Sentinel Vision
EVT-1071
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2D Layerstack

The Great Green Wall against desertification built by Africa, an example in Senegal

Sentinel-2 MSI acquired on **23 April 2016** at 11:33:22 UTC
Sentinel-2 MSI acquired on **27 September 2016** at 11:21:12 UTC
Sentinel-3 OLCI FR acquired on **19 March 2018** at 10:48:03 UTC
Sentinel-2 MSI acquired on **24 September 2021** at 11:33:21 UTC
Sentinel-2 MSI acquired on **24 April 2022** at 11:21:09 UTC

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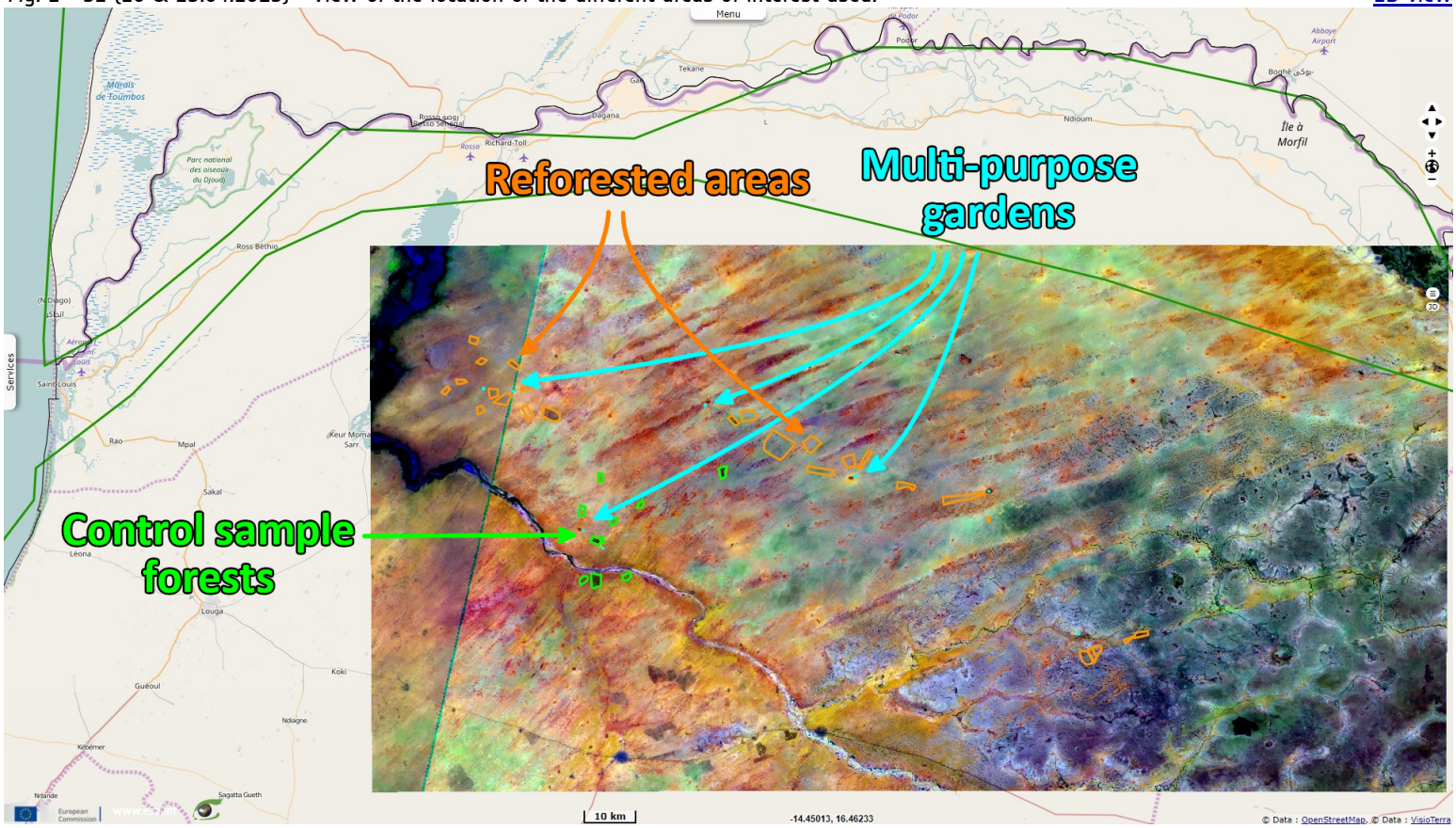
Fig. 1 - S3 OLCI (19.03.2018) - The area where the impact of reforestation has been studied lies at the western end of the Great Green Wall, in northern Senegal.

