observatories of NATECO and NFGA in China. These data will be used to train and validate models for our products intended for different levels of users. Products related to the remote sensing-based monitoring of pests and diseases will use evaluation indexes to improve monitoring accuracy based on the in situ data. For the remote sensing-based forecasting of pest and disease development, we will determine the confidence level of the product based on in situ data and provide more accurate user references, guides, and protocols.

C2: There are several technical challenges associated with the development of our proposed products and services. These challenges include determining the proper standards for data production; estimating the specifications for products and services; and addressing factors such as inconsistencies in software development languages and tools, poor user feedback regarding service, and policy-related restrictions. Solutions: To address technical issues related to data production standards and service specifications, this initiative will abide by the GEOSS data sharing and management principles and GEO ethical standards. Academic articles, modelling methods, and will be shared on the GEO Knowledge Hub to ensure that the outputs are synchronized and updated in the GEO community. To address poor service and user feedback and other policy-related restrictions, we have built a long-term and stable cooperation facility where end users can provide feedback. We will further promote internal cooperation within the GEO work programme activities (AOGEO, GEOGLAM, GEO BON, and EO4SDG, among others) and continue our ongoing cooperative projects. This will ensure efficient user efficient and help optimize outputs and updates at the global, regional, subregional, national, and local scales.

**Does the Initiative expect to complete any key new outputs, improvements to existing**

## **outputs, or improvements to the methods of producing outputs, in the 2023-2025 period?**

Yes

### **Please describe these new outputs or improvements.**

(1) In this initiative, our new outputs are pest and disease monitoring and forecasting function modules, and we will further integrate them into GEO platform. We develop function modules for our intelligent dynamic monitoring and forecasting methods and models with the capacity of spatio-temporal expansion, and integrate them into the GEO platform using API, XML, LIB, etc., for easier and efficient circulation, to promote our cooperation with GEO work programme activities and to support a wide range of users with maximizing value.

(2) In this initiative, our new improvements are comprehensive pest and disease monitoring and forecasting products, to identify and satisfy application needs. We improve our pest and disease monitoring and forecasting products from key serious damaged areas and time to spatio-temporal continuous products which update dynamically. These multi-scales comprehensive products include pest and disease dynamic spatial distribution, occurrence and spread thematic maps and reports in global scale, regional scale, subregional scale, national scale, and local scale.

(3) In this initiative, our new improvements are services at the multiple and wider end users. We will provide space information, scientific prevention and control intelligent linkage information charitable and commercial services, for support decision making of governments to warn the current status and future spread risk of pest and disease, for support management of plant protection technology extension departments to assist making scientific and green control strategies, for support commercial companies, farmers, etc., to fill the industry application gap of cost savings and efficiency gains and better facilitate the achievement of SDGs and DRR objectives.

### **Please identify the key tasks that must be implemented to ensure delivery of these changes, with target dates for completion.**



<b>Task</b>	<b>Task description</b>	<b>Expected completion (month/year)</b>
Task1: Develop and optimize remote sensing monitoring and forecasting models for vegetation pests and diseases.	Task 1.1: Modelling of pests and diseases occurrence hotspots based on intelligent identification techniques. Task 1.2: Coupling multiple models for long time series forecasting of pests and diseases.	Task 1.1: March 2023, updated every 6 months. Task 1.2: June 2023, updated every 6 months.
Task2: Develop comprehensive products to meet the needs of multi-level users.	Task 2.1: Produce reports detailing the dynamic occurrence of pests and diseases at global and national scales. Task 2.2: Produce reports and thematic maps detailing the dynamic spatial distribution of pests and diseases for extension departments working on plant protection technology. Task 2.3: Produce local disaster assessment data and precision pesticide application plans for users such as commercial companies and farmers.	Task 2.1: May 2023, updated depending on pests and disease types in key regions and countries. Task 2.2: May 2023, updated depending on departmental needs and plans for control and prevention. Task 2.3: May 2024, updated depending on user needs.
Task3: Deliver services and products for valuable capacity development.	Task 3.1: Provide efficient cloud computation services for the monitoring and forecasting of pests and diseases. Task 3.2: Provide information services for the development of scientific prevention and control techniques. Task 3.3: Build closer cooperation with multiple end users and provide charitable and commercial services.	Task 3.1: October 2023, updated depending on user needs. Task 3.2: October 2023, updated depending on user needs. Task 3.3: October 2024, updated depending on user needs.

