Job 25-06171 (information submitted by Morocco for the midterm review of the "Space2030" Agenda – fair copy)

Translated from French

Royal Centre for Remote Sensing

Midterm review of the "Space2030" Agenda

Report of CRTS

I. CRTS projects on the use of Earth observation technology to support the Sustainable Development Goals

Earth observation for monitoring drought in Morocco

Overarching objective: 1 and 2	Actions: 1.2 and 1.7 Actions: 2.3, 2.4 and 2.5
Country/Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	• Ministry of Agriculture • Ministry of Infrastructure and Water • Universities
Short project summary and goals	In Morocco, drought has become a feature of the climate, and has disastrous consequences for the national economy given that the contribution of agricultural GDP to the country's overall gross domestic product is closely linked to the amount of annual precipitation. The spatio-temporal variability of drought in Morocco complicates drought risk management. The use of Earth observation-based indices and indicators has become an essential tool for drought monitoring. At CRTS, remote sensing technologies are used to monitor drought during agricultural seasons, on the basis of indicators calculated using satellite data. The methodology consists in the production of a composite index combining four parameters extracted from satellite data. Those parameters are: the standardized precipitation index, calculated using satellite data (CHIRPS); anomalies in the difference between day and night land surface temperatures; evapotranspiration anomalies; and anomalies in the normalized difference vegetation index (using MODIS and VIIRS data). Since 2003, composite drought index (CDI) maps have been generated monthly at the national scale during growing seasons.
Relevant SDGs	SDG 1, SDG 2, SDG 6 and SDG 15
Space/satellite solution:	The input data used for drought monitoring are derived mainly from space-based observations. Surface temperatures and the vegetation index are obtained from the MODIS and VIIRS satellites. The evapotranspiration parameter is also calculated using surface energy balance models incorporating satellite data. CHIRPS data combine real-time meteorological data with infrared data to estimate precipitation at the global level. The role of space in this project is to facilitate periodic access to Earth observation data in order to monitor exposure to drought risk and assess vulnerability to drought.
Project impact	• CDI maps with a spatial resolution of 0.05° have been generated monthly at the national scale since 2003. The maps, which are gridded,

	show areas with different drought intensity levels (moderate, severe, extreme and exceptional). They will help decision makers to identify areas where priorities need to be set in terms of water and/or food distribution. • Bulletins are published monthly and distributed to end users during agricultural seasons with the aim of linking drought information to the monitoring and management of agricultural land. • A global map of structural vulnerability to drought has been generated on the basis of historical CDI data, soil types, land use types and a multidimensional poverty index. The map shows drought zone frequency.
Reference	N. Bijaber, A. Rochdi, M. Yessef and H. El Yacoubi (2024), *Cartographie de la vulnérabilité structurelle à la sécheresse au Maroc* ("Mapping structural vulnerability to drought in Morocco"), International Journal of Engineering and Geosciences, 9 (2), 264–280. N. Bijaber, D. El Hadani, M. Saidi, M.D. Svoboda, B.D. Wardlow, C.R. Hain, C.C. Poulsen, M. Yessef and A. Rochdi, 2018, *Développement d'un indicateur de surveillance de la sécheresse par télédétection pour le Maroc* ("Developing a remotely sensed drought monitoring indicator for Morocco"), Geosciences 2018, 8, 55.

Earth observation for water resources assessment in Morocco

Overarching objective: 1 and 2	Actions: 1.2 and 1.7 Action: 2.2
Country/Observer Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	Ministry of Infrastructure and Water
Short project summary and goals	This project involves estimating groundwater abstractions for irrigation during periods of drought. The methodology is based on the use of very high resolution satellite images combined with in situ data to identify the main land use types for which irrigation was used during the summer of 2024, namely continuously irrigated crops, fruit trees and all types of greenhouse crops. The map generated for the areas under study will be supplemented by field data (crop types and amount of water consumed by each type) in order to estimate the overall amount of water used for irrigation during the study period. Since no surface water was available for irrigation in any part of the country in the summer of 2024 (owing to drought), all cultivated areas were irrigated using groundwater. Thus, the study provides information on the overall rate of groundwater use for irrigation.
Relevant SDGs	SDG 1, SDG 2, SDG 6 and SDG 15

