EO AFRICA Water Management

D11
Policy Highlights

Document Id.:	P22S1956-57-v0	15/01/2023
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Client Reference:	ESA Contract No 4000139810/22/I-DT	

Document History

List of reviews			
Version	**Authors**	**Date**	**Note**
1.0	CIHEAMB and Planetek Hellas	15/01/2025	

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1. Summary

This document, titled “Policy Highlights” corresponds to deliverable D11 under ESA Contract No. 4000139810/22/I-DT and Project Proposal P22S1956-02-v0.

The primary aim is to evaluate the potential for adopting and integrating remote sensing applications, with a particular focus on agricultural water management, across various user categories. These categories include governmental organizations, private sector companies, research institutions, and PhD researchers affiliated with the UN/E-University Network.

This assessment seeks to identify how remote sensing technologies can be leveraged to enhance water management practices, addressing the specific needs and capacities of each user group to facilitate broader adoption and impact. The focus was on understanding the existing practices, specific needs and challenges related to remote sensing technologies within the Egyptian context. This understanding was essential to derive precise requirements and expectations from potential users, which were then carefully integrated into the Earth Observation (EO) solution, referred to as the Final Product, in alignment with relevant policy frameworks.

To accurately identify user needs, a multi-step approach was employed, involving e-surveys, interviews, and direct communication with potential end-users. These interactions were key to gathering insights into user expectations and feeding them back into the development cycle to ensure the solution was both relevant and user-friendly. In developing the final product, a strong emphasis was placed on prioritizing requirements, ensuring that the most critical needs were addressed first.

The Final Product is an EO observation platform capable of estimating the actual water consumed by the monitored crops, known as actual Evapotranspiration. This output is based on Hyperspectral data imagery and thermal imagery acquired from PRISMA and ECOSTRESS missions, respectively.

The survey revealed that remote sensing applications hold significant potential for improving agricultural water management in the Egyptian context. However, key challenges must be addressed to ensure successful adoption. By focusing on **accessibility, affordability**, and **user-centered design**, the development of a crop evapotranspiration mapping tool can meet the diverse needs of governmental bodies, private enterprises, researchers, and academic institutions, driving innovation and efficiency in the agricultural sector.

1.1. Applicable documents

- “EO Africa Water Management” proposal “P22S1956-02-v0”
- “EO Africa Water Management” Negotiation Points P22S1956-03-v0.1
- “EO Africa Water Management” Minutes of the Preparatory Meeting P22S1956-06-v0
- Contract with ESA 4000139810/22/I-DT
- P22S1956-15-v1.1_D15_EO_AFRICA_EXPLORERS_PMP: Project Management Plan

1.2. Acronyms

AARSE	African Association of Remote Sensing of the Environment
AI	Artificial Intelligence
EO	Earth Observation
RS	Remote Sensing
ETa	Actual Evapotranspiration
GERD	The Grand Ethiopian Renaissance Dam
APIs	Application Programable interface
PS	Private Sector
GO	Governmental Organization
RC	Research center
RS	Remote Sensing
ROI	Return on Investment

2. Contextual background

Water scarcity is a growing crisis that threatens to destabilize vital systems. By 2030, the demand for freshwater is projected to exceed supply by 40%, driven by population growth, climate change, and unsustainable water practices (du Plessis, 2023).

Approximately one-fifth of the world's population lives in water-stressed areas, and this trend is likely to worsen if the current trends, threats, and pressures, are not fully understood and appropriately managed (Bhaga et al., 2021).

Globally, 70% of the fresh water consumption is directed to irrigated agriculture (Wu et al., 2022). Water scarcity is the main limiting factor for agricultural expansion, especially in arid and semi-arid regions where crop water consumption exceeds precipitation. In such regions, the water crisis could have severe impacts beyond agricultural production and food security, potentially leading to social and political instability.

2.1. Water management policies and the role of data

Unsustainable water resources management policies not only threaten food security but also impacts social stability and could lead to geopolitical tensions over shared transboundary water resources (Gleick, 2014).

To overcome such challenges, good governance and effective, efficient policies are required. Information is crucial to assess the need and urgency to develop a policies, mobilize instruments for implementation, control and enforce proper execution, and monitor and evaluate impacts (De Leeuw et al., 2010). Thus, data channels, and reliable information are essential for an efficient policy cycle. However, access to these data sources is often problematic, as data are frequently stored in locations obscured from those who need to be informed. The available data, particularly through the internet, are usually sectoral, and there are significant difficulties when attempting to combine two or more datasets (Awad et al., 2009). Data availability and reliability challenges become critically important when discussing water resources management. As a scarce and precious resource, poor policy design and implementation resulting from data scarcity and/or scatteredness could lead to social instability and even international conflicts.

2.2. Water management policy challenges (Egypt as a case study)

Egypt faces significant challenges in water resources management due to its reliance on the Nile River, which provides over 95% of the country's freshwater supply. With a growing population of over 100 million people, the per capita water availability has dropped below the water poverty threshold of 1,000 cubic meters per year, exacerbating concerns over water scarcity (El-Rawy et al., 2019). Additionally, Egypt's agricultural sector, which consumes around 85% of the available freshwater, is heavily dependent on the Nile, leading to conflicts over allocation between sectors such as industry, agriculture, and domestic use (Mohie El Din and Moussa, 2016, Negm, 2019, Elkholy, 2021). The country's water management policies have long focused on large-scale infrastructure projects However, growing water demand, coupled with increased evapotranspiration due to rising temperatures and inefficient irrigation methods, is putting additional stress on Egypt's water resources (Luo et al., 2020).

The Grand Ethiopian Renaissance Dam (GERD), under construction on the Blue Nile in Ethiopia, has intensified the urgency for improved water management policies in Egypt, as it threatens to reduce the flow of the Nile, Egypt's primary water source (Wheeler et al., 2020, Aty, 2022). The Egyptian government has responded by implementing policies aimed at optimizing water use efficiency, including modernizing irrigation systems, expanding wastewater treatment and reuse, and promoting the cultivation of less water-intensive crops (Omran and Negm, 2020, Allam and Allam, 2007). However, many of these initiatives face hurdles such as inadequate funding, institutional inefficiencies, and the need for stronger regulatory frameworks to enforce water conservation policies (El-Sadek, 2010). As water scarcity becomes a more pressing issue, Egypt's ability to implement adaptive and sustainable water management policies will be crucial in maintaining water security and ensuring long-term socio-economic stability.

Another critical challenge stems from policy and governance inefficiencies. Egypt’s irrigation management policies have traditionally been centralized, with limited participation from local farmers in decision-making processes (Abdelkader & El-Sayed, 2020). This top-down approach often fails to account for the specific needs and conditions of different regions, resulting in mismatches between policy design and on-the-ground realities. Moreover, there is insufficient enforcement of existing regulations aimed at reducing water consumption, with many farmers continuing to grow water-intensive crops despite efforts to promote crop rotation and water-saving practices (El Nazer & Ibrahim, 2017). Climate change adds further complexity to irrigation management, with rising temperatures increasing water demand for crops while reducing overall water availability. Adapting irrigation management policies to these evolving challenges requires decentralizing decision-making, improving farmer education on sustainable practices, and investing in infrastructure upgrades to ensure more efficient water use in the agricultural sector.

2.3. Remote sensing as an integrated tool for enhanced water policy monitoring and evaluation

Remote sensing offers a powerful tool for enhancing the monitoring and evaluation of water management policies by providing timely and accurate data on various water-related parameters. One of the primary contributions of remote sensing is its ability to monitor surface water bodies, such as rivers, lakes, and reservoirs, over large areas and at regular intervals. Satellite-based sensors, such as Landsat, Sentinel, and MODIS, can capture high-resolution imagery that allows for the tracking of water levels, surface area changes, and sediment loads in real-time(Ouma and Tateishi, 2014). This information is crucial for evaluating the effectiveness of water management policies, particularly in regions experiencing rapid environmental changes due to climate variability or human interventions. For instance, remote sensing data can help assess the impact of irrigation policies on river basins and detect illegal water withdrawals, providing policymakers with the evidence needed to adjust strategies in response to emerging water-related challenges (Feng et al., 2018).

Remote sensing also plays a key role in monitoring agricultural water use, which is essential in evaluating the effectiveness of irrigation management policies. Remote sensing technologies such as thermal infrared imaging and multispectral sensors enable the assessment of crop water stress and evapotranspiration rates across vast agricultural lands (Gao & Liu, 2013). These technologies provide insights into how much water is being consumed by crops, helping to identify areas of over-irrigation or under-irrigation. By using these data, policymakers can evaluate the performance of policies aimed at promoting efficient water use, such as subsidies for drip irrigation or regulations on water-intensive crops.

Additionally, satellite imagery can support the enforcement of water allocation policies by identifying discrepancies between allocated and actual water usage, ensuring that resources are being used as intended (Thenkabail et al., 2015).