## Resources

**Have all resources required to implement the Initiative's planned work in the 2023-2025 period been secured?**

- Other gaps

### **Please describe the other resources required by the Initiative?**

This initiative will integrate the various models, methods, and reports into the GEO Knowledge Hub to provide services to a wide range of users. We need various resources and channels to encapsulate our functional modules and products. This would improve uploading, integration, and updating on the GEO Knowledge Hub and promote wider circulation.

### **What actions is the Initiative taking to obtain the required resources?**

In this initiative, we will apply to the GEO Secretariat to obtain the necessary information and permissions for resource integration. Simultaneously, we will actively establish cooperation with GEO work programme activities to support the large-scale monitoring and forecasting of plant pests and diseases and to obtain

information regarding the forms and rules necessary for resource integration. Ultimately, the functional models will be integrated into the GEO Knowledge Hub, and the monitoring and forecasting reports will be uploaded following the GEOSS data sharing principles, data management principles, and GEO ethical standards.

**Please list all financial and non-financial contributions to the Initiative (other than in-kind, voluntary participation by individual contributors) having a value of more than USD 50,000.**

Contributing Organization	GEO Status	Type of Resource	Value	Currency
Ministry of Science and Technology of China	China	Financial	3,900,000	RMB
Chinese Academy of Sciences	China	Financial	1,200,000	RMB
Alliance of International Science Organizations	China	Financial	1,300,000	RMB
Food and Agriculture Organization of the United Nations (FAO)	China	Financial	500,000	USD

## Lessons from the 2020-2022 Period

**Were all planned activities for the 2020-2022 period implemented as expected?**

Yes

**Were there any key challenges faced by the Initiative in the 2020-2022 period?**

No

**Were there any impacts or changes to operations due to COVID-19?**

Yes

### **Please describe.**

Due to the impact of COVID-19, we changed the acquisition method of pest and disease observation data from field experiments to multi-unit joint acquisition during the implementation of CROP PEST MONITORING. In addition, some of the results of CROP PEST MONITORING have been circulated to UN and countries governments, plant protection technology extension departments, commercial companies and farmers through online ways.

**Please describe the key changes proposed for the 2023-2025 period, for example, new projects, new areas of focus, or adjustments to the activity governance.**

(1) Our team is constructed with FAO, GBIF, CABI, PMAS-Arid Agriculture University Rawalpindi, Manchester Metropolitan University, National Research Council of Italy, AIR-CAS, NATESC and NFGA to promotion the application of our outputs with maximizing value. And, we have the support from MOST, CAS, ANSO to provide useful data, funding, application users to ensure the smooth progress of the initiative.

(2) In this initiative, we develop and integrate our new pest and disease monitoring and forecasting function modules into GEO Knowledge Hub, and then to produce comprehensive pest and disease monitoring and forecasting products and provide services for wider end users to better facilitate the achievements of SDGs and DRR objectives.

**Does the Initiative have outputs (products, services, etc.) available to users now, even if only on a pilot or testing basis?**

Yes

**Please provide any available information describing this usage (for example, user statistics, results of user testing) and/or feedback from users (for example, user comments, evaluations).**

Our implementation of CROP PEST MONITORING (2017-2019 and 2020-2022) follows strictly the recommendations of the 'FAIR Guiding Principles for scientific data management and stewardship' on data labeling and organization to manage pest and disease monitoring and forecasting products. We use DOI and other international identifiers to label the data, provide sufficient metadata to describe the product, and establish effective links between related data. In addition, the products are publicly released with supporting reports, papers, monographs, news, etc. These references or citations are posted on the products download page, and the accuracies and confidences of the products are also provided to the users on the same page. Our outputs have been selected into the GEO highlight achievements and GEO Week 2021 Accelerating action. The pest and disease monitoring and forecasting outputs are integrated into the FAO platform (<https://data.apps.fao.org/map/catalog/srv/eng/catalog.search#/metadata/c3916b80-ec82-4576-87ab-63d608e75c1d>) to help Asian and African countries keep track of the occurrence of desert locust. Also these products have been incorporated into the GBIF global database (<https://www.gbif.org/dataset/dfa36691-529b-43b6-9e61-b76275d94ffc>) and CASEarth of AIR (<https://data.casearth.cn/en/contentEditReport/toContentEditReportIndex?>), and have been adopted by UN-SPIDER; have received letters of appreciation and positive feedback from the Agricultural Extension Department (AED) in Eritrea, the Ethiopian Space Science and Technology Institute (ESSTI), and departments in Somalia. Our outputs are incorporated into the information dissemination system of MOST, pest and disease monitoring, forecasting and control business system of the MARA and NFGA, and applied in farmland and grassland in 19 provinces in China, reducing the application of pesticides by 20-30% in key areas. The achievements have also been news promotion by Italy and Japanese media and CBCGDF.