2D view

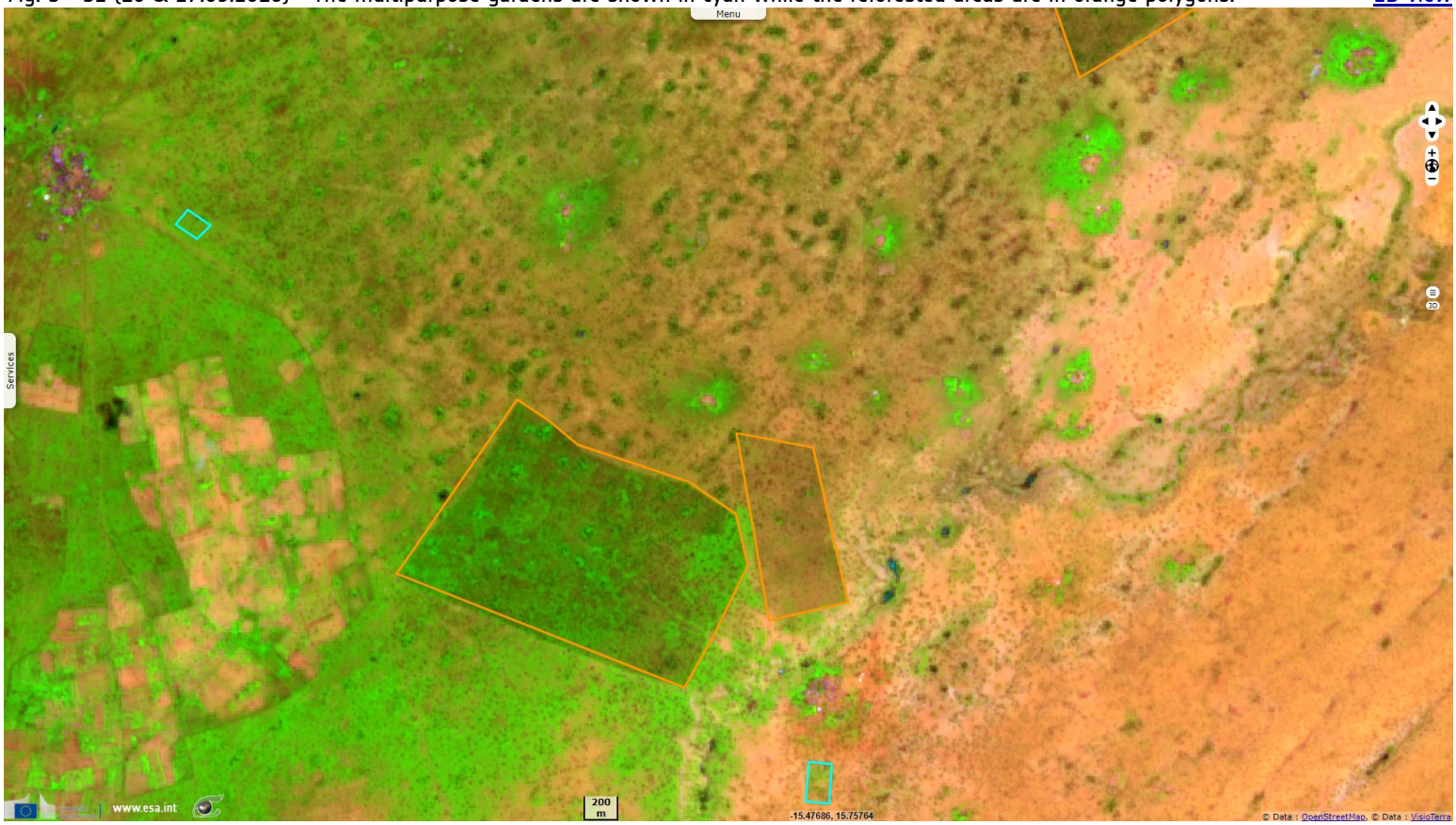
The African Union is "*leading the implementing of initiatives that will build the resilience of communities and ecosystems in the dry lands of Africa by combating land degradation, desertification, loss of bio-diversity and climate change through the promotion of Sustainable Land Management and Restoration. Under our Great Green Wall (GGW) initiative the AU is implementing actions to end or reverse land degradation, loss of biodiversity in African drylands and to ensure that ecosystems are resilient to climate change, continue to provide essential services and contribute to human well-being and the elimination of poverty and hunger. The GGW Initiative aims to support over 425 million Africans living in the drylands to embrace sustainable development practices that protect the environment and fight against hunger and poverty.*", wrote the African Union.

Fig. 2 - S2 (20 & 23.04.2015) - View of the location of the different areas of interest used. 2D view



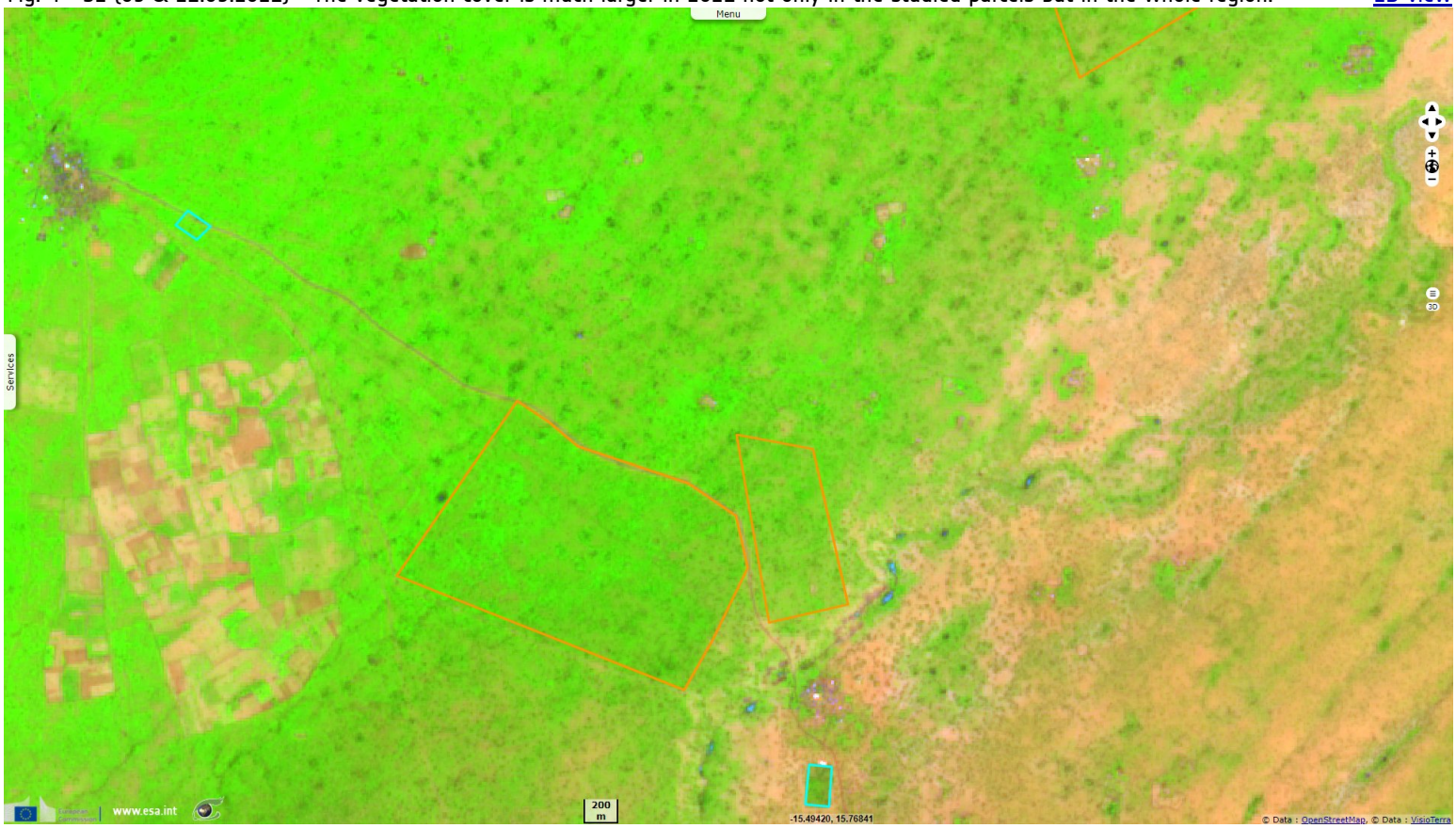
The website dedicated to this project completes: "*Desertification, climate change and land degradation have a strong impact on the main levers of economic growth, social cohesion, stability and security of Sahelo-Saharan States. The recurrence and resurgence of impacts despite various control action plans reminded us of the urgency of a regional approach based on a common commitment and concerted action. The Heads of State and Government of Burkina Faso, Djibouti, Eritrea, Ethiopia, Mali, Mauritania, Niger, Nigeria, Senegal, Sudan and Chad, referring to the decision of the 7th CEN-SAD Summit of June 1 and 2 2005 in Ouagadougou (Burkina Faso) set up the Great Green Wall Initiative (IGGW), endorsed in 2007 by the African Union as the Great Green Wall Initiative for the Sahara and the Sahel.*"

