

Section 5. Terms of Reference (TOR)

Joint Team of AI private company (Developer of Solution) and AI Academic researcher in the field of Artificial Intelligence for the implementation of an AI Proof-of-Concept

1. Background

Artificial Intelligence (AI) plays a crucial role in fostering comprehensive social and economic development across various sectors. By harnessing the potential of AI technology, we can effectively achieve the objectives of sustainable development and adapt to the challenges of the fourth industrial revolution. Embracing AI enables us to stay abreast of rapid technological advancements and leverage the abundant opportunities it offers to boost economic growth and enhance the performance of governmental entities. AI also creates new job opportunities, contributing to the labor market and fosters an environment conducive to innovation and entrepreneurship. Moreover, AI implementation enhances the efficiency, quality, and accessibility of public services while reducing associated costs. These ensure that all segments of society can benefit from improved services and experiences.

The Ministry of Digital Economy and Entrepreneurship (MoDEE) of Jordan has developed and published “AI Strategy and Implementation Plan (2023-2027)” (hereinafter referred to as “the AI Strategy”) with the vision of making Jordan a regional leader in the field of AI and providing a unique and attractive technological and entrepreneurial environment for AI to be effective, supportive and an essential component of the national economy.

Under these circumstances, Japan International Cooperation Agency (JICA) has started an international cooperation project with MoDEE titled “The Project for Promoting Artificial Intelligence Ecosystem in the Hashemite Kingdom of Jordan”. JICA is dispatching a consultant team to provide technical advice and assistance with the project implementation. The project purpose is to operationalize a **Public-Private-Academia platform** for promoting use of emerging technologies (especially AI) in Jordan. To achieve the project purpose, two major activities are being implemented. One is to establish and improve the capacity of the said platform. Another is to implement PoC (Proof of Concept) programs to promote AI use in real society by means of **Public-Private-Academia consortium**.

The National AI Steering Committee has been established for supervising the implementation of the AI Strategy and Implementation Plan (2023-2027) and takes role to discuss and monitor its progress with selected high-level members from the government (MoDEE), academia, and industry. The JICA project is working closely with the Committee, and the PoC program described in this ToR is selected based on the discussions of the Committee. A Project Secretariat has also been established to help implementation of the project including the PoC program.

This ToR document outlines the requirements for a Joint Team of private IT company and academic AI researcher to implement a PoC program.

2. Description of the future PoC program

2.1 Title of the target PoC program

Determining soil fertility for agriculture with water saving using satellite imagery and AI

2.2 Background and overview of the target PoC program

The agricultural sector in Jordan faces significant challenges related to soil fertility and water scarcity. The use of advanced technologies such as satellite imagery and artificial intelligence (AI) can provide a comprehensive and scalable solution for assessing soil properties, enabling efficient water usage and informed agricultural practices. This PoC aims to develop and test an AI model capable of predicting essential soil properties required for agriculture including soil moisture using satellite imagery correlated with ground-truth data. This PoC also aims to develop another AI model (or the addition to the same AI model as above) capable of predicting appropriate water irrigation timings of agricultural land using satellite imagery by learning past water irrigation routine data of farmers.

2.3 Objectives of the target PoC program

- To train an AI model by using pairs of following data to find a correlation between satellite imagery data and soil properties (including soil moisture).
 - Soil property data (either measured in the past survey or newly measured during the PoC) at several locations in Jordan.
 - Satellite images of the same location as the soil property data taken in the same date as soil property measurement.
- Target soil properties are at least, but not limited to, the followings.
 - NPK (Nitrogen, Phosphorus, Potassium)
 - pH
 - Electrical Conductivity (EC)
 - Soil moisture
- Target sites to conduct the PoC are: the Jordan Valley and Upland areas. The exact location of the PoC sites will be determined by discussion with stakeholders.
- To train another AI model (or simple machine learning method) by using the past dates that farmers performed water irrigations and the same satellite imagery so that the AI model would be able to predict appropriate water irrigation timing of farmland from the satellite imagery. The AI model might also be merged into the AI model for soil property prediction if the applicant of this PoC considers appropriate.

The figure below illustrates the overview of AI model to develop in this PoC program.

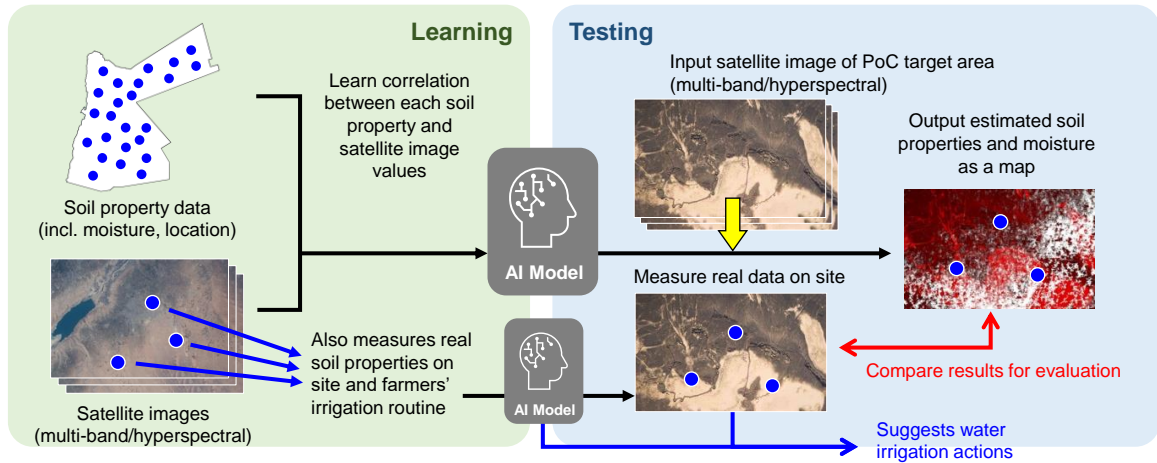


Figure 1: Overview of the AI model to develop in this PoC program

2.4 Scope of Work

Overall scope of work is illustrated in the figure below.

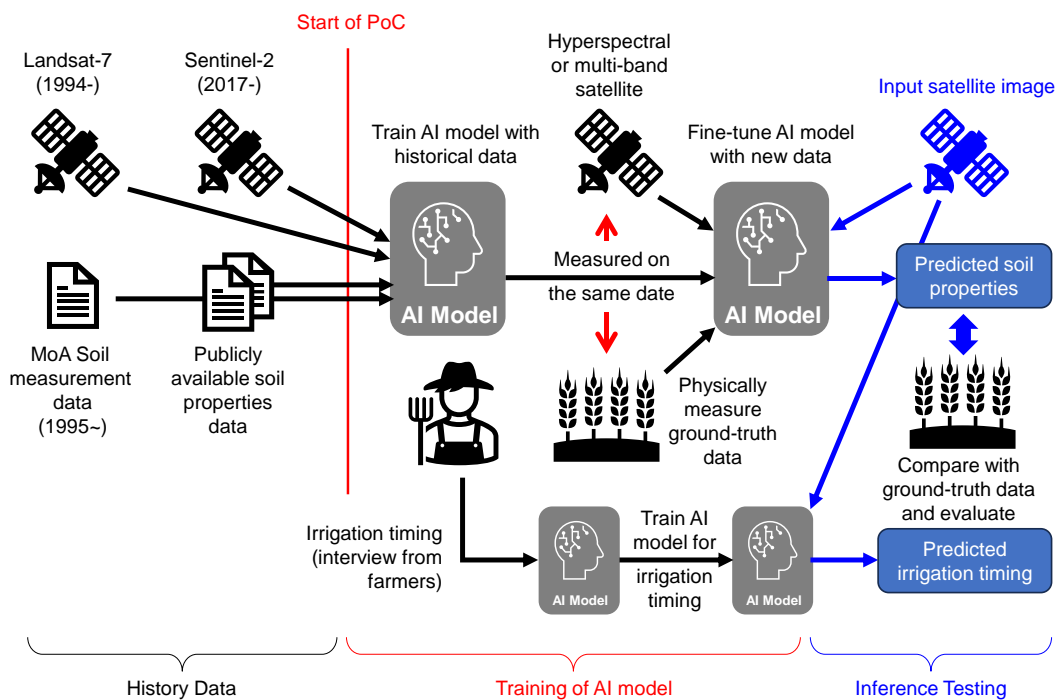


Figure 2: Overview of Scope of Work of PoC program

(1) Determine the satellite to use in this PoC

The applicant should propose which satellite imagery to use in this PoC and should include the cost of purchasing the satellite images in the financial proposal. There are several technical considerations required for the selection of satellite as follows.

- Each satellite normally employs different types of sensors and there are virtually no identical satellites that are fully compatible in terms of sensors (except for satellites in the same series of

deployment). Therefore, the satellite to be used in this PoC must be carefully chosen.

- Satellite imagery has “revisit time” so that a satellite typically flies over the same location on the earth only once in several days (typically 5~7 days). This means that ground-truth soil properties data must be measured at the same time (same day) as the satellite visits the same location. It is therefore required to plan the date(s) that the chosen satellite will visit the target pilot site (to take the image) and perform ground-truth soil properties measurement on the same date(s).
- The minimum requirements of the satellite imagery for this PoC are as follows.
 - More than 10 multi-band or hyperspectral ranging from
 - Spatial resolution: 50 m or less
 - Revisit time (the period of visiting the same location): 1 week or less
- Ideally, a satellite with hyperspectral sensor is the best option for this PoC. In order to correctly predict soil properties from the image, it is considered that large number of different narrow-spectrum images are required. The more the number of narrow bands in a specific image area, the better the expected accuracy (see this¹ and this²). However, hyperspectral satellites are rather new and there are not so many choices available. The cost of hyperspectral satellite images is significantly higher than multi-band satellite images. Since this is a PoC with very limited and fixed budget, we cannot use too costly satellite images.
- Though the spectrum resolution is not as high as hyperspectral images, multi-spectral images with more than 10 bands can also be used in this PoC. For example, there are many agricultural satellite imagery services in the world using ESA (European Space Agency)’s Sentinel-2³ satellite imagery because of the following benefits.
 - Total of 12 bands sensors ranging from 442~2202 nm (central wavelength)
 - Spatial resolution of 10~60 m depending on the band
 - Two identical satellites are continuously taking images so that the revisit time of a location is 5 days or less.
 - Data is open to the public through “Registry of Open Data on AWS”⁴.
- There are other satellites that could be used in this PoC such as those listed in Table 2 of attached document “Academic Research in the Field of Remote Sensing in Agriculture and AI”.

(2) Preparation of available historical ground truth data and its matching satellite images

- Compile a comprehensive dataset of soil properties, including NPK (Nitrogen, Phosphorus, Potassium), pH, Electrical Conductivity (EC) and soil moisture with location data.
- MoA has historical data of soil fertility parameters (NPK, pH, EC) across 35,000 locations

¹ https://en.wikipedia.org/wiki/Hyperspectral_imaging

² <https://www.eoportal.org/other-space-activities/hyperspectral-imaging>

³ <https://en.wikipedia.org/wiki/Sentinel-2>

⁴ <https://registry.opendata.aws/sentinel-2/>

throughout Jordan measured in 1995. However, there is very few choice for corresponding satellite images of the same measurement date for this data (such as Landsat 7 as shown in Figure 2). MoA might have other soil properties measurement data. These historical data can be used for training of the AI model with fewer number of bands.

- There are several potential datasets for training AI model available on the internet as follows. However, the first two datasets are not directly downloadable and communication with the dataset owners is necessary.
 - AI for Earth Observation: Seeing Beyond the Visible⁵
 - DKRZ: Dataset Details⁶
 - Hyperspectral benchmark dataset on soil moisture⁷
 - Database of hyperspectral images of phosphorus in soil⁸
- Collect information on the dates of irrigation from the farmers at PoC site. The applicant should periodically ask farmers when they did irrigation via phone (chat), email, etc. Note that before interviewing farmers, the applicant should provide briefing session for farmers to understand the purpose and benefit of this PoC.

(3) Obtain new ground truth data of soil property and satellite images

- In this PoC, the applicant should physically collect soil samples to measure soil properties at the target PoC sites. The collected samples should be sent to Lab for measuring soil properties. Available soil properties measurement labs are listed in the attached document.
- Plan a date that the chosen satellite will take an image and perform ground-truth measurement of the PoC site by using the purchased sensor. Measure multiple locations within the same satellite image boundary to collect as many physical data as possible.
- Purchase (or download) satellite images of the corresponding PoC locations of the same date as ground-truth measurement.
- (Optional) If the sensor has IoT connectivity, deploy the sensor at selected locations to measure the soil properties continuously (at least for the PoC testing period ~ 3 months). This is possible only if the physical security of the sensor is ensured so that the sensor would not be stolen.

(4) Train AI model

- Train an AI model by using historical ground-truth data first. Since the spectral / spatial resolution of historical satellite images are less than the hyperspectral satellite, interpolation techniques and / or adjustment of image data may be required to produce consistent output. For better output, the center frequency of each band of satellite imagery should be treated as a

⁵ <https://platform.ai4eo.eu/seeing-beyond-the-visible/data>

⁶ <https://b2find.dkrz.de/dataset/89fb17b7-dd23-543c-8c4a-8dbbdb9dd99c>

⁷ <https://zenodo.org/records/1227837>

⁸ <https://data.mendeley.com/datasets/fvgswwt5ws/3>

parameter for the training.

- Fine tune the same AI model by using the new ground-collected soil property data matched with the new multi-band / hyperspectral satellite imagery.
- Train another AI model that inputs satellite image and farmers' manual irrigation operation dates to learn correlation between satellite image and the farmers' irrigation timings.

(5) AI Model Testing and Validation:

- Plan a date to test the trained AI model when the satellite image is available.
- Collect ground-truth soil properties data at the same or different locations as in (3).
- Purchase or download satellite images of the corresponding PoC locations of the same date as the above ground-truth measurement.
- Deploy and test the trained AI model using the newly acquired satellite image.
- Validate and evaluate the model's performance by comparing the predicted soil properties by AI model with the newly measured ground-truth data from these sites.

(6) Evaluation and Report writing

- Evaluate the results with beneficiary organization (MoA)
- Write a comprehensive final report on the PoC (See later for detail).

2.5 Key Performance Indicators (KPI)

- Since the capability to correctly determine all soil properties from the satellite imagery will heavily depend on the type of satellite to use and also on the available ground-truth data, we will not set target value of KPI at this point.
- However, the correlation between satellite image and soil properties is expected to be high. The target value and KPI will be determined through discussion among stakeholders and applicant.

3. Implementation body of the PoC program (Important)

This PoC program shall be implemented by a Public-Private-Academia consortium consisting of members from the target government organization (beneficiary of the PoC, and provider of data to be used in the AI system), private IT company (developer of the PoC solution), and academic researcher in the field of smart agriculture (the technical advisor in the field of the agriculture with digital technology and / or Satellite imagery). The reason for formulating the three-parties consortium is to demonstrate the importance of collaboration among government, industry and academia for accelerating the development of local AI industry which contributes to solving socio-economic problems in Jordan. the focus of JICA project is to try to develop and enhance the capacity of local AI industry and academia instead of relying on foreign companies so that it would also contribute to generating local employment in the field of advanced technologies like AI. There is another reason to employ three-parties collaboration in this PoC that such collaboration has been proved to be very successful in Japan.

In this PoC program, the target government organization is Ministry of Agriculture (MoA). A representative person will be appointed from MoA for this PoC and this person will be a member of the PoC consortium. Private IT company and Academic researcher will be selected by a tender process as a joint team based on this ToR. This means that the applying party must not be an IT company alone or researcher alone, but must be a joint team of both. All tender processes will be implemented by the Project Secretariat together with JICA consultant team.

The expected roles of the three parties are summarized in the table below.

Table 1: Expected roles of PoC consortium members

Roles	Government Organization	Private IT company	Academic researcher
Basic role	Beneficiary of solution, Provider of data	Developer of AI solution	Technical advisor on agricultural method / satellite imagery to apply in PoC
Reporting	<ul style="list-style-type: none"> Communicate with both private IT company and academic AI researcher 	<ul style="list-style-type: none"> Communicate with both government organization and academic AI researcher. 	<ul style="list-style-type: none"> Communicate with both government organization and private IT company
		<ul style="list-style-type: none"> Must have a unified contact point for reporting to and communicating with stakeholders (see chapter 4 below) 	
Designing	<ul style="list-style-type: none"> Provide input as the initiator of problem to be solved. Assess availability of data to be used in the solution. Provide sample data for designing the solution. 	<ul style="list-style-type: none"> Collaborate as a team to do the followings. Interview government organization for requirements Design prototype PoC solution based on the result of interview as well as information on available data Validate the system design and its required data 	
Implementation	<ul style="list-style-type: none"> Provide full data that is necessary to build / train AI model. 	<ul style="list-style-type: none"> Collaborate as a team to do the followings. Develop a prototype working solution for the PoC 	
Testing	<ul style="list-style-type: none"> Evaluate the result of testing and provide advice from the standpoint of data owner 	<ul style="list-style-type: none"> Perform testing of the PoC solution and solve issues found in the testing 	<ul style="list-style-type: none"> Verify and validate the test result and provide technical advice on the improvement of AI model from the standpoint of domain expert
Evaluation	<ul style="list-style-type: none"> Evaluate the performance by comparing the result with human 	<ul style="list-style-type: none"> Evaluate the result from the standpoint of implementation methods 	<ul style="list-style-type: none"> Evaluate the result from the standpoint of performance of applied technologies

4. Unified Contact Point of the Joint Team (Focal point)

The Joint Team must have a single, unified point of contact (focal point) to reporting to and communicate with stakeholders (MoDEE, AI Steering Committee, JICA consultant team, target

government organization) which represents both private IT company and academic AI researcher. Any coordination among the consortium members must be done internally within the consortium, and each member must not communicate independently or directly with the stakeholders. Stakeholders will not provide any coordination within the consortium, but it would be possible for the unified point of contact (focal point) to consult such matters with stakeholders.

5. PoC Coordinator and AI Engineer / Data scientist for data preparation

The required data for this PoC (such as historical data of soil properties from Ministry of Agriculture, statistical data from DOS, etc.) must be obtained from the owner of the data (Ministry of Agriculture, DOS, etc.) through official procedures of the government. The Joint team (private company) must assign the following two persons to work closely with MoDEE to prepare and proceed with the official procedures to request and obtain required data.

- PoC Coordinator (to perform any required official procedures to obtain data by closely working with MoDEE)
- An AI engineer or a Data scientist to provide technical input (such as preferred data format, data conversion, etc.) to the PoC Coordinator in the process of requesting data.

6. Requirements for private IT company

- a. Must be a Jordanian company registered with the CCD with relevant licensing segmentation to provide technology services. A valid licensing permit must be present.
- b. If the applicant is a consortium of Jordanian companies, all must be registered with the CCD and have a valid licensing permit. Should the consortium include foreign companies, they should not be consortium leaders nor can they render more than 20% of work required.
- c. Must have a major IT development / data cleansing team in Jordan that consists of 80% or more team members who are Jordanian nationals or permanent residents in Jordan.
- d. Experience in development of systems that employ machine learning technologies and other AI-related technologies.
- e. Minimum one (1) year in system development or AI research business.
- f. Must be able to work with stakeholders from public sectors and academia.
- g. Must be able to form and work as a qualified team of IT engineers and academic researcher(s).
- h. Must perform roles described in Table 1 at the column of “Private IT company”.
- i. Must have audited financial statement for the last two (2) years.
- j. Must commit to the ethics of artificial intelligence (Jordan AI code of Ethics)

7. Requirements for academic researcher

- a. Must be a researcher or a professor at a university or a research institute in Jordan in the field of

AI.

- b. Minimum five (5) years' experience as a researcher with three (3) years in the field of academic research of related technology.
- c. Experiences in research of applying AI to agriculture is a plus.
- d. Must be able to work with stakeholders from public sectors and IT industry.
- e. Must be able to form and work as a qualified team with IT engineers of private company.
- f. Must perform roles described in Table 1 at the column of "Academic researcher".
- g. Must commit to the ethics of artificial intelligence (Jordan AI code of Ethics)

8. Tasks of the joint team

The Joint Team should perform following tasks:

- a. Review on MoDEE's AI Strategy and Implementation Plan (2023-2027) and the Work Plan of JICA project (provided separately) to gain understanding of the background of the PoC program.
- b. Hold a kick-off meeting of the PoC consortium consisting of the Joint Team and representatives from target government organization (beneficiary of the PoC program) to discuss and confirm the content and schedule of the development of PoC solution.
- c. Participate in meetings related to the implementation of the PoC program with sub-committee of the AI Steering Committee as well as JICA project team members.
- d. Perform tasks of three data preprocessing / cleansing use cases described in 2.
- e. Report the progress of PoC program to AI Steering Committee on regular basis (bi-weekly).
- f. Submit all deliverables specified in 9.
- g. At the end of the work, write a fully comprehensive completion report and submit the report to the AI Steering Committee.

9. Deliverables

The Joint Team should submit the following deliverables:

- a. The trained AI model that can be used by the beneficially organization (MoA).
- b. Bi-weekly progress reports.
- c. Fully comprehensive completion report that includes the following.
 - ① Methodologies, technologies, satellites, and data used in the PoC with clear description of how they are chosen among possible candidates.
 - ② Detailed result on the performance of developed AI model (with KPI)
 - ③ Lessons learned and recommendations for areas to improve for possible full-scoped project in future.

All deliverables must be reviewed and approved by the beneficially organization (MoA) before submitting to JICA, so that the applicant shall allocate enough time to prepare for the deliverables by taking required time for the review by MoA into account.

10. Duration and Timeline

The duration of this PoC program is six (6) months from the beginning of assignment at maximum. Total duration shall not exceed six months. The expected timeline of PoC program is shown in the table below. The applicant could propose different timelines but shall provide clear explanation of the reason.

Table 2: Expected timeline of the PoC program

Activity	Month					
	1	2	3	4	5	6
1. Kick-off meeting and discussion on the methodologies and technologies to be used in the PoC	■					
2. Collection of available historical data for AI model training	■					
3. Training AI model with historical data and satellite images		■				
4. Training another AI model for irrigation timing		■				
5. Perform new ground-truth measurement of soil properties		■				
6. Fine-tune the AI model by ground-truth measurement data and corresponding satellite images			■			
7. Plan and implement ground-truth measurement for evaluation of trained AI model				■		
8. Evaluate the performance of trained AI model by comparing newly acquired satellite image and ground-truth data					■	
9. Make and submit deliverables						■

Note: When the applicant makes quotation, the cost of remuneration for required human resources must be appropriately calculated by clearly and accurately estimate their efforts.

The expected amount of main personnel assignment and its schedule (for the entire PoC combining all three use cases) is shown in the table below. The applicant can propose a different assignment schedule, but with clear reasoning.