2.4. Hyperspectral-based EO Solutions for enhanced water management

Hyperspectral imaging is more capable of identifying and discriminating the targeted features of certain objects making it more informative in a policy cycle assessment. Using data from the PRISMA and ECOSTRESS missions, the developed solution will be capable of estimating and mapping potential and actual crop evapotranspiration using crop coefficient (Kc) and water stress coefficient (Ks). From such information, two main applications could be developed for large scale areas: i) vegetative growth ii) Agricultural water consumption.

Water resources management policies necessitate the existence of non-destructive regional scale tools for periodical monitoring and assessment. Using the two main mentioned applications, the developed model could be a fixable tool to be integrated into policy cycles. However, the challenges of integrating such tool into policy cycles are not limited to technical obstacles. Therefore, an analysis had to be performed to identify and cluster the existent challenges and the expected features from the final product by the potential users.

What is a policy and what is the potential of integrating EO solutions into policy cycles?

Before discussing the challenges of integrating remote sensing applications, brief definitions are necessary. A policy is generally defined as a set of ideas or a plan of action agreed upon officially by a group of people, a business organization, a government, or a political party (Turner, 2006). According to the reasons for development, policies could be categorized into two main groups:

- **Re-active Policy**: a policy designed to remedy an existing challenge.
- **Pro-active Policy:** a policy designed to prevent a concern, problem, or emergency from occurring.

Policy making and dynamics can be understood using the policy cycle proposed by Lasswell (1956), the founder of modern policy analysis.

The policy cycle is a heuristic tool through which different stages of the ongoing and never-ending dynamics of policy processes can be segmented and then analyzed (Capano and Pritoni, 2020). This segmentation allows for grasping specific dynamics occurring in any given stage along with defining the relevance and potential of the proposed tools - such as remote sensing models - at each stage of the policy cycle (Figure 1).

In its simplest form, the policy cycle consists of five main stages:

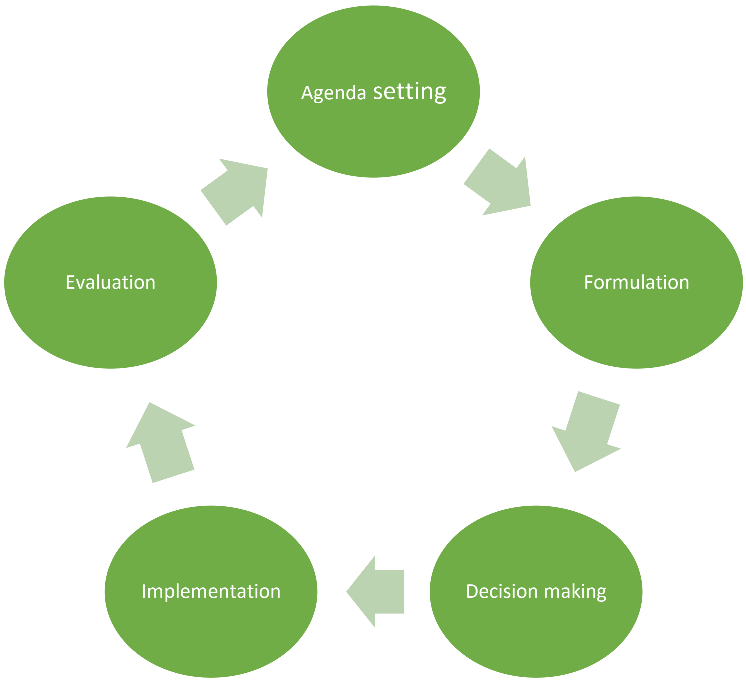


Figure 1 Policy Cycle stages

- **Agenda setting:** The stage where problems are defined and prioritized according to the main actors and stakeholders. This prioritization is a strategic phase that pre-structures the following stages and is mainly associated with other concepts such as: power, conflict management, and lobbying. However, as the main objective of this deliverable is to discuss the potential of integrating RS models for policy implementation and management, these concepts will not be deeply discussed.

- **Formulation:** in this stage the available solutions are characterized and assessed. While stakeholders were the main actors in the previous stage, experts and professionals are the main contributors in this one (Dunlop, 2013). Interest groups also need to be included in this stage as bearers of information and data for the professionals and policymakers (De Bruycker, 2016).

- **Decision-making**: This is the stage where the final solution is selected and pursued, including the process of its legitimation. Politicians and decision-makers exercise their sovereignty here, but other actors can influence the outputs of the decision-making process, and trade-offs must be assessed.

- **Implementation**: Previously considered a mere execution of agreed-upon plans, the implementation stage has its own autonomous logic, dynamics and characteristics (Bardach, 1977, Pressman and Wildavsky, 1973). This means that implementation is structurally characterized by a tendency to distort goals. As it is a different arena, other factors, including stakeholders, can influence the implementation approach and outcomes according to their interests (Capano and Pritoni, 2020). Yackee and Yackee (2006) noted that implementation is the stage where the stakeholders excluded from the agenda setting stage can exercise their influence on the final outcomes.

Thus, Implementation is a strategic stage of the policy cycle as it represents the link between the established goals and the actual outcome of a policy. It is believed by the authors to be the main arena for integrating RS models into the water resources policy cycle (along with the next stage).

- **Evaluation**: as the last stage of policy cycle, evaluation implies the periodic assessment of policy outcomes and impacts. It facilitates evidence-based policy design and implementation, increasing the policy's accountability and transparency, demonstrating achievements towards policy objectives, and assessing the policy's effectiveness, efficiency, results and impacts. However, periodical evaluation demands systematic monitoring tools, another area where RS models and tools excel. This will be further illustrated when discussing examples from the Egyptian context.

3. Identifying the potential users and their Challenges/requirements

To ensure that the final product fulfills the end users' requirements, a continuous process of surveying, processing, analyzing feedback and channeling the results to the developers was embedded within the Final Solution development process.

An online survey was used as a tool to correlate and trace the final user requirements, ensuring alignment with the project's objectives throughout the development. This analytical approach systematically maps policy requirements and goals to the technical specifications, functionalities, and features of the remote sensing model, ensuring that every aspect of the model supports the intended policy outcomes.

The survey also aimed to identify the current situation regarding the available tools, models, level of proficiency, and the level of integration of EO models in policy cycles. Targeted potential user profiles included researchers, private sector representatives, governmental officials, and educational institutions.

While targeting the early adopters involved in the project is fundamental, the survey was extended to include other stakeholders. This was done using a categorization approach to ensure an inclusive vision of the needed functions of the developed tools, along with fostering dissemination and outreach.

In addition to the filled surveys, other tools such as recorded interview were used to build the dataset. These interviews were conducted mainly with high-caliber officials to ensure the robustness of the final outcome through deeper discussions.

The survey was designed to answer four categories of questions in mind:

- **Contextual**: Meant to identify what already exists on site, including: the available models and tools, the technical know-how and the awareness about RS potential and outreach. This information is essential to establish a baseline of the environment where the developed solution will be deployed.

- **Diagnostic**: Aimed at understanding the reasons behind the existing situation (clarified from above). It investigates the institutional and structural challenges relevant to RS models.

- **Evaluative**: Focused on assessing the effectiveness of the existing RS models and tools and gauging the satisfaction levels of the targeted groups.

- **Strategic**: The most important part of the questionnaire, where the targeted groups identify their requirements and expectations from the developed solution.

3.1. How the dataset was processed

The gathered dataset was analyzed using the four simple steps:

Familiarization: The analyst becomes familiar with the transcripts of the data collected (e.g. interview or focus group transcripts, observation or field notes) and gains an overview of the existing EO solutions environment, including recurrent themes, comments, challenges, and doubts.

Identifying a thematic framework: The questionnaire is expected to generate recurrent emergent themes regarding RS models, such as opinions, challenges, narratives, and requirements. The main outcome of this stage is to cluster the ideas into a thematic framework.

Indexing: Codes are allocated to identify portions or sections of the data that correspond to a particular theme. This process is applied to all the gathered textual data (e.g. transcripts of interviews). It is significantly important when the surveyed sample is relatively large. In this case, the sample was relatively small, thus indexing was not essential as themes could be easily tracked throughout the answers.

Charting: Data is lifted from its original textual context, weighed through identified themes, and visualized on charts.

Mapping and interpretation: The final stage involves analyzing the key characteristics as laid out in the charts. This analysis should provide a schematic diagram guiding the analyst in interpreting the data set. The main outcome is to identify the main requirements and expectations of the targeted groups regarding EO based models and to investigate more use cases. The requirements and expectations of this stage are an inputs to trace the solution development and are used as evaluation criteria of the final product (developed solution) features and capabilities.