Fig. 3 - S2 (10 & 27.09.2016) - The multipurpose gardens are shown in cyan while the reforested areas are in orange polygons. 2D view



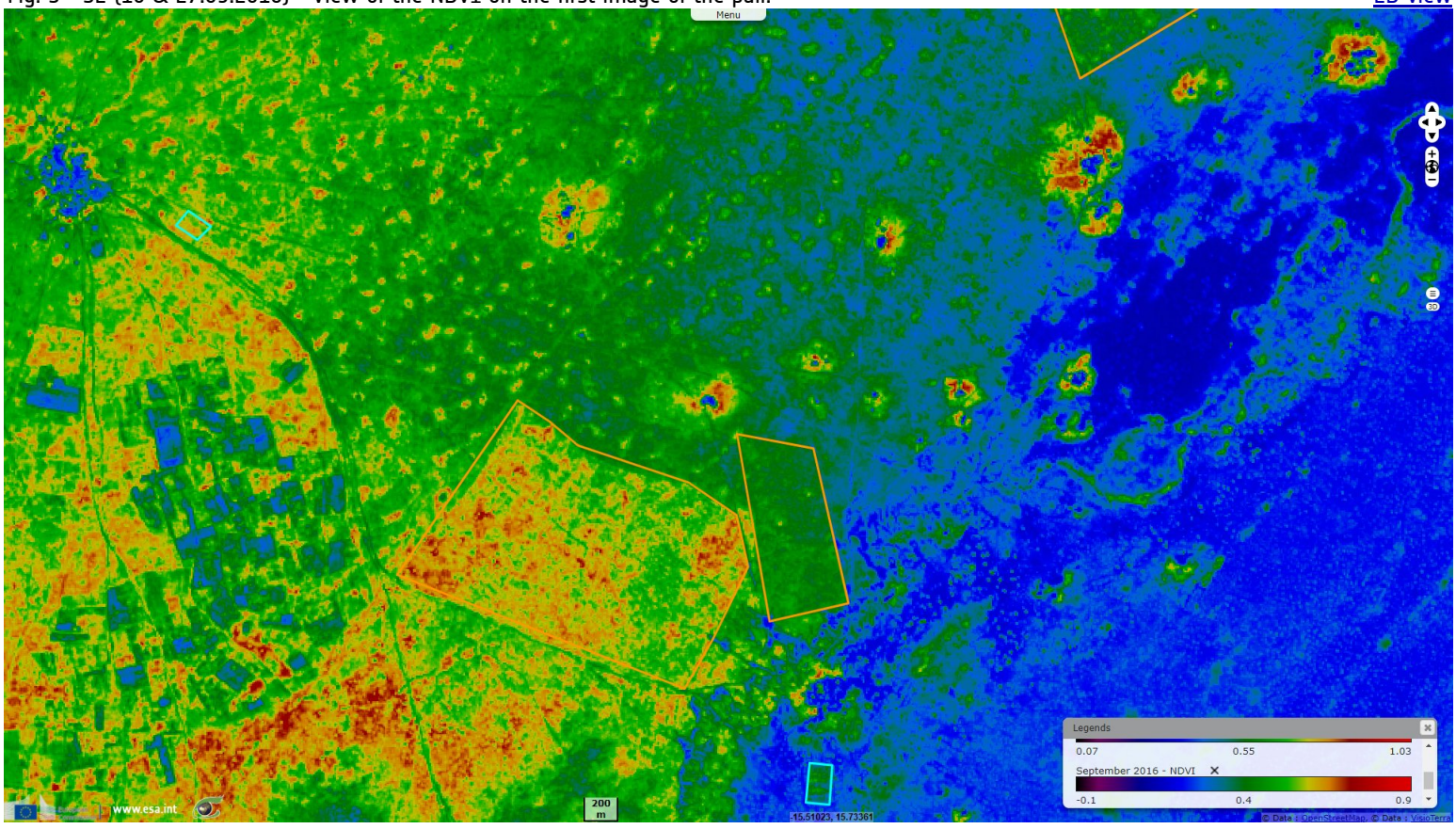
"*In order to provide the Initiative with mechanisms for coordinating, harmonizing actions and supporting the mobilization of resources, the Pan-African Agency for the Great Green Wall (APGMV) was created on June 17, 2010 in N'Djamena, Chad, under the auspices of the African Union and CEN-SAD. The PAGGW is an interstate organization with international legal capacity.*"