Space/satellite solution:	The most important information for this project is generated from satellite images. Therefore, unlike traditional methods used to manage and monitor water resources, new methods and technologies based on space data are now essential for capturing data in real time and reducing human bias, particularly in remote or inaccessible areas. The first part of the project involves the application of machine learning to ESA Sentinel-2 data in order to rapidly generate maps of irrigated areas (crops, fruit trees and greenhouses). Detail is then added to the maps using very high resolution data from Moroccan satellite Mohammed-6. The maps obtained will be complemented by reference data in order to estimate the total quantity of groundwater resources abstracted.
Project impact	• The project will demonstrate the importance of using space technology to assess water "supply" and "demand" in space and time. • Enabling the Government of Morocco (Ministry of Infrastructure and Water) to detect the main areas and land use types that consume the most water during periods of drought. • Satellite data integrated with geospatial tools and in situ data enable more efficient and more precise management of water resources at every level of the watershed.

Earth observation for urban planning and land-use management in Morocco

Overarching objective: 1 and 2	Actions: 3.1 and 3.2
Country/Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	• Ministry for Land-Use Management, Housing and Urban Policy • Ministry of the Interior • Regional councils and regional project implementation agencies • Urban agencies and local authorities • Engineering and consulting firms
Short project summary and goals	High-resolution satellite imagery plays an essential role in monitoring urban growth in developing countries, where traditional data collection methods are often unable to keep pace with rapid urbanization. These projects provide detailed information on the evolution of land use and infrastructure development, enabling end users and partners to map urban expansion and identify areas at risk of uncontrolled growth. The main objective is to provide up-to-date images and maps of the target areas. Each partner defines its own requirements in terms of the area to be covered, the mapping scale and the precision needed. A feasibility study is then carried out and a contractual framework is put in place to bring the project to fruition. In addition to cartographic deliverables, the CRTS project team provides support and transfers expertise through capacity-building for partners.
Relevant SDGs	SDG 11.3: Inclusive and sustainable urbanization

Space/satellite solution:	High-resolution satellite imagery significantly improves the accuracy of monitoring of urban growth by providing detailed, spatially comprehensive data on land-use changes and urban expansion. Such imagery enables accurate mapping of built-up areas, infrastructure and environmental impacts at a precise level of detail, sometimes at a resolution of 50 cm or 30 cm, thus making it possible to detect even small-scale developments.
Project impact	• The creation of data sets and maps in the long term makes it possible to identify trends in urban sprawl and assess progress made towards sustainable development goals such as poverty reduction and equitable access to infrastructure. • Satellite data are strategic tools for appropriate land management, as they make it possible to gain a clear understanding of available resources in terms of distribution, evolution and dynamics, and of the interaction between the various stakeholders, options and conflicting uses. • Satellite data contribute to efficient resource management and ensure sustainable urban growth while minimizing environmental degradation.
Reference	www.crts.gov.ma

Earth observation for coastal management in Morocco

Overarching objective: 1 and 2	Actions 1.1 and 1.2 Actions 2.2 and 2.7
Country/Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	Ministry of Infrastructure and Water Directorate of Ports and Public Maritime Areas
Short project summary and goals	The aim of the project is to achieve remote sensing coverage of the national coastline with recent, very high resolution images over a 5 km-wide area, and to produce a coastal map of that area with a maximum buffer zone of 1 km from the coastline. The area to be covered extends over 3,500 km of Atlantic and Mediterranean coastline. Specific objectives: Over a five-year period, the project will provide regional authorities with satellite images and thematic maps based on a specific nomenclature in order to map the coastline in general and monitor certain key areas in particular (such as sand quarries, public maritime areas and coastal infrastructure).
Relevant SDGs	SDG 11 and SDG 15
Space/satellite solution:	Detailed coastal mapping of all coastal structures (covering sandy areas, rocky areas, coastal infrastructure and coastal geomorphology) has been carried out along the entire national coastline, using a nomenclature agreed with the Department of Infrastructure. Coastline position markers have also been mapped. This updated information has been produced with the help of the Mohammed IV A and B satellites.