3.2. About the analyzed sample

As mentioned, the analyzed sample was broken into four different categories to reflect the variability of the potential deploying environments:

- **Governmental organizations (GO):** These are key stakeholders in water resource management, agriculture policies, and environmental regulation. They often have the responsibility for managing water allocation, irrigation systems, drought monitoring, and sustainable farming practices at district or national levels. Their mandate to improve food security and manage scarce water resources makes them pivotal in understanding the policy and operational aspects of adopting remote sensing technologies.

  Responses from this category will offer insights into how remote sensing can support large-scale decision-making, monitoring of water usage, and policy enforcement. Government agencies usually emphasize regulatory and bureaucracy challenges, the need for accurate and readily available data, and the opportunities for integrating satellite data into national agricultural water management systems.

- **Private Sector (PS):** Particularly agricultural services companies (farmers, agribusiness, irrigation technology providers, etc.), can benefit from remote sensing through increased efficiency in water usage, precision irrigation, and resource management. As water becomes scarcer, private firms are looking for cost-effective ways to optimize water resources and improve crop yields.

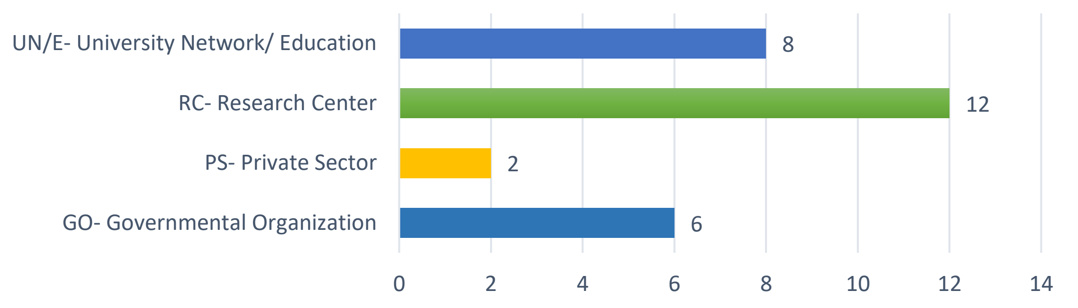
  It is expected that the private sector will identify practical applications of remote sensing in agriculture, such as precision irrigation, crop health monitoring, and water usage optimization. Private businesses may provide insights into the financial viability of remote sensing solutions, the barriers to adoption (such as cost or technical know-how), and the return on investment for such technologies in real-world agricultural settings.

- **Researchers from Research Centers (RC):** Mainly from The National Authority of Remote Sensing and Space Sciences (NARSS)**,** a leading governmental organization dedicated to the development and implementation of remote sensing, can provide deep technical insights into the innovative uses of remote sensing technology for water management in the Egyptian agricultural sector. Their perspective is essential for understanding current technological limitations, opportunities for enhancing accuracy, the development of new algorithms for water monitoring, and collaboration opportunities between the scientific community and other sectors.

- **PhD Researchers affiliated with the UN/E-University Network (Education):** Bring in-depth theoretical knowledge and cutting-edge research to the conversation. Their focus on education and innovation is vital for understanding the future directions of remote sensing applications. They can provide insights into emerging technologies, new methodologies, and potential academic collaborations that could drive facilitate deploying the final product into their educational environments.

By involving these four categories, the survey aims at building a comprehensive range of perspectives, from policy and academic research to commercial and governmental applications. This diverse input is crucial for assessing the full potential of remote sensing technologies and identifying pathways for their development and implementation.

Figure 2 shows the number of responses from each category. From the number of responses presented, it could be implied that the main user of remote sensing applications in the Egyptian context is the research and education sector. However, it is worth to mention that research and education institutions are much more active in social surveys such as this one. Therefore, more dedicated investigation is needed before drawing definitive conclusions. For the coming surveys, it is suggested to plan targeted outreach strategies to increase the sample size and ensure broader participation across key stakeholder groups. This will include direct engagement with networks and institutions that were underrepresented in the initial survey, specially, the private sector. This could be done through dedicated information sessions, personalized invitations, and the use of focal points within regional and thematic communities.



	GO- Governmental Organization	PS- Private Sector	RC- Research Center	UN/E- University Network/ Education
Total	6	2	12	8

Figure 2 The distribution of the analyzed sample among categories

3.3. The nature of the respondents (Supplier or demander)

Defining whether the respondent is a supplier or demander of remote sensing technologies is critical as it allows the survey to gather more targeted and insightful data regarding the needs, expectations, and challenges faced by different stakeholders.

Demand-side respondents such as companies, government agencies, or researchers who rely on remote sensing for decision-making, can provide crucial insights into how they use these applications and what specific requirements or challenges they face. Potential insights useful for final product development include:

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- **Application needs:** What are the main sectors or fields (e.g., agriculture, environmental monitoring, disaster management) requiring remote sensing?
- **Usability concerns**: Are there any technical or operational difficulties users encounter when utilizing remote sensing data?
- **Desired features:** What improvements or additional functionalities are demanded to make remote sensing more effective for their work?
- **Market demand:** How large is the demand for remote sensing applications, and how does it vary by sector?

On the other hand, **supply-side respondents** such as companies, research institutions, or government agencies developing and providing remote sensing technologies, can provide insights into the current capabilities and innovations being offered. Potential useful inputs include:

- **Technological advancements:** What new technologies or methods are being developed to improve remote sensing data quality or analysis?
- **Service offerings:** What kinds of products or services (e.g., satellite imagery, data analytics, GIS services) are currently provided?
- **Challenges in service delivery:** What hurdles do suppliers face in delivering high-quality remote sensing applications, such as data processing limitations, costs, or market adoption?
- **Growth opportunities:** What sectors or applications show the highest potential for future market growth?

The distinction between suppliers and demanders allows the survey to explore potential gaps or mismatches between what is offered by suppliers and what is needed by end-users. For instance:

Unmet needs: If demanders identify specific features or applications not currently available, this could signal opportunities for suppliers to innovate.

Market readiness: Understanding whether demanders are fully utilizing the technology or if there are barriers to adoption (e.g., cost, technical complexity, knowledge gap) helps the developers tailor their products or dissemination strategies accordingly.

Defining whether potential users are on the supply or demand side in the survey enables a more precise analysis for remote sensing potential. It helps capture insights from both those who develop and provide the technology, as well as those who use it, leading to more actionable and comprehensive results.

Within the surveyed sample, **50%** of the respondents identified themselves as both demanders and suppliers for RS applications, while the only demanders and only suppliers were **18%** and **32%**respectively.

4. Most used media for data flow in RS applications

Another important aspect of the analyzed sample is the used media for data transmission when using RS applications. The most reported answers were:

4.1. Mobile platforms

Personal mobile devices and tablets can serve as platforms for both collecting and receiving remote sensing data, often equipped with GPS and sensors. They enable users in the field to directly interact with remote sensing systems, contributing to real-time data flow. Mobile devices were selected as the most used platform for RS data flow by the analyzed sample.

4.2. Output from Models and Simulators

Remote sensing data is often processed using various simulation models. These models generate outputs that are critical for interpretation, forecasting, or decision-making. This option ranked as the second most used option for RS data.

4.3. Drones

Despite the bureaucratic complexity of using UAVs in the Egyptian context, drones were reported as the third most preferred media. Drones are increasingly used in remote sensing for capturing high-resolution images or data from hard-to-reach areas. The responses imply that drones are seen as valuable means for data collection and flow, rather than their actual feasibility.

4.4. IoT Sensors

Internet of Things (IoT) devices and sensors provide real-time, continuous data from various sources like weather stations or agricultural fields. Ground data is essential for RS models' calibration and validation, making IoT sensors an important asset for RS applications development. However, in the analyzed sample, IoT sensors were ranked the fourth most used media in data flow systems related to RS applications. This could imply the use for conventional ground sensing methods, either direct sampling or non-wireless indirect sensing.

4.5. Social Media

Social media platforms can provide geotagged data and crowd-sourced information, which, when combined with remote sensing data, can offer insights into human activities or events. This option was ranked fifth and was often deemed unimportant or left blank by the analyzed sample.

However, it could be valuable to segregate the answers according to the predefined potential user categories to gain a deeper understanding of the main prioritized means, as shown in Figure 3.

Two main assumptions can be drawn from the segregation of the dataset:

i) **Drones in Educational and Research Environments:** Drones as a mean for RS data is significantly more valued in educational and research environments. The purpose of the question was to evaluate the tendency towards adoption or familiarity with various remote sensing data sources.

However, the frequent selection of drones seems to indicate their perceived potential value future applications rather than their current integration into existing remote sensing practices. This is further emphasized by the reluctance of the private sector and governmental organizations. As previously noted, the bureaucratic procedures and permissions required for drone operations make them impractical with commercial business models or governmental frameworks. Despite their recognized potential, these regulatory hurdles significantly hinder their widespread adoption and integration into current RS applications.

ii) **Social Media as a Data Source** The value of social media as a data source for RS applications was recognized only by the private sector, likely reflecting their focus on market-driven insights and consumers behavior. The private sector, particularly in agribusiness and tech-driven solutions, may view social media as a complementary data source for remote sensing that could be integrated with satellite or aerial data to enhance decision-making, marketing strategies, and real-time monitoring of agricultural activities. This preceptive is still absent in the other sectors presumably due to a gap in understanding its value.