Fig. 4 - S2 (09 & 21.09.2021) - The vegetation cover is much larger in 2021 not only in the studied parcels but in the whole region. 2D view



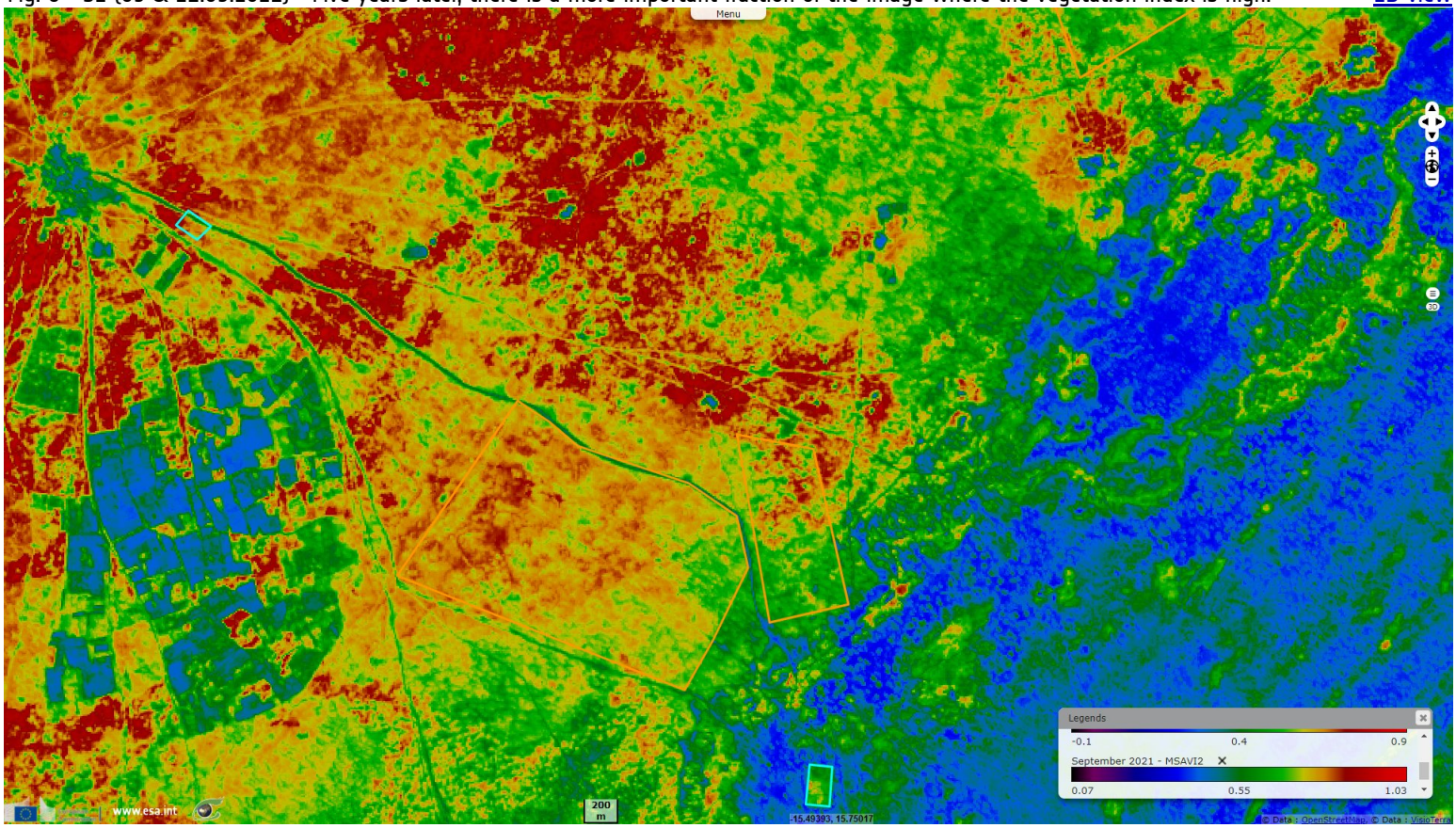
"*The mitigative GGW is the expression of cooperation between States in the fight against environmental and climatic challenges based on the "GMV Concept". The concept, in its vision and its objectives integrates the three (03) Rio Conventions and is part of the logic of national and sub-regional policies of Restoration-Conservation-Protection of Natural Capital (RCPCN), and Local Economic Development of lands. It globally targets the Saharo-Sahelian zone of the Circum-Sahara, between isohyets 100 and 400 mm.*"

Fig. 5 - S2 (10 & 27.09.2016) - View of the NDVI on the first image of the pair. 2D view



"*The overall objective of Land Management is to stabilize and then reverse the current process of land degradation with a view to achieving Land Degradation Neutrality. Sensitization and supervision of populations to the best techniques and practices for the sustainable management of natural resources and land and rural production systems most suited to the land are given priority. This is essentially based on the Operational Information and Communication System (DOIC), the creation and monitoring of experimental perimeters at the CADT level.*"