	The geospatial data generated by CRTS are available in regional infrastructure directorates and currently integrated into the Geo Web platforms of the Ministry of Infrastructure.
Project impact	• Crucial information on coastal monitoring provided by very high resolution satellite images in a timely manner • Thematic maps of the coast made available to local authorities • Monitoring of coastal hotspots • Training of relevant bodies in the use of satellite images • Improved knowledge of coastal vulnerability • Creation of databases for coastal data
Reference	www.crts.gov.ma

Earth observation for risk management in Morocco

Overarching objective: 2 and 3	Actions 2.2, 2.5 and 2.8 Actions 3.4, 3.6 and 3.8
Country/Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	Ministry of the Interior of Morocco Directorate for Natural Hazard Management of Morocco Solidarity Fund for Catastrophic Events (FSEC)
Short project summary and goals	This project involves the use of space technologies for natural disaster preparedness and response. Specific objectives: (1) Using satellite products, establish and train joint technical teams responsible for the rapid preparation of cartographic products in order to help respond to natural disasters and address all risk-related aspects, such as vulnerability maps and risk modelling; (2) Use the International Charter on Space and Major Disasters through cooperation with UN-SPIDER and other international organizations; (3) Work with the bodies concerned to create space platforms specific to each type of hazard, particularly floods, earthquakes, landslides and tsunamis.
Relevant SDGs	SDG 3, SDG 6, SDG 11, SDG 13, SDG 15 and SDG 17
Space/satellite solution:	Haouz earthquake (September 2023): CRTS monitored affected areas using several types of satellite, including the Mohammed IV A and B satellites. The products generated, which highlighted the buildings affected and the extent of destruction, were made available to the departments involved in the operation and to FSEC. Floods: For several years, CRTS has been monitoring various floods (in Gharb, Mohammedia, Tata and Tétouan) by satellite, providing the departments concerned with maps of the affected areas and conducting spatio-temporal monitoring of those areas. In the case of the Tata floods (September 2024), the International Charter on Space and Major Disasters was activated by CRTS with the support of UN-SPIDER. That action made it possible for some dozen international space agencies to pool their satellite images of the affected areas. CRTS

	also participated in that process through its contribution to the preparation of value-added products (Value Adder) (such as maps of affected areas and change detection maps).
Project impact	• Improvement of knowledge about the risk cycle through the use of space observation • Development of databases containing geospatial data on risk areas • Pooling of knowledge for effective crisis management • Facilitation of the exchange of knowledge, especially space information for crisis management • Improvement of crisis management processes in the event of a disaster • Development of geospatial platforms according to hazard type
Reference	www.crts.gov.ma https://cgt.disasterscharter.org/en/913

Earth observation for agriculture and water in Morocco: the IRRISAT project

Overarching objective: 1 and 2	Actions 1.1 and 1.2 Action 2.2
Country/Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	Water basin agencies, Ministry of Infrastructure and Water Regional offices for agricultural development, Ministry of Agriculture Farmers
Short project summary and goals	The IRRISAT-Morocco project has made it possible to operationalize the production of information and indicators on irrigation water at plot, watershed and irrigated perimeter levels through the IRRISAT interface. IRRISAT uses the SEBAL model to estimate evapotranspiration (actual, potential and reference), biomass and soil moisture, and to produce indicators of irrigation water consumption, requirements and productivity. An online platform has been developed to make that information available to regional directorates responsible for agricultural development, farmers in the region and water basin agencies. Specific objectives: The IRRISAT platform has been used to generate maps of actual evapotranspiration, biomass and soil moisture: • On a daily basis in the watershed (on the basis of VIRRS data) • On a weekly basis along the irrigated perimeter (using Landsat data) during the agricultural season In order to produce indicators with good spatial resolution on a daily basis, research has been carried out with a view to enhancing the resolution of the thermal channel of the VIIRS sensor from 375 m to 30 m/20 m using Landsat/Sentinel-2 sensors. As part of that research, machine learning and deep learning algorithms have been tested in order to link the VIIRS thermal channel to Landsat and Sentinel-2 reflectance.
Relevant SDGs	SDG 1, SDG 2 and SDG 6
Space/satellite solution:	Satellite data: • VIIRS, 375 m resolution