The widespread prioritization of mobile devices across all sectors underscores the importance of ensuring that the final product is available as a cloud-based application, making it easily accessible to potential end users. This highlights the need for mobile-friendly, user-friendly platforms that can be accessed anytime, anywhere.

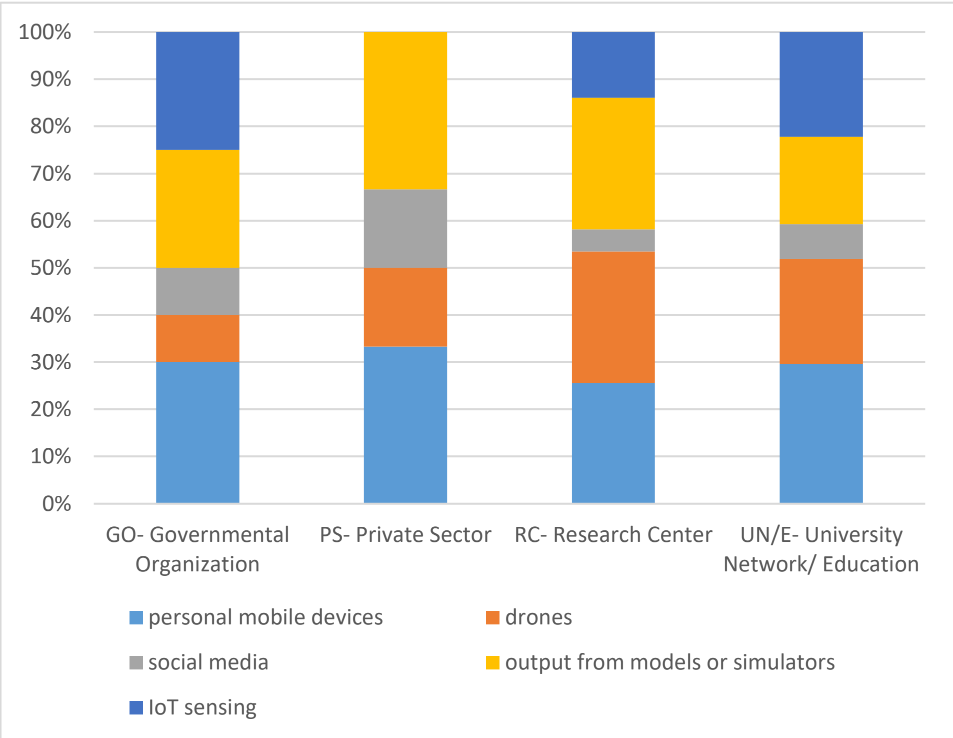

Figure 3 The main reported data flow media for RS applications

5. Most used satellite data types

Different types of satellite data require varying levels of technical expertise and resources to process. Organizations using raw data likely have more advanced technical capabilities, including expertise in data processing and interpretation. In contrast, those relying on data products may prioritize ready-to-use information and have fewer technical resources. To understand the potential users' expertise and technical capabilities, the analyzed sample was presented with three types of data representing three levels:

5.1. Raw Data

Raw data refers to the unprocessed or minimally processed measurements directly received from satellite sensors. This data is in its most basic form and typically consists of raw radiance or reflectance values recorded by the satellite's sensors across various spectral bands.

5.2. Processed Data

Processed data has undergone radiometric and geometric corrections to remove errors or distortions caused by the satellite's sensor, atmosphere, or perspective. Radiometric correction adjusts for sensor noise and lighting conditions, while geometric correction aligns the data with a map projection to ensure accurate spatial representation.

5.3. Data Products

Data products refer to fully processed satellite data that has been transformed into actionable information or real-world variables. These variables may include surface temperature, soil moisture, vegetation indices (e.g., NDVI), chlorophyll-a concentration, rainfall rates, and other environmental indicators relevant to specific applications.

By understanding which data types are most commonly used, developers can better tailor the final product and its services to fit potential user needs. It could also help identify expected barriers to the adoption of the final product. For example, if many organizations report using processed data or data products instead of raw data, it may indicate that access to raw data or the expertise required for its processing is a challenge.

In the analyzed sample, **39%** of the respondents reported raw data, **36%** used processed data, and **25%** used final products. Figure 4 shows that the surge in raw data is primarily from the respondents affiliated with research centers and universities. Conversely, governmental organizations (GOs) and the private sector (PS) predominantly use processed data. This distinction can be attributed to the different roles, objectives, and technical capacities of categories. GOs and PS focus on practical applications such as agricultural monitoring, water management, and decision-making, making processed data more viable. Processed data is already corrected for radiometric and geometric distortions, ready for use in operational systems without requiring extensive technical processing.

This suggests that these organizations may lack the advanced scientific or technical capacity and time frames needed to handle raw data (in the context of agricultural services providers). Processed data, being ready-to-use, requires less specialized knowledge and infrastructure, making it more accessible for non-technical users.

On the other hand, research centers and universities are often at the forefront of developing new methodologies, algorithms, and models for remote sensing. They rely on raw data as it provides the flexibility to apply custom processing, test novel techniques, and extract precise measurements tailored to their specific research needs. This is particularly important for cutting-edge research in fields like climate change, hydrology, and environmental monitoring, where access to unprocessed data is critical for accuracy and innovation.

The main conclusion from this result is that the final product should be a user-friendly application that delivers ready-to-use, actionable insights. This could involve features such as dashboards, decision-support tools, and APIs that provide processed data with minimal user input, ensuring simplicity and efficiency for the end user.

Although a reasonable number of the respondednts reported using raw data, it is advisable that the final product be accessible to the vast majority of potential users. Reporting raw data can reflect the level of sophistication in the analysed sample, wich is valuable information that could prove usfuel in building partnerships and tailoring training programs.

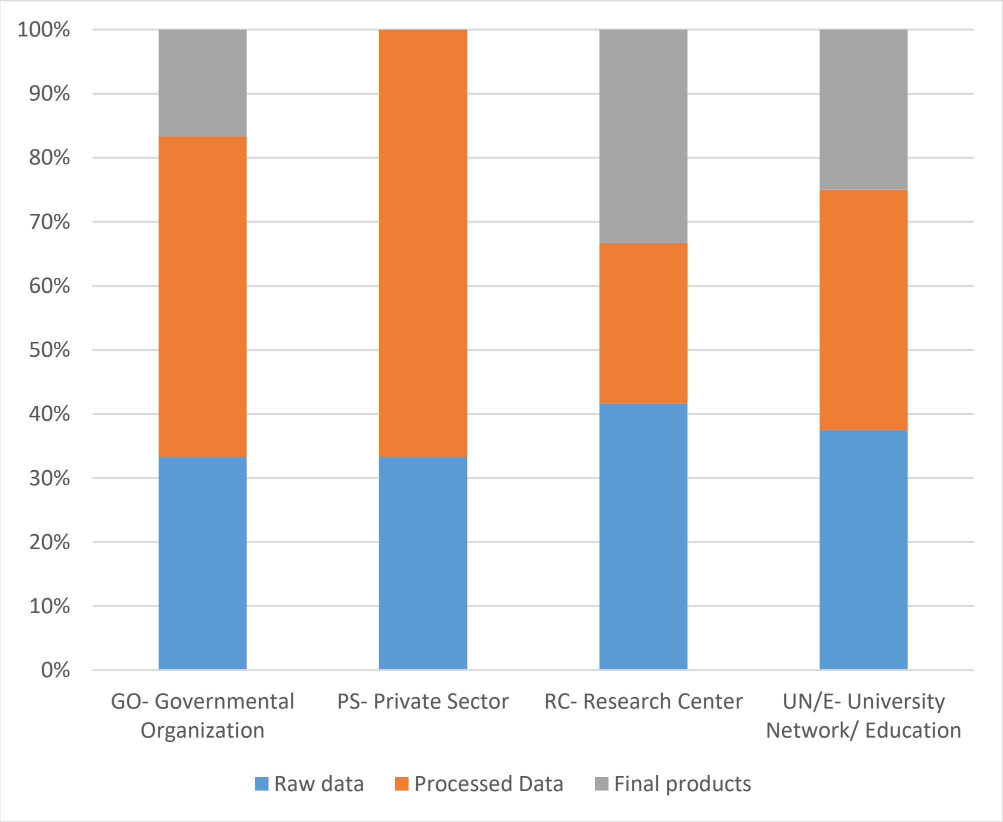

Figure 4 The most used datatype by the respondent/entity

6. Defining the main area of interest for RS applications in the agricultural sector

Understanding the main applications of RS is essential for mapping out the current uses, sectoral differences, and potential gaps in the application of RS models. Organizations might have different priorities or scales, such as water resource planning for governments or precision irrigation for private firms. This question allows for a more granular analysis of how RS is applied, enabling final product developers to create solutions that match the needs of each sector or at least define the most fitting potential users.