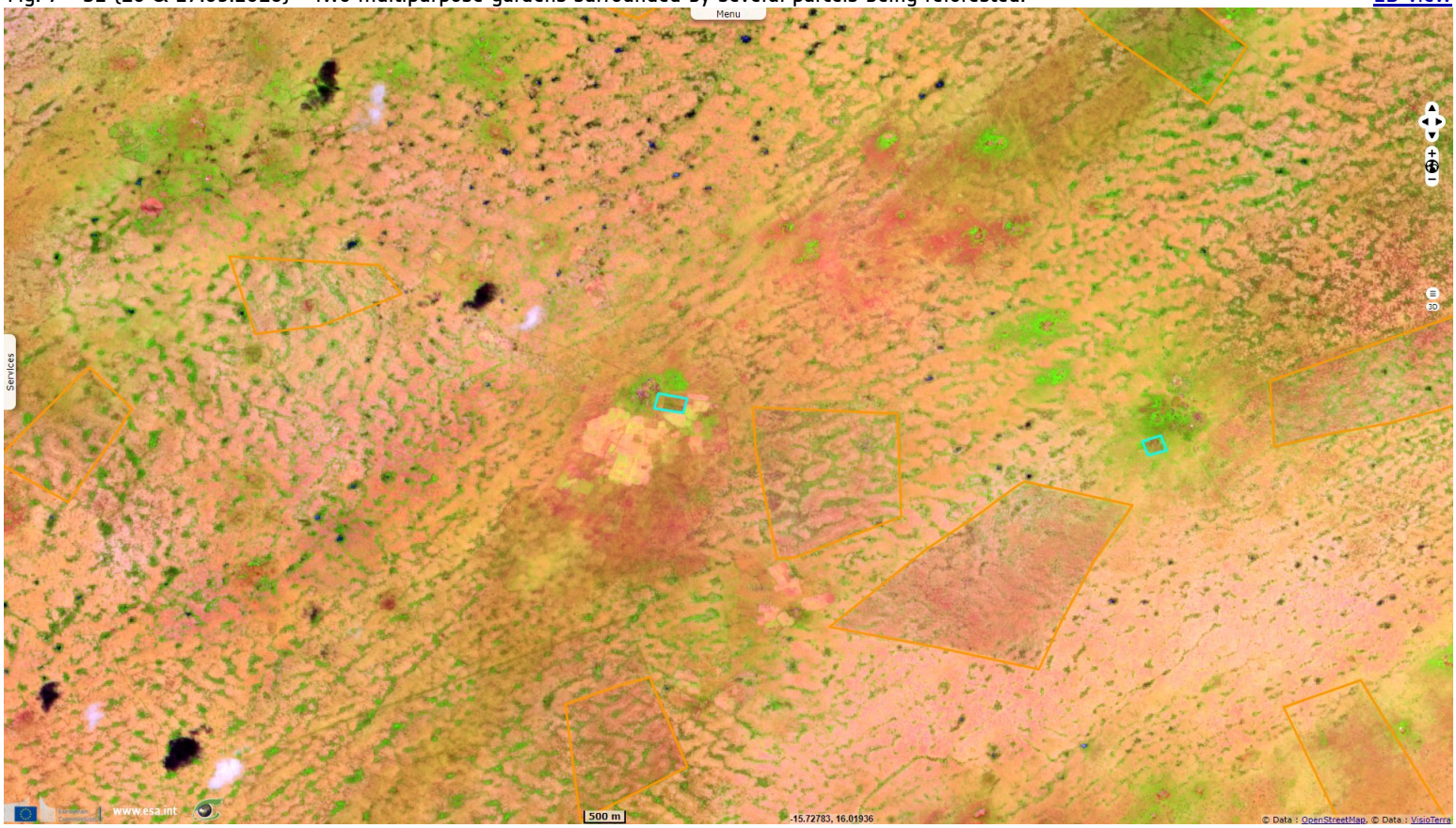
Fig. 6 - S2 (09 & 21.09.2021) - Five years later, there is a more important fraction of the image where the vegetation index is high. 2D view



"*The Logical Framework of Intervention provides for a framework of coherence, a model of local governance and a framework of orientations and Monitoring-Evaluation of itineraries and impacts through a multi-modular system including a Geographic Information System, a Climate Observatory /LED and an Early Warning and Response System.*"

"*The financing of the Five-Year Plan of Activities (PAQ) 2016-2020 estimated at approximately three (03) billion US dollars is the subject of a specific GGW financial intervention plan, accompanied by a mobilization strategy through mechanisms and innovative instruments focused on climate finance. It is a GGW Carbon Bank, a GGW Fund for Climate Adaptation and Resilience and Local Development, accreditation for Climate Funds and admission to an Executing Agency for implementation activities. implementation of the GGW. In support of these mechanisms and instruments, a round table of technical and financial partners is planned.*"

Fig. 7 - S2 (10 & 27.09.2016) - Two multipurpose gardens surrounded by several parcels being reforested. 2D view