**Please provide supporting documentation if available.**

- annex1\_applications\_and\_users\_feedback.pdf ([link](#))

**Do you have evidence of any impacts that have occurred in part as a result of using the outputs of the Initiative (for example, policy decisions taken, behaviour changes by users, risks mitigated)?**

Yes

**Please provide examples, with evidence where available.**

Our results have been applied in seven countries in Asia and Africa to support the prevention and control of desert locust. The research results were included in FAO work plan, GBIF global database, GEO work plan and highlight results, and it supports decision makers to more scientific policy decisions and end users for efficient management.

**Please provide supporting documentation if available.**

- no supporting documents provided -

**Have there been any internal or external reviews or evaluations of the Initiative since 2019?**

No

**Please indicate any GEO Work Programme activities with which you have ongoing collaboration.**

- AOGEO - Asia-Oceania Group on Earth Observations
- CROP-PEST-MONITORING - Global Crop Pest and Disease Habitat Monitoring and Risk Forecasting

**Please indicate any additional GEO Work Programme activities with which you would like to establish new collaborations.**

- AOGEO - Asia-Oceania Group on Earth Observations
- CROP-PEST-MONITORING - Global Crop Pest and Disease Habitat Monitoring and Risk Forecasting

## **Stakeholder Engagement and Capacity Building**

**Are there specific countries or organizations that your Initiative would like to engage?**

Yes

**Please list these countries, regions or organizations.**

UN Organizations and Countries: FAO, UN-SPIDER, Italy, UK, Pakistan, Ghana, Kenya, Australia, China, and Canada.

Other Organizations: GEO, GBIF, and CABI.

**What are your plans to engage them?**

In this initiative, we implement customized pest and disease monitoring and forecasting products and services intended for multi-level user needs. In Italy, UK, Pakistan, Ghana, Kenya, Australia, China, and Canada, we provide information on the status and trends of major migratory and epidemic-related pests and diseases. This assists the countries in making preventive decisions and improves their pest and disease control capabilities, thus attracting their participation in our initiative. For international organizations such as the GEO, FAO, GBIF, and CABI, we provide reports on global pest and disease trends and conduct time-series dynamic monitoring and forecasting of pests and diseases in areas that are of interest to these organizations. By placing our products on the platforms of international organizations, we can enhance their international impact and attract them to participate in our initiative.

**Does your Initiative engage users in the work of the Initiative (for example, consultation, testing, co-design)?**

Yes

**Please briefly describe the Initiative's approach to engaging users.**

CROP PEST MONITORING (2017-2019 and 2020-2022) has already engaged some users, and some of them are planning to participate in this initiative. This initiative serves multiple levels of users, including international organizations, plant protection departments, commercial companies, and general farmers. As such, we plan to engage different types of users in the following ways.

1. We will research the needs of our users before producing our monitoring and forecasting products, so that the products we provide reflect the information our users care about most. For example, we provide international organizations with information on the intercontinental migration and spread of major migratory and epidemic-related pests and diseases; we provide national plant protection departments with information regarding the occurrence of pests and diseases on a national scale; commercial companies are provided with information regarding damage assessment; and farmers are provided with specific pesticide application programmes and thematic maps.

2. We will test the products and use a reasonable sampling method to identify users who participate in the test. We provide users with products such as thematic maps of variable pesticide spraying, damage assessment reports, and roadmaps for drone spraying of pesticides. This helps acquaint users with the development of pesticide-spraying drones and helps in the prevention and control of pests and diseases. The outputs also help optimize the amounts of pesticides used, the spatial extent of the thematic maps, and the

equipment carried by the drones based on feedback from users.

3. After the product is tested and published, we will establish a regular user feedback mechanism to adjust the content and focus of the product according to the needs of users. This will ensure that the product can really play a role in the prevention and control of pests and diseases.

**Does the Initiative have a user engagement strategy or similar kind of document?**

No

**Are there categories of users that are not represented at this time, but you would like to engage?**

No

**Does the Initiative have a documented capacity development strategy?**

No

**Please describe the approach to capacity development that is being implemented by the Initiative?**

(1) enhances the development capacity of functional modules and improves product quality through cooperation with GEO members and participating international organizations;

(2) improves the quality of products and services and enhances their capacity based on user feedback;

**Are there any commercial sector organizations participating in this Initiative?**

No

**Are there opportunities for commercial sector uptake of the outputs of the Initiative?**

Yes

**Please describe these opportunities.**

This initiative will produce customized pest and disease monitoring and forecasting products and services to help companies (e.g., UAV, pesticide, insurance companies), farmers, etc. decide if it is necessary and suitable to apply chemical fungicides/biological fungicides/ecological technologies to vegetation.