	• Landsat, 30 m resolution • Sentinel-2, 10 m resolution • Mohammed VI A and B, ~ 0.5 m resolution
Project impact	• More effective management and rationalization of the use of surface water and groundwater • Reduced demand for water for irrigation • Farmers can maximize the benefits of water resources and contribute to the overall resilience of agricultural systems • Farmers benefit from more efficient water use and higher crop yields
Reference	www.crts.gov.ma

Assessment of tsunami risk along the Moroccan coast

Overarching objective: 1 and 3	Action 1.6 Actions 2.2, 2.3 and 2.5
Country/Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	• Ministry of the Interior of Morocco, Directorate for Natural Hazard Management (DGRN) • Solidarity Fund for Catastrophic Events (FSEC)
Short project summary and goals	This project involves establishing a simple, transferable methodology for assessing tsunami risk along the Moroccan coast and producing maps illustrating tsunami risks, the vulnerability of buildings and potential damage to buildings. Main objectives: • Development of a robust tsunami risk assessment that can be applied to any coastal zone in the country • Production of maps illustrating tsunami risks, the vulnerability of buildings and potential damage to buildings • Creation of a tsunami risk atlas covering most of the Moroccan coastal areas at risk from tsunamis.
Relevant SDGs	SDG 1.1. Make cities and human settlements inclusive, safe, resilient and sustainable SDG 1.2. Take urgent action to combat climate change and its impacts
Space/satellite solution:	The assessment of tsunami risk on the Moroccan coast is based on a combination of modelling data, in situ data and satellite observations. Various data used as input for tsunami risk modelling, such as the digital elevation model and coastline maps, are extracted from high-resolution images. The very high resolution satellite imagery is used extensively to define the vulnerability level of buildings located in coastal areas that could be inundated by tsunami waves.
Project impact	• Improved knowledge about the threat posed by tsunamis and identification of coastal areas at risk • Tsunami risk taken into account in the national strategy for natural hazard management • Production of valuable information for use in the future tsunami warning system

Reference	• A. Atillah, D. El Hadani, H. Moudni, O. Lesne, C. Renou, A. Mangin and F. Rouffi, 2011, *Tsunami vulnerability and damage assessment in the coastal area of Rabat and Salé, Morocco*, Natural Hazards and Earth System Sciences, 11, 3397–3414. • C. Renou, O. Lesne, A. Mangin, F. Rouffi, A. Atillah, D. El Hadani and H. Moudni (2011), *Tsunami hazard assessment in the coastal area of Rabat and Salé, Morocco*, Natural Hazards and Earth System Sciences, 11, 2181–2191, 2011 11

Use of thermal satellite data to generate upwelling indices for the Atlantic coast of Morocco

Overarching objective: 1 and 2	Actions: 1.2, 1.6 and 1.7 Action: 2.2
Country/Organization	Morocco/Royal Centre for Remote Sensing (CRTS)
Project partners	National Institute for Fisheries Research (INRH), Ministry of Fisheries
Short project summary and goals	The aim of this project was to develop an application for creating an upwelling index for the Moroccan coast on the basis of thermal satellite images. Main objectives of the project: • To identify cold water upwelling areas along the Moroccan coast • To monitoring upwelling variability in time and space • To understand the impact of fluctuations in upwelling on variation in fish stocks, for improved and more efficient management of fishing effort
Relevant SDGs	SDG 1 and SDG 2
Space/satellite solution:	The proposed solution is an operational tool for producing upwelling indices by means of thermal satellite imagery, enabling the National Institute for Fisheries Research to understand the influence of that phenomenon on fluctuations in stocks of marine resources, mainly pelagic fish. The Moroccan Atlantic upwelling system is one of the most productive coastal systems in the world, characterized by high temporal and spatial variability. The proposed satellite data-based solution for generating upwelling indices makes it possible to acquire up-to-date information on the situation with regard to this phenomenon (spatio-temporal variation) and its potential impact on the abundance and distribution of fish stocks.
Project impact	• The results of this project in terms of the application of upwelling indices provide a simple means of obtaining, in real time, valuable information that could be used in the development of fisheries management measures. • The monitoring of these natural phenomena will help fisheries managers to detect and predict abrupt changes that have a direct impact on fish catches. • The production of a long series of upwelling indices will improve understanding of the relationship between variation in marine resources and fluctuations in the upwelling phenomenon, and of the impact of climate change on that phenomenon.