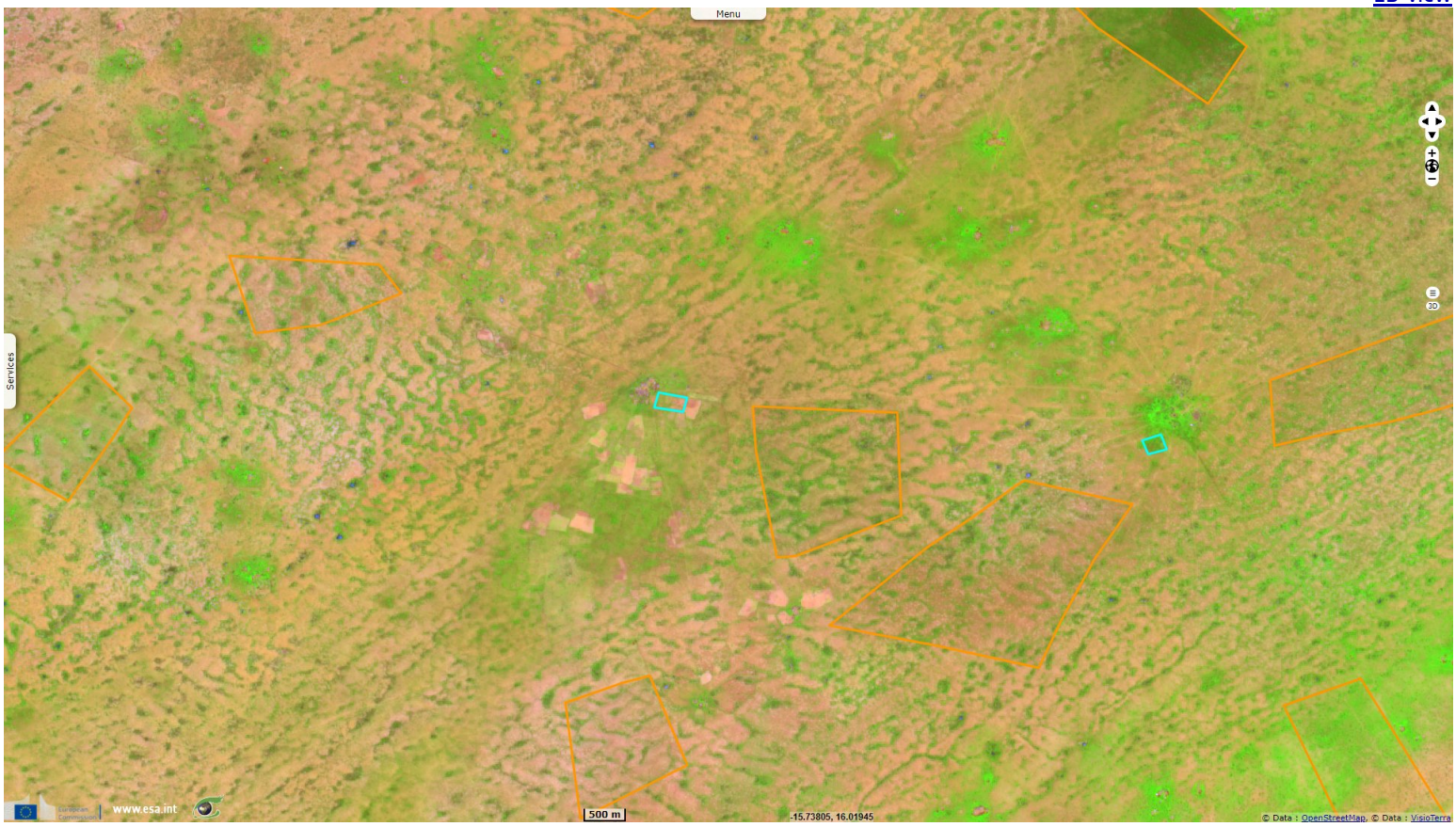


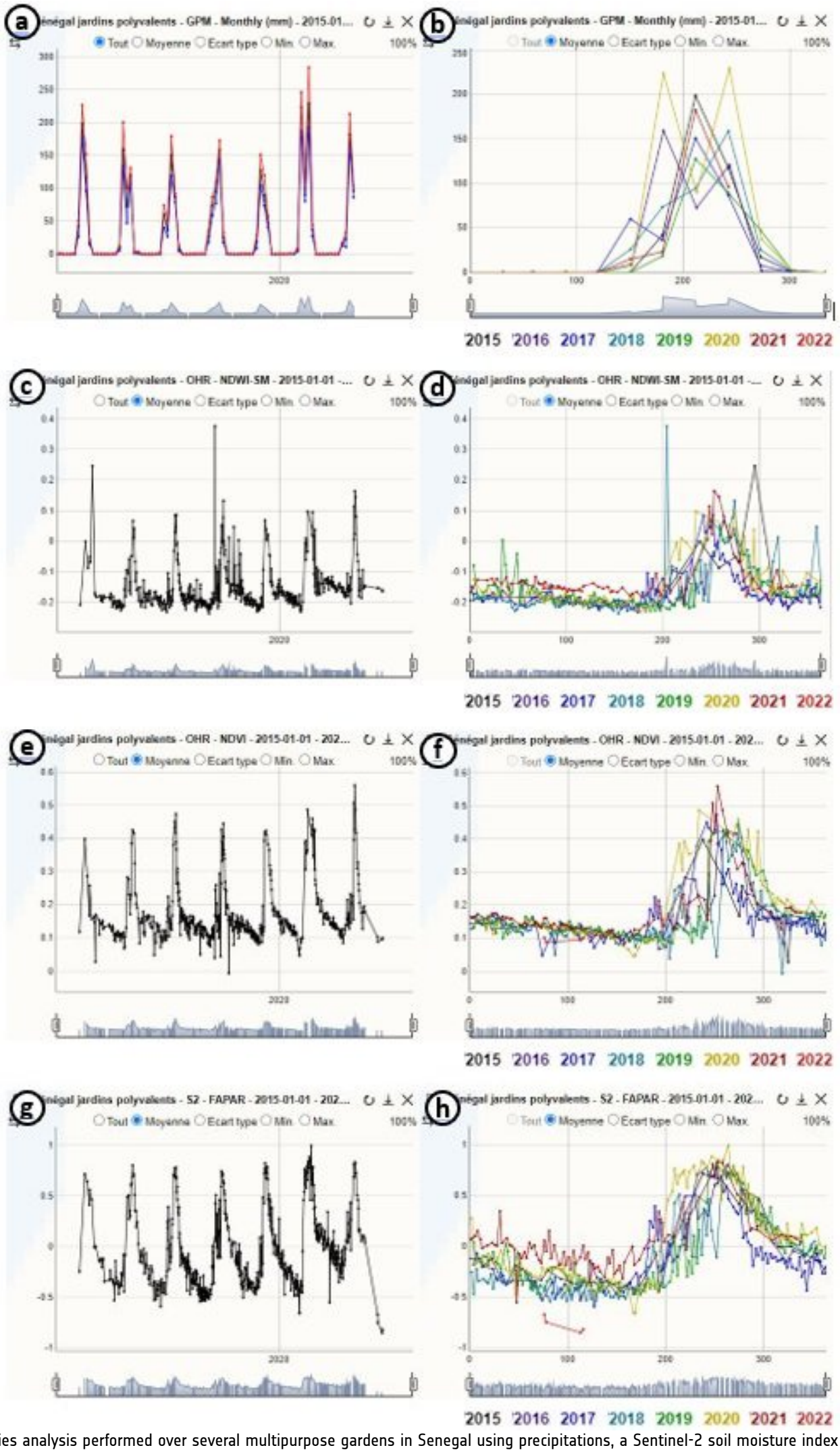
As a pioneer country in the implementation of the Great Green Wall, Senegal plants nearly 2 million Senegal Acacia trees every year, especially in the north of the country. This tree species is particularly well adapted to the arid climate. And some positive results are already beginning to be seen, particularly in terms of fauna, with some extinct birds reappearing.