**Is there already commercial uptake occurring?**

No

**Are there opportunities for further commercial sector participation in the Initiative?**

Yes

**Please describe these opportunities.**

This initiative produces pest and disease monitoring and forecasting products can effectively guide farmland operations, have great commercial value, and have the opportunities to further engage the commercial sector participation.

**Does the Initiative have a plan for commercial sector engagement?**

No

## **Governance**

**Please describe the roles of each of the key leadership positions, as well as any team**

## **structures involved in day-to-day management.**

This initiative is supported by some countries, international organizations and professional institutions. The participating organizations and institutions in CROP PEST MONITORING (2017-2019 and 2020-2022) will also be involved in this initiative. Some new international organizations, institutions and government departments will also be involved in the implementation of this initiative, such as FAO, GBIF, CNR-IMAA, PMAS, ANSO, NRSCC and NFGA. These organizations and institutions will contribute their strengths and resources to ensure the successful implementation of this initiative.

The participants of this initiative are divided into leadership, contributing organizations and participating organizations. The initiative will also share results and collaborate with existing GEO Work Programme and GEO Members, as illustrated as follow.

(1) Leadership. The leadership of this initiative is Department of International Cooperation of MOST. On the one hand, the Department of International Cooperation will guide the initiative to complete the overall design of the project, including the organization of the initiative's staff, the way of collaboration among the participating institution and the way of promoting the results, etc. On the other hand, it will guide the initiative in the promotion and sharing of the results among GEO members, work programs and international public platforms.

(2) Contributing Organizations. The contributing organizations of this initiative are FAO, ANSO, NRSCC and CAS. FAO is an important source of in situ data for global vegetation pests and diseases, and an important extension channel for the results in large farms and farmers. ANSO has a significant impact on countries and regions along the Belt and Road, and is the implementing agency for the localization of pest and disease monitoring and forecasting systems in these regions, as well as an important channel for the application of the initiative's results in these countries. NRSCC can help promote the application of initiative's results in the Chinese government and technicians. CAS is mainly responsible for providing knowledge on the occurrence mechanism and control of crop pests and diseases.

(3) Participating Organizations. The participating organizations of this initiative are GBIF, CABI, MMU, CNR-IMAA, PMAS, AIR-CAS, NATESC and NFGA. GBIF provides biodiversity assessment models and biological interaction model, as well as knowledge of ecological control of pests and diseases. CABI provide in situ data of global vegetation pests and diseases, and provide biological mechanisms for the occurrence and development of pests and diseases. MMU provides cutting-edge machine learning algorithm models for this initiative to support the construction of pest and disease monitoring and forecasting models. CNR-IMAA provides remote sensing inversion models of vegetation parameters for the initiative and contributes to the application of the results in Italy. PMAS mainly provides agro-meteorological models and develops remote sensing monitoring and forecasting systems for vegetation pests and diseases using GIS technology, and is an important channel for the application of the results of this initiative in the construction of the China-Pakistan Economic Corridor and agricultural production in Pakistan. AIR-CAS has many years of experience in remote sensing data analysis and model construction for pest and disease monitoring and forecasting, and is the implementation agency for model development and product production for this initiative. NATESC has extensive experience in crop pest and disease control and has over 1000 crop pest and disease observation sites in China, so it can provide ground survey data and crop pest and disease control strategies for this initiative. NFGA is the main pest and disease control department for forestry and grass in China, providing ground survey data and control strategies for forestry and grass pests and diseases for this initiative.

(4) Linkages across GEO Work Programme. These linkages, facilitated by GEO-PDRS, will support the implementation and sustainability of the AOGEO, including mission, goals, objectives, and activities.

(5) Linkages across GEO Members. These linkages, facilitated by GEO-PDRS, will advance GEO members (Italy, UK, Pakistan, Ghana, Kenya, Australia, Canada, China, etc.) on priority areas and cross-cutting matters.

(6) Working Groups. The working groups mainly include three major parts: modification and integration of pest and disease monitoring and forecasting functional modules; development of spatial information products on pest and disease; providing pest and disease information services to multi-level users. The working groups hold regular meetings to discuss current research progress, coordinate to solve existing problems, and deploy next steps.