Another important aspect to consider is identifying the shared interests among various sectors. An application frequently mentioned across different sectors could be highlighted as **highly demanded**, thus pointed out to the developers of the final product.

The applications reported by the respondents can be summarized into five main options:

6.1. Water Resources Management

RS models are used to monitor and manage water availability, distribution, and quality. These models provide insights into surface water bodies, groundwater reserves, precipitation, and evapotranspiration rates. Remote sensing is usfuel for tracking droughts, water pollution, and the health of watersheds and river basins.

6.2. Crop Health Monitoring

This involves the use of RS to assess vegetation health and detect stress factors in crops, such as diseases, pests, or water shortages. Satellites can monitor plant growth, detect chlorophyll levels, and provide data that reflects the overall vitality of crops in real time.

6.3. Crop Classification

Using RS data to identify and differentiate between different types of crops within agricultural areas is essential for crop mapping, estimating yields, and tracking agricultural patterns. Classification models analyze spectral data from satellite images to determine which crops are being grown and how much area they cover.

6.4. Early Warning Systems

These systems are designed to predict and monitor environmental hazards such as floods, droughts, pest infestations, and disease outbreaks. RS provides data that can help predict these events by monitoring variables such as temperature, precipitation, and vegetation stress.

6.5. Urban Planning

RS is used to analyze land use, infrastructure, population growth, and environmental impacts in urban areas. Satellite imagery helps planners monitor urban expansion, land cover changes, and environmental risks such as flooding or heat islands.

Within the analyzed sample, water resources management and crop health monitoring were the most common applications among the four categories (Figure 5). Water resources management appears to be of great importance to the governmental sector, with 45% of the surveyed sample from GOs prioritizing it over the other four options. In Egypt, water resources management at the national level is centralized, meaning the government is the sole entity responsible for ensuring a sustainable water supply for agriculture and public use. In a region characterized by water scarcity, it is expected that water resources management applications will be of great significance. Furthermore, remote sensing offers a way to monitor large areas and ensure water security at regional and national levels.

Nevertheless, crop stress and health monitoring was the most commonly reported application among the surveyed sample. It is a critical application for optimizing yields, reducing losses, and improving productivity, leading to better economic returns. Thus, this application is highly demanded and should be considered in the final product.

Other important points that could be noted from the results include the absence of early warning systems and urban planning from the private sector applications. This could reflect the difficulty of monetizing such applications or building business models around them in the Egyptian context.

Another identified opportunity is the misrepresentation of crop classification applications in the GO responses, which could imply a knowledge gap that could be easily addressed. As previously mentioned, crop classification could be of great value in addressing agricultural policies and water resources management.

Finally, the near-identical results between universities and research centers are noteworthy. The prioritization of applications is almost the same, which could reflect a coherent behavior regarding their interests in RS applications.

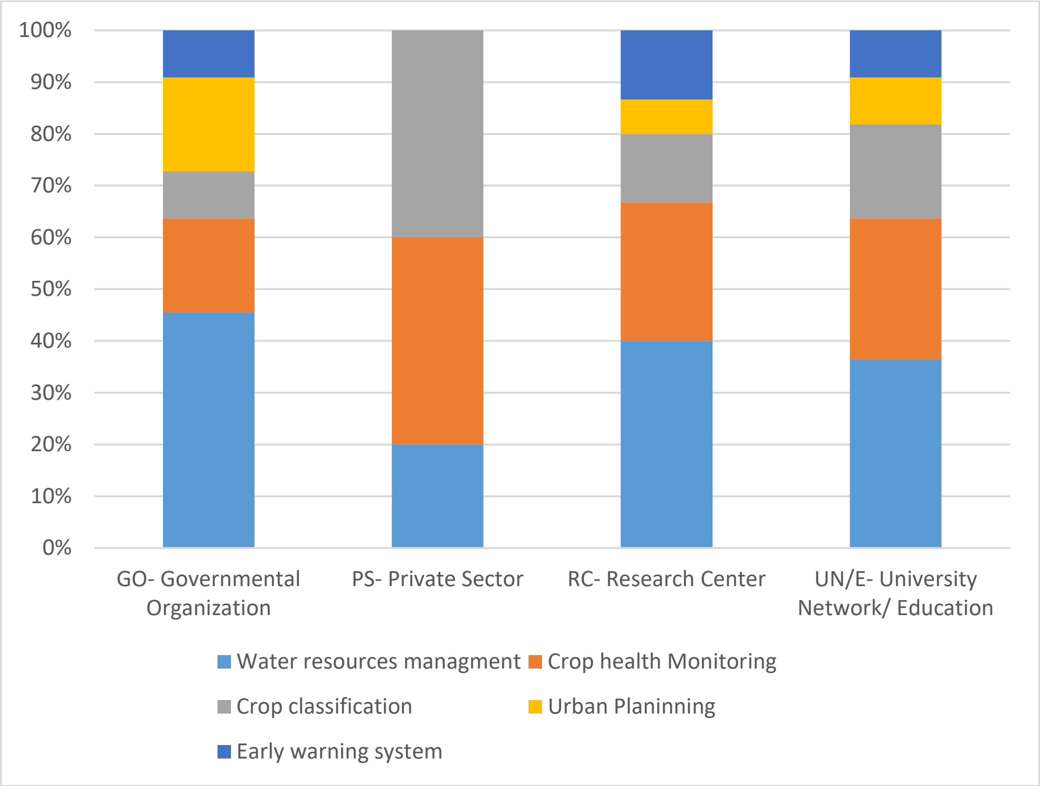

Figure 5 Mostly used RS applications by category

7. Anticipated Challenges in Integrating Remote Sensing Applications into Existing Frameworks

After defining the best platform interface, the level of complexity, and the main required applications in the previous sections, it is crucial to address the anticipated challenges and obstacles that may arise during the deployment of the final product.

The challenges pointed out by the respondents ranged from technical, institutional and financial constraints hindering RS applications from fulfilling their potential. By understanding these barriers, policymakers and stakeholders can address specific needs and tailor strategies to improve the adoption and integration of RS.

These defined challenges were then used as a starting point to analyze the status of RS applications. This was done by using the recurrently reported challenges as talking points with high-caliber figures, former officials, and some of the respondents themselves in direct interviews, along with searching existing literature. In the next section, the most reported challenges will be presented along with the resulting discussions. The overall results are shown in Figure 6.

7.1. Lack of an Overall Framework for Engaging the Private Sector

Private sector engagement is essential for innovation, scaling technologies, and driving market solutions in remote sensing. Without a structured framework, collaboration between the private sector, government, universities and research institutions becomes fragmented, limiting the development and integration of RS technologies. This creates a barrier to leveraging the private sector's technical expertise, funding capabilities, and potential for scaling up RS applications.

When this point is raised in discussions, it is usually tied to the absence of comprehensive framework, which often results in inconsistent regulations and unclear policies regarding the use of RS data, technology deployment, and data sharing in the Egyptian context. This affects the private sector's willingness to invest in or adopt RS solutions, particularly in sectors like agriculture and water management, where regulatory clarity is crucial. Government and research institutions may also struggle to integrate private sector innovations into national or regional strategies.

Without an overall framework, there is a disconnect between technological capacity in the private sector and the practical needs of governmental organizations and researchers. It is worth to mention that "technological capacity" in this context means the sustainability of the RS final product and its future development. This limits the commercialization and scalability of RS innovations - even if proven to be effective and helpful- that could benefit sectors like agriculture, environmental management, and urban planning. An established framework would encourage private companies to develop solutions that meet real-world challenges, fostering growth and innovation.

Tied to this institutional challenge -and a consequence of it- are the inefficient mechanisms for data access, sharing, and collaboration between public and private entities. Many organizations in Egypt, especially in government and research, may struggle to access high-quality data or tools developed by private companies. A well-defined framework would facilitate smoother data exchanges and collaboration, unlocking the potential of more comprehensive RS solutions.

7.2. Lack of technical know-how to exploit RS applications

This challenge was reported as the second most significant barrier for RS integration into existing frameworks. This could be partially attributed to technical complexity. Earth observation data -especially raw satellite data- can be highly complex and requires specialized skills in data processing, analysis, and interpretation. Many organizations, particularly governmental bodies and private sector companies may lack the in-house expertise or technical infrastructure needed to effectively utilize EO data. This limits their ability to fully exploit the potential of RS technologies.

Even when EO data is available, users often need to apply advanced techniques such as radiometric and geometric corrections, image classification, and modeling. Without trained personnel or advanced tools, organizations struggle to process and derive actionable insights from raw EO data.