Multipurpose gardens are much smaller entities than reforestation plots. They are often located near towns or villages. These multi-purpose gardens are rendered at a larger scale (100 m scale), whereas the reforestation plots in the previous figures were rendered at a smaller scale (200 m scale). These gardens produce previously unknown fruits and vegetables, not all of which require watering. This is a new source of income for local people, for whom water scarcity is a major problem.

Fig. 8 - S2 (09 & 21.09.2021) - The second, greener, image of the pair shows not only the gardens and reforested areas benefited the increase in vegetation cover.

2D view





Time series analysis performed over several multipurpose gardens in Senegal using precipitations, a Sentinel-2 soil moisture index and two Sentinel-2 vegetation indices.

- a: GPM monthly precipitations time series calculated over the parcels from 2015 to 2022, chronological view.
- b: GPM monthly precipitations time series calculated over the parcels from 2015 to 2022, seasonal view.
- c: Normalized Difference Water Index - Soil moisture (NDWI-SM) time series calculated over the parcels from 2015 to 2022, chronological view.
- d: NDWI-SM time series calculated over the parcels from 2015 to 2022, seasonal view.
- e: Normalized Difference Vegetation Index (NDVI) time series calculated over the parcels from 2015 to 2022, chronological view.
- f: NDVI time series calculated over the parcels from 2015 to 2022, seasonal view.
- g: Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) time series calculated over the parcels from 2015 to 2022, chronological view.
- h: FAPAR time series calculated over the parcels from 2015 to 2022, seasonal view.

For the monthly total precipitation data, if a pixel of the data intersects at least one area of interests (AOI), its value is used to compute to mean shown in the graphs. The other indices are based on Sentinel-2 data. The index is computed for each pixel of each AOI (several hectares to several square kilometres) and the mean of all these values added to the graphs.

Figures a and b show most precipitations in this area of northern Senegal are received between June and September. Measured rainfalls decreased from 2015 (225 mm peak) to 2019 (150 mm peak) then increased again (275 & 200 mm peak in 2020 & 2021). There is usually one large peak in August but it was delayed to September in 2018. There were two peaks in July and September in 2016 and 2020, both very high in the latter, and a sharp decrease in August in both cases. The precipitation data has a coarse resolution compared to the size of the areas of interests (AOIs) and the AOIs of each class are relatively close to each other, this implies the monthly precipitations time series is very similar in each class.

Regarding soil moisture in the multipurpose gardens (Figures c and d), the index is maximum during the rainy season reaching values usually between 0.1 and 0.2. Then then slowly but steadily decreases during the wet season down to -0.2. 2020 had generally high values during the wet season which was generous in rainfall as seen above. 2021 had relatively higher values all year-round while 2015 and 2016 seemed to be the years withing which the soil of these gardens was the driest.

The NDVI behaviour (figures e and f) is quite similar with that of the soil moisture index: it usually peaks 0.4 and 0.5 during August then drops slowly to 0.1 at the end of May. 2021 reached a higher maximum but during a short amount of time while the NDVI measured in gardens in 2020 was generally the highest during the rain season. 2015 and 2016 seem to be the years during which this index was the lowest.

The FAPAR values (figures g and h) usually vary between 0.7 and 0.8 in August and decrease between -0.4 and -0.5 at the end of the dry season. The values found in the multipurpose gardens were usually high during 2021 but topped by 2020 during the rainy season. Again, the lower FAPAR values are found during from 2015 to 2017.

Fig. 9 - S2 (10 & 27.09.2016) - A multipurpose garden and a cluster of reforested parcels near the city of Téssékéré. 2D view