## **Is there a steering committee or other governance bodies that advise the Initiative but are not involved in day-to-day management?**

Yes

**Please describe the roles of each body. If there are multiple governance bodies, please describe the relationships among them (such as through a governance structure diagram).**

The steering committee of this initiative includes MOST and AOGEO. MOST is responsible for coordinating and arranging resources related to initiative implementation. AOGEO ensures that all activities of the initiative are reasonable and comply with GEO regulations. The MOST and AOGEO act as the steering committee of the initiative to guide initiative setting and operation, ensuring the effective link between the initiative and the application.

- [annex2\\_supporting\\_organizations\\_and\\_projects.pdf](#) ([link](#))
- [team\\_structure.pdf](#) ([link](#))

**What methods does the Initiative use to communicate with its participants?**

- Email / e-newsletters
- Regular conference calls
- Website
- Regular events

**Please describe the key risks that could delay or obstruct the completion of the planned activities and outputs of the Initiative, along with any actions taken to mitigate these risks.**

Description of the hazard	Description of the possible impacts	Scale of impact	Likelihood of occurrence	Mitigation measures
<p>There may be disturbing factors in the integration and joint development of pest and disease monitoring and forecasting methods and models by the initiative institutions, such as inadequate standards and specifications, non-uniform data formats and uncontrollable development languages and systems; in addition, there may be network limitations in the sharing of data models between the Chinese and foreign sides.</p>	<p>May affect the data/products sharing</p>	<p>Limited</p>	<p>Possible</p>	<p>The implementation of the initiative is based on the long-term technical reserve of each institution, and the key technical issues involved have a good foundation, and there will be regular meetings for communication, so that the technology can be synchronized and updated to ensure the technical advancement of the initiative implementation process. In addition, the initiative will choose a stable and reliable cloud service platform for data model sharing to ensure that the data and methods and models are synchronized and updated between the Chinese and foreign partners.</p>
<p>Different countries have different policies and attitudes towards the local operation and application of initiative outputs.</p>	<p>May affect the initiative application.</p>	<p>Limited</p>	<p>Possible</p>	<p>The initiative organizers and foreign participants have rich experience in the application of pest and disease application technology, and have global branches and research centers for the application of outputs, which can guarantee the localized operation and application of initiative results in many countries.</p>

**What methods are used by the Initiative to monitor its effectiveness?**



- Informal discussions with users / beneficiaries
- User or beneficiary surveys
- Website statistics
- Consultations or events
- Evaluations

**Would the Initiative be interested in assistance from the GEO Secretariat for developing an impact plan?**

Yes

**How are the results of the monitoring and evaluation activities shared with participants and the wider GEO community?**

- (1) We will integrate methods and models into the GEO Knowledge Hub, and circulate the products and services in GEO summits, workshops, weeks, etc. to improve the impact of results in GEO community.
- (2) We will expand the variety and number of users by sharing our products on international platforms FAO, GBIF, CABI, etc.
- (3) We will cooperate with GEO Work Programme Activities such as AOGEO, and conduct product development, technology sharing and integrated management to contribute to the sustainable development of agricultural and ecological systems.
- (4) We will provide products to countries, plant protection technology extension departments, commercial companies and farmers through our websites and GEOSS, app and emails to ensure the maximum use of our services.

**Are any monitoring or evaluation activities required by funders/contributors?**

Yes

**Please describe and provide reports if available.**

The funders/contributors of this initiative include GEO, MOST, CAS and ANSO. We need to provide regular reports to GEO to ensure that we are applying GEOSS data in a reasonable and compliant manner. Also, we need to regularly provide project progress reports to the MOST, CAS and ANSO to ensure the smooth progress of the initiative.

- no supporting documents provided -

## **Participants**

**Please list the active individual participants in the Initiative**

First name	Last name	Email address	Member	Org
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## Other information

**Please provide any other comments or information that was not included in the previous sections, but you would like to appear in the Implementation Plan.**

2017-2019 and 2020-2022 GEO community activities CROP PEST MONITORING have gotten fruitful results. Our products have been adopted by many institutions and organizations such as FAO, GBIF, CABI, CNR-IMAA, PMAS, NFGA, etc., and we have carried out international cooperation with GEO members such as UK, Pakistan, Italy, etc. We have got support letters and project assignments from the above countries and organizations in the attachments, which can prove that we have good results and influences in remote sensing monitoring and forecasting of vegetation pest and disease. We believe that through the implementation of this initiative GEO-PDRS, we can boost global cooperation on pest and disease prevention to help ensure global food security and conservation of biodiversity, ultimately serving objectives of SDGs and DRR.

- geo\_pdrs.pdf ([link](#))
- response\_to\_reviewer\_s\_comments.pdf ([link](#))

## Co-Editor Management

### List of co-editors for this initiative

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