RS, geospatial analysis, and EO data interpretation are specialized fields that require significant training in areas like geoinformatics, data science, and satellite image processing. Many organizations, especially in developing regions or smaller companies, face a shortage of skilled professionals who can handle the technical demands of working with EO data.

Additionally, many employees may lack the necessary up-to-date training to keep pace with advancements in RS technologies, leaving organizations unable to adopt or integrate newer, more powerful tools and datasets effectively. For example, in agriculture, integrating EO-based crop monitoring with traditional farming practices requires a workforce that understands both the technical and practical aspects of the data.

As EO data becomes more accessible, many organizations need training programs to bridge the gap between availability and usability. Without proper capacity-building efforts, organizations miss opportunities to fully leverage EO data.

Existing educational or training programs may be outdated or insufficient to cover the rapidly evolving RS landscape. Without targeted training initiatives, many organizations fail to develop the necessary in-house capabilities to maximize the benefits of EO data.

Capacity-building efforts are also crucial in making EO data more accessible to non-technical users. Simplifying the data and developing user-friendly platforms is important, but without training on how to interpret the results and integrate them into decision-making processes, organizations remain under-equipped to use these tools effectively.

Beyond human expertise, processing and analyzing EO data often requires substantial computational resources, such as high-performance computing systems, cloud storage, and software for data analysis. Many organizations, particularly those in the public sector or academia, may lack the financial or technical resources to invest in the necessary infrastructure to handle large-scale EO datasets.

7.3. Lack of financial resources

This barrier is common across the four categories, as RS technologies often require substantial upfront investment in hardware, software, and infrastructure. Organizations looking to use satellite data must often acquire expensive imagery or pay for specialized data-processing platforms and cloud computing resources to handle large datasets. Additionally, organizations may need to purchase advanced tools for geospatial analysis, which can be cost-prohibitive for smaller businesses or public institutions with limited budgets.

Beyond initial investments, there are ongoing costs associated with maintaining and utilizing remote sensing applications. These include the costs of data subscriptions (such as for high-resolution satellite imagery), regular software updates, and access to cloud-based processing platforms. Additionally, organizations must continuously invest in training personnel.

For smaller companies in the private sector or underfunded research institutions, these recurring costs can be unsustainable, especially when the return on investment (ROI) is not immediate or clear. Public sector agencies may face strict budget constraints, limiting their ability to fund the necessary tools or infrastructure to implement RS projects at scale.

Another frequently reported challenge is the inadequate funding of research centers and universities. Despite being key players in the development of RS applications in the Egyptian context, they often suffer from a lack of funding to pursue large-scale projects. Research in RS is typically dependent on grants, which may be limited, competitive, or focused on short-term objectives. This financial constraint hinders the ability of research institutions to explore new applications, develop innovative models, or conduct long-term studies that could enhance RS capabilities. This lack consequently impacts the ability to hire skilled personnel, procure the latest technology, and maintain the infrastructure needed to process and analyze complex EO data. For PhD researchers and universities, this creates a barrier to advancing RS research and integrating cutting-edge solutions into real-world applications.

7.4. Temporal frequency and Data Reliability

Temporal frequency refers to how often satellite data is collected and updated for a specific location. For an RS application to be integrated into a policy cycle, it must be reliable. Monitoring crop health, water resources, or environmental changes requires frequent data updates to be effective. However, many satellites do not revisit the same area often enough to provide the continuous, real-time monitoring needed for certain management systems.

Free satellite data, such as from Landsat or Sentinel missions, may offer a lower temporal frequency (e.g., every 10-16 days) compared to commercial satellites, making it unsuitable for applications that require daily monitoring.

For example, in agriculture, daily or even hourly updates might be needed to monitor crop growth, detect early signs of stress, or assess the impact of irrigation. When data is only available on a weekly or monthly basis, it may miss critical events like sudden weather changes, pest infestations, or drought conditions, making the data less useful for real-time decision-making a require integration with other data sources to be efficient.

Coverage refers to the geographical area that satellites can observe. While some satellites provide global coverage, others may only focus on specific regions or have limited observational capabilities due to their orbital paths. This results in gaps in data for certain regions, particularly remote, rural, or underdeveloped areas, where RS data is most needed for agriculture, water management, and environmental monitoring.

Many developing countries or regions with less infrastructure may not receive consistent satellite coverage, leaving them at a disadvantage when it comes to applying RS technology.

This lack of comprehensive spatial coverage can prevent these regions from benefiting from EO data in managing natural resources, mitigating climate risks, or improving agricultural practices.

Another important raised point is Cloud Coverage and Atmospheric Interference. Many optical RS satellites can be obstructed by clouds or atmospheric conditions, reducing the availability of usable data. This significantly limits the temporal frequency of data collection. For organizations that rely on clear, consistent data, this presents a major barrier. A lack of alternative sources for cloud-free data reduces their ability to monitor events consistently, leading to gaps in the data, which can undermine the accuracy of models and assessments.

When it comes to data reliability, different sectors reflected different interests.

- **Governmental Sector**: Focused on areas like water resource management, which needs regular data updates to track and manage water availability, flood risks, and irrigation schedules at a regional scale. Gaps in data coverage could result in missed opportunities to prevent water scarcity or manage droughts.
- **Private Sector:** Particularly in agriculture, relies on frequent data to make real-time decisions regarding crop health, resource allocation, and pest control. The inability to get timely data makes these operations less efficient and may result in financial losses.
- **Research Centers and Universities:** Need consistent temporal coverage for environmental studies, climate change research, and urban planning. Incomplete data leads to uncertainties in research findings, making it difficult to draw accurate conclusions or make informed recommendations.

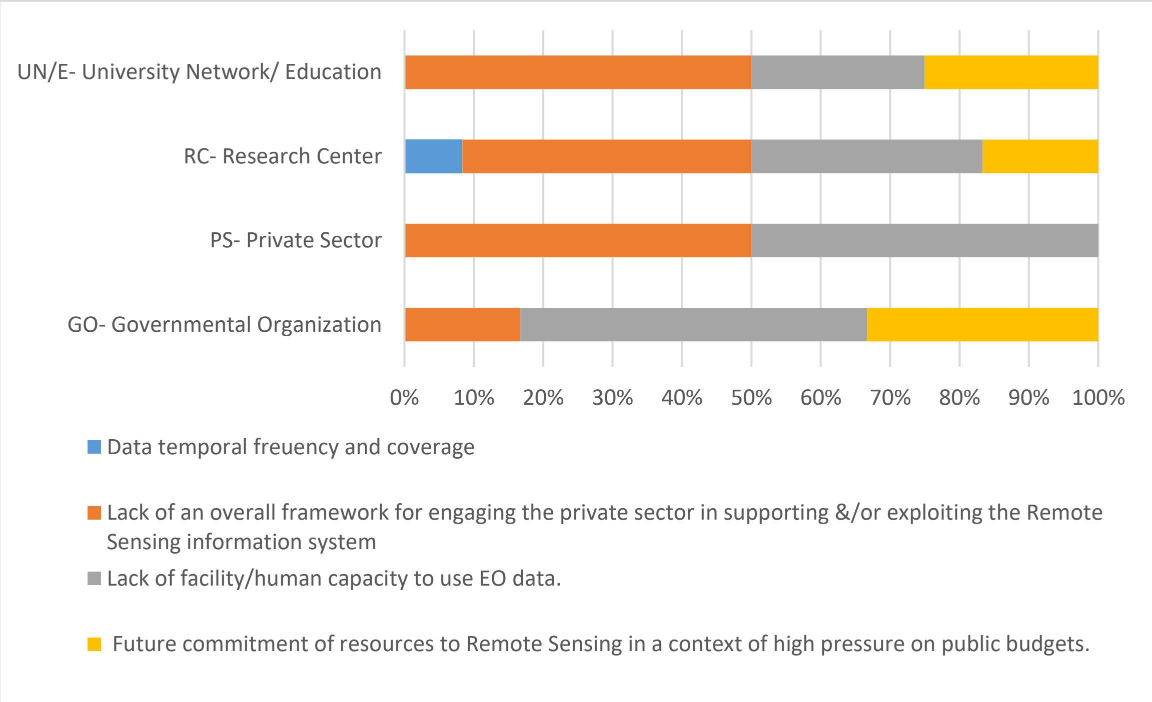

Figure 6 Top identified challenges for RS applications integration

8. Defining the potential users' requirements from the output product

In this section, the conclusions from the reported answers in the survey will be converted into clear, specific and traceable requirements expected from the output product by the potential end-users. The requirements are mainly related to the web platform to access the output maps. One of the main output of EO AFRICA WRM is the realization of a web platform to access the ETa, NDVI and CWSI products realized during the demonstration of the proposed technique over the pilot site in Northern Egypt. The platform is available at the following url: "eo-africa-water-management-geonode.planetek.it" The definition of the user requirements represents an important outcome of the project and can be used as reference for future developments of the provided solution.