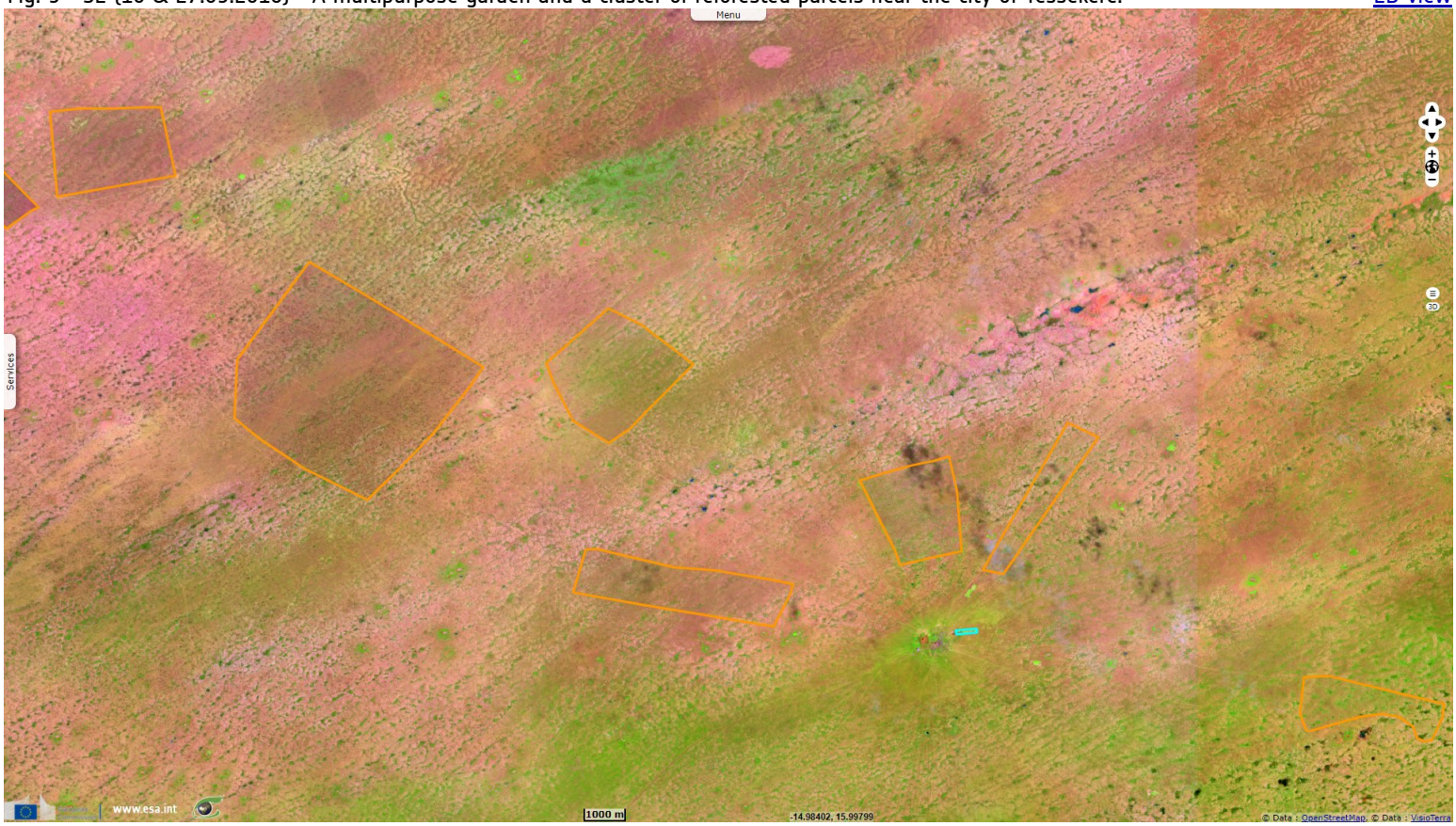
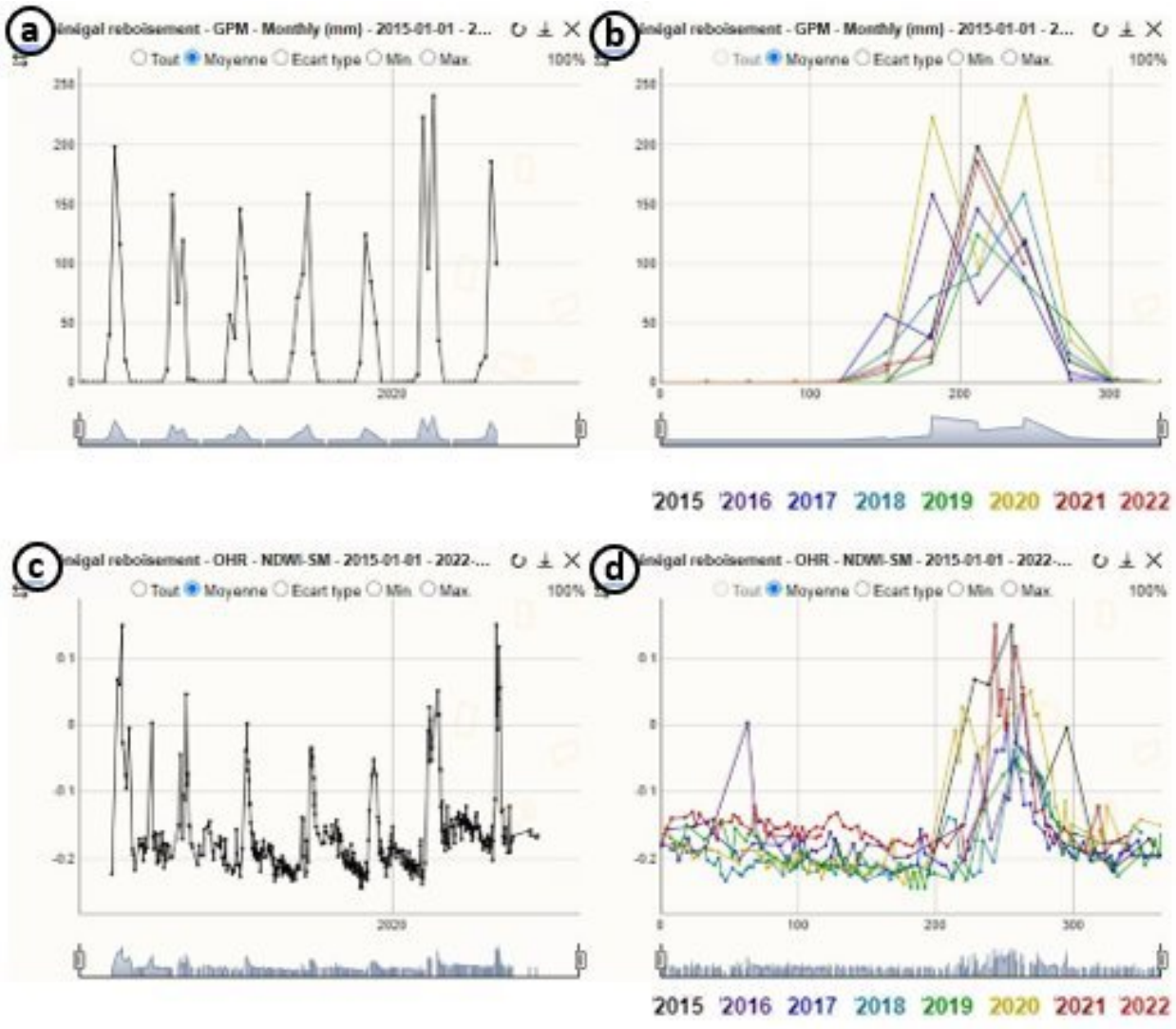