Part of these requirements have been already covered during the development of the proposed solution that can be considered as a pre-operational tool.

Future developments could incorporate the full set of requirements to make the solution fully operational into the existing frameworks of the targeted environments (governmental, private sector, research and educational). In the paragraphs below, each requirement's fulfillment in the current version of the proposed solution is explained.

8.1. User-Friendly Interface

Given that all sectors emphasized ease of use, the application must have a simple and intuitive interface that requires minimal training. This lowers the barrier for adoption, especially among private sector users and governmental organizations with limited technical expertise.

Requirement fulfillment

The web platform provides a clean and intuitive user interface, designed to minimize complexity and facilitate easy navigation. The users have the possibility to upload auxiliary data andand accessible visualizations ensure that users from different sectors can use the platform effectively without extensive training.

8.2. Accessibility

The prioritization of mobile devices by all sectors indicates that the application should be accessible via mobile platforms (smartphones and tablets). Farmers, agricultural consultants, and field workers need to access data on the go, making mobile compatibility essential.

Requirement fulfillment

The platform is optimized for mobile devices (with unique mobile-specific buttons), ensuring that users can easily access it from smartphones and tablets, whether they are in the field or on-site. This accessibility could be critical for sectors that require real-time data updates while on the move.

8.3. Cloud-Based Platform

Cloud-based solutions are critical for reducing the need for local hardware investment. This is particularly important for organizations with limited financial resources, allowing for scalable and cost-effective remote sensing processing.

Requirement fulfillment

The platform is deployed on cloud. Potentially we could offer in a scalable manner more data storage and processing capabilities –with extra cost- without requiring extensive local infrastructure. This model ensures that organizations with limited resources can still leverage the power of the platform.

8.4. Data Integration from Multiple Sources

To overcome issues with temporal frequency and spatial coverage, the final product should allow for data integration from multiple RS platforms, such as satellite imagery, drones, and ground sensors. This will provide comprehensive coverage, even in areas with limited satellite revisit rates.

Requirement fulfillment

The platform integrates data from various sources, including satellite imagery, and other complex products providing comprehensive geospatial and temporal coverage. For example: PRISMA data are integrated with Sentinel-2 and Landsat data. Future developments could foresee the integration of even further satellite sensors in order to enhance the capabilities related to temporal frequency and spatial coverage.

8.5. Actionable Insights and Decision-Support Tools

Users, particularly in the private sector, prioritize ready-to-use insights over raw data. It would be highly appreciated if the final product included dashboards, automated alerts, and decision-support tools that provide direct recommendations for irrigation scheduling or water management based on evapotranspiration data.

Requirement fulfillment

The platform includes an interactive time slider which enables users to easily navigate through the evapotranspiration, NDVI and CWSI time series maps realized over the entire time range. This offers actionable insights and represents a useful decision-support tool that directly aid irrigation scheduling and water management.

8.6. Customizable Data Outputs

Different users have different needs. For example, research centers may require access to raw data for detailed analysis, while governmental organizations may prefer processed data or data products. Allowing users to customize outputs (e.g., raw data, processed data, or data products) ensures the application meets diverse user requirements.

Requirement fulfillment

The platform allows users to customize their data outputs, enabling them to choose between raw data, processed data, and generated products. This ensures that each user can tailor the data according to their specific requirements. Also, users can upload their own data and choose which other users can view, manage or download them.

8.7. Integration with Existing Systems (APIs)

Many organizations already have systems for agricultural management or water resource planning. Providing API integration could allow users to import data into their internal tools, increasing usability and reducing friction in adoption.

Requirement fulfillment

The platform supports API integrations, enabling users to seamlessly import data into their existing systems for agricultural management and water resource planning, thus enhancing usability and facilitating adoption. This is a requirement that could be fulfilled during future developments during a potential operational tool design.

8.8. High-Resolution Data Availability

For applications like crop health monitoring and irrigation planning, high-resolution data is crucial. The final product should use PRISMA and ECOSTRESS missions. This data should offer high spatial and temporal resolution options, especially for users in the private sector that need granular data for decision-making.

Requirement fulfillment

The platform currently allows access to evapotranspiration, NDVI and CWSI time series maps realized by this demonstration project aimed to test the integration of PRISMA with other missions in order to be applied to the purpose of water resources monitoring.

8.9. Data Temporal Frequency Controls

If possible, the final product should allow users to select and manage the frequency of data collection based on their needs. For instance, daily updates for precision agriculture or less frequent updates for seasonal water resource monitoring.

Requirement fulfillment

The platform currently make accessible all the products realized for the entire dataset of input images collected along the time range of analysis. The users are enabled to select and download the users to select and download the desired dates.

8.10. Real-Time Monitoring and Alerts

The private sector and governmental organizations involved in water resource management and agriculture often require real-time data to make timely decisions. Real-time monitoring and automated alerts (e.g., when ET levels suggest water stress) will enhance decision-making.

Requirement fulfillment

The current demonstration platform was not designed to provide real-time alerts, but this need could be used as reference during future developments of a possible operational tool.

8.11. Offline Mode

Since certain regions may face data coverage issues or limited internet access, it could be useful if the final product offered an offline mode that allows users to cache data for use in the field and sync it once internet access is restored.

Requirement fulfillment

The platform includes the possibility of downloading the entire set of evapotranspiration, NDVI and CWSI time series maps, enabling users to use highly portable data for field use, ensuring continuous usability even in areas with limited connectivity.

8.12. Integration with Local Weather Data

Evapotranspiration calculations rely heavily on local weather data (e.g., temperature, humidity, wind speed). The application should integrate with local meteorological stations or provide weather-based predictive models for more accurate ET mapping.

Requirement fulfillment

The platform can integrate local weather stations as long as the data formats correspond to the vast list of formats the platform supports.

8.13. Training and Capacity Building

The lack of facility/human capacity to use RS was identified as a major barrier. The application should include tutorials, documentation, and training modules to improve the technical skills of users, particularly in research institutions and government agencies.

Requirement fulfillment

The platform is delivered with training resources, including documentation and user guides. Also a training workshop has been organized during the project to improve the technical skills of users in research institutions and government agencies.

8.14. Financial Assistance/Grant Integration

To address the financial constraints, it may be helpful if the final product provided guidance and updates on available grants or subsidies for RS technologies. This would help potential users fund their adoption of the technology and increase the dissemination of the final product, especially in the context of developing countries.

Requirement fulfillment

This requirement could be fulfilled during future developments of the platform exploiting the WordPress blog which is currently included in the tool. This could be used by the admins to disseminate information on available grants or subsidies for RS technologies to interested users.

8.15. Local Language Support

To increase accessibility, especially for small-scale farmers, small agri-businesses or local government users, the final product may support multiple international languages.

Requirement fulfillment

The platform interface supports five different languages, and the users can create data in their own languages.

8.16. Visualization Tools (GIS Integration)

Effective ET mapping requires strong visualization tools. Integration with Geographic Information Systems (GIS) will allow users to visualize evapotranspiration data spatially, overlaying it with other layers like soil maps, crop types, and irrigation zones.

Requirement fulfillment

The platform includes a time-series feature that allows users to view data as it evolves over time. It can include in the future other ancillary GIS layers put at disposal by the users as further background dataset.

8.17. Environmental and Sustainability Metrics

Increasingly, organizations are focused on sustainable water management and environmental impact. It would be helpful if the final product included metrics related to water use efficiency, carbon footprint, and other sustainability indicators, helping users optimize their water resources for both economic and environmental benefits.

By focusing on affordability, user accessibility, data integration, customization, and actionable insights, the final product should meet the diverse needs of multiple stakeholders in the agricultural sector. The final product should be flexible enough to be used by both technical and non-technical users, ranging from the private sector to governmental organizations, ensuring wide adoption and practical use in agricultural water management.

Requirement fulfillment

The current platform allows users to access values of evapotranspiration, NDVI, and CWSI variations over a specified time range. This data can serve as a valuable reference for calculating other metrics, for instance water use efficiency metrics. Addressing this need could guide the design of a future advanced version of the platform, leveraging existing tools to integrate the needed derived products related to other environmental metrics.

9. Policy implications

This section focuses on connecting the key findings of the study and the demonstrated potential of the developed evapotranspiration monitoring techniques to relevant policy implications. The primary goal is to illustrate how remote sensing-based solutions, particularly those leveraging hyperspectral and thermal data, can directly inform and support evidence-based policymaking in water resource management and agriculture. The recommendations below present concrete pathways where the outcomes of the study can drive policy innovation and support the broader integration of Earth Observation (EO) tools into national frameworks.

9.1. Enhancing Crop Water Use Efficiency and Food Security

The integration of remote sensing-derived actual evapotranspiration (ETa) products enables accurate monitoring of agricultural water consumption across different spatial and temporal scales. This advancement supports more efficient irrigation scheduling, optimizes resource use, and reduces unnecessary water loss which are key actions to safeguard food security under increasing water scarcity.

To maximize this impact, policymakers should encourage the incorporation of EO-based ETa data into national irrigation advisory services and agricultural water management strategies, directly supporting Egypt's efforts to achieve sustainable agriculture targets under its National Climate Change Strategy 2050.

9.2. Strengthening Early Warning Systems for Drought and Water Stress

Hyperspectral and thermal EO applications offer a significant opportunity to detect early signs of crop water stress before visible symptoms occur, allowing for timely interventions to minimize drought-induced crop losses. **Integrating such remote sensing-based alerts into national disaster risk reduction (DRR) frameworks and agricultural insurance schemes will enhance Egypt's resilience to climatic shocks and contribute to more proactive risk management policies within the Ministry of Agriculture's strategic planning.**

9.3. Supporting Evidence-Based Water Allocation and Integrated Water Resources Management

Systematic monitoring of evapotranspiration rates through EO technologies provides critical, real-time evidence for optimizing water allocation between agriculture, industry, and domestic sectors. This capability addresses the growing need for transparent and equitable water distribution in the context of Nile water uncertainties. **Therefore, remote sensing data products should be formally incorporated into national integrated water resources management (IWRM) assessments and linked to Egypt's Water Resources Strategic Plan 2037 to strengthen data-driven decision-making.**

9.4. Fostering Private Sector Engagement and Innovation in Digital Agriculture

The study revealed a significant need to better engage the private sector, particularly agribusinesses and technology providers, in leveraging remote sensing applications. By making EO data platforms more accessible and tailored to non-expert users, Egypt can stimulate private innovation and drive the adoption of precision agriculture solutions. **To capitalize on this potential, policy frameworks should promote public-private partnerships (PPPs) and incentivize the integration of EO tools in agricultural modernization initiatives aligned with Egypt's Vision 2030 for digital transformation.**

9.5. Building Technical Capacities and Sustainable Knowledge Transfer

A major barrier identified was the limited technical capacity among many user groups to fully exploit remote sensing tools for operational water management. Addressing this gap is critical to ensure the effective use of the developed EO techniques. **National policies should embed EO data literacy and remote sensing training into agricultural extension services, university programs, and professional certification schemes, reinforcing Egypt's knowledge economy and ensuring long-term sustainability of EO adoption across sectors.**

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11. Annex

The on-line survey

In this section the online form which reflects the four categories of questions is presented:

Stakeholder Questionnaire:

Earth Observation (EO) Africa Explorers is an initiative by the European Space Agency (ESA) that aims to i)assist African countries in overcoming the challenges related to the collection, analysis, and use of geo-information and to ii)exploit the advantages of EO technology for an effective and sustainable water resources management at national and regional scale thus, contributing to the mitigation of the widespread water scarcity in Africa.

In this framework, an EO, open source, innovative and integrated model is being developed to assess in near-real-time actual crop evapotranspiration (ETa). This information will serve as a Decision Support System (DSS) to improve irrigation water management. Collaboration with both the private and the public sectors is essential for disseminating EO models and promoting their adoption. To ensure the product's alignment with expected requirements and the effective integration of EO models into policy frameworks, the needs, and preferences of Early Adopters (EAs) and stakeholders shall be identified, and distortions and inefficiencies in current policies addressed. Please contribute, by filling in this questionnaire, to meet the challenge.

Personal Information:

1. **Name ……………………………………………………………………………………**
2. **Email ……………………………………………………………………………………**
3. **Position/Role……………………………………………………………………………..**
4. **Organization/Institution: ………………………………………………………………….**

- RC- Research Center
- UN/E- University Network/ Education
- GO- Governmental Organization
- PS- Private Sector

5. **Do you use Remote Sensing (RS) tools in your work?**
   □ yes □ No

6. **What kind of role does RS/EO play in your current activities?**

- Central
- Occasional
- Peripheral
- No specific role, but I have a general interest in EO

7. **As for EO, are you primarily interested in providing EO data, information and/or products to meet other users' needs (on the supply side) or in identifying EO-based solutions for a specific interest/need (the demand side)?**

- EO supply side
- EO demand side

- Both supply & demand sides
- NONE OF THE ABOVE

8. Do you consider these emerging EO data flows as strategic assets for water resources management?

	Yes, I entirely agree	Yes, I agree to some extent	No, I disagree to some extent	No, I entirely disagree	I don't know
Observation data from personal mobile devices					
Data from drones					
Data extracted from social media					
Data output from models or simulators					
Data from objects linked to the internet (e.g. sensor and actuators)					
Other significant emerging EO data streams (please specify):					

9. Is the organization/ entity you work with directly involved in EO or Remote sensing activities?

- Yes
- No
- I don't know.
- I don't belong to an organization.

10. What type of satellite data is your organization using?

1. Raw data (i.e., sensor measurements as received from satellites)
2. Processed Data (i.e., radiometrically, and geometrically corrected data)
3. Data products (i.e., processed data that describe real world variables such as chlorophyll-a concentration, rainfall rate, surface temperature, soil moisture or other essential variables)
4. Information products (i.e., management relevant information for decision support, for example, eutrophication state of an open water body, flood risk for a river delta)
5. Global datasets (i.e., land cover data, Digital Elevation Model, etc)
6. Analysis Ready Data (i.e., data cubes and other data processed to a set of minimum requirements and organized into a form that allows immediate value-adding and analysis without additional user effort)
7. Others

11. What are the main applications of RS models used in your organization?

…………………………………………………………………………………

…………………………………………………………………………………

12. Do you think that the available tools and applications are suitable for the challenges that you are facing? Please Justify your answer.

1. Very Low
2. Low

3. Medium
4. High
5. Very High

……………………………………………………………………………………………

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13. If not satisfied with the available tools and applications, can you suggest any new where an EO-based solution is relevant?

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14. What are the key reasons that justify a stronger Egyptian approach to Remote sensing & Earth observations, & what opportunities would such an approach offer? Please specify.

- Remote sensing helps promote research & innovation. It is a unique forum for coordinating the whole observation of agriculture and irrigation.
- Remote sensing is a way of leveraging existing EO-related infrastructure, programs, projects & activities; it boosts its major contributors' local standing.
- Egypt could benefit from the current data revolution & the Internet of Things, which have huge potential for innovative uses of EO data & products.
- The full & open data access to remote sensing & in-situ observations advocated by Remote sensing offers opportunities for innovation & growth.
- Other (please specify) …………………………………………………………………………… ………………………………………………………………………….

15. What are the main barriers to a stronger Remote Sensing approach in Egypt?

- Future commitment of resources to Remote Sensing in a context of high pressure on public budgets.
- Remote sensing added value & impact not demonstrated enough.
- Lack of an overall framework for engaging the private sector in supporting &/or exploiting the Remote Sensing information system
- Remote sensing synergies with some governmental programmers, Ministries & initiatives not sufficiently well developed.
- Uncertainty about the extent to which Remote Sensing will be implemented.
- Availability of relevant EO data
- Access to EO data Storage and processing of EO data
- EO data integration with statistical data
- Data quality assessment
- Data continuity or temporal coverage of data
- Data cost
- Lack of facility/human capacity to use EO data.
- Compatibility with the current reporting method
- Reluctance to change current workflows and data flows.
- Institutional coordination and bureaucracy
- Lack of understanding of values EO data provide.
- Others

16. What technical obstacles have you encountered in implementing remote sensing technologies in the water sector?

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17. How can technical challenges be addressed to ensure seamless implementation?

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18. How do financial limitations impact the adoption and implementation of remote sensing policies?

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19. In what ways do capacity and skill gaps among policymakers hinder effective utilization of remote sensing tools?

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20. **How important are the following to create and improve the accessibility and quality of remote sensing data and implementation of Remote sensing policy in water sector of Egypt?** Please rate the following measures as high, medium, or low priority

- Demonstrating / promoting new businesses opportunities based on mobile RS-based applications for local needs by non-expert users.
- Setting up public-private partnerships (PPPs) for Earth observation to facilitate RS engagement & take-up by the Egyptian EO service industry.
- Increasing awareness of Remote sensing in 'local' Egyptian companies, especially small & medium-sized firms & start-ups involving young entrepreneurs that could potentially benefit from it.
- capacity-building initiatives be strengthened.
- collaboration with remote sensing technology providers be enhanced to overcome implementation challenges.
- Public-private partnerships contribute to addressing obstacles in remote sensing policy implementation.
- to empower policymakers in utilizing remote sensing effectively.
- Other additional recommendations do you have for overcoming barriers and ensuring successful policy implementation in remote sensing for the water sector.

21. Is cooperation at African level essential for easy access to Earth observation systems & open data?

- Yes, I entirely agree.
- Yes, I agree to some extent.
- No, I disagree to some extent.
- No, I entirely disagree.
- I don't know.

22. Do you have any other comments/lessons learned regarding the use of EO data for irrigation?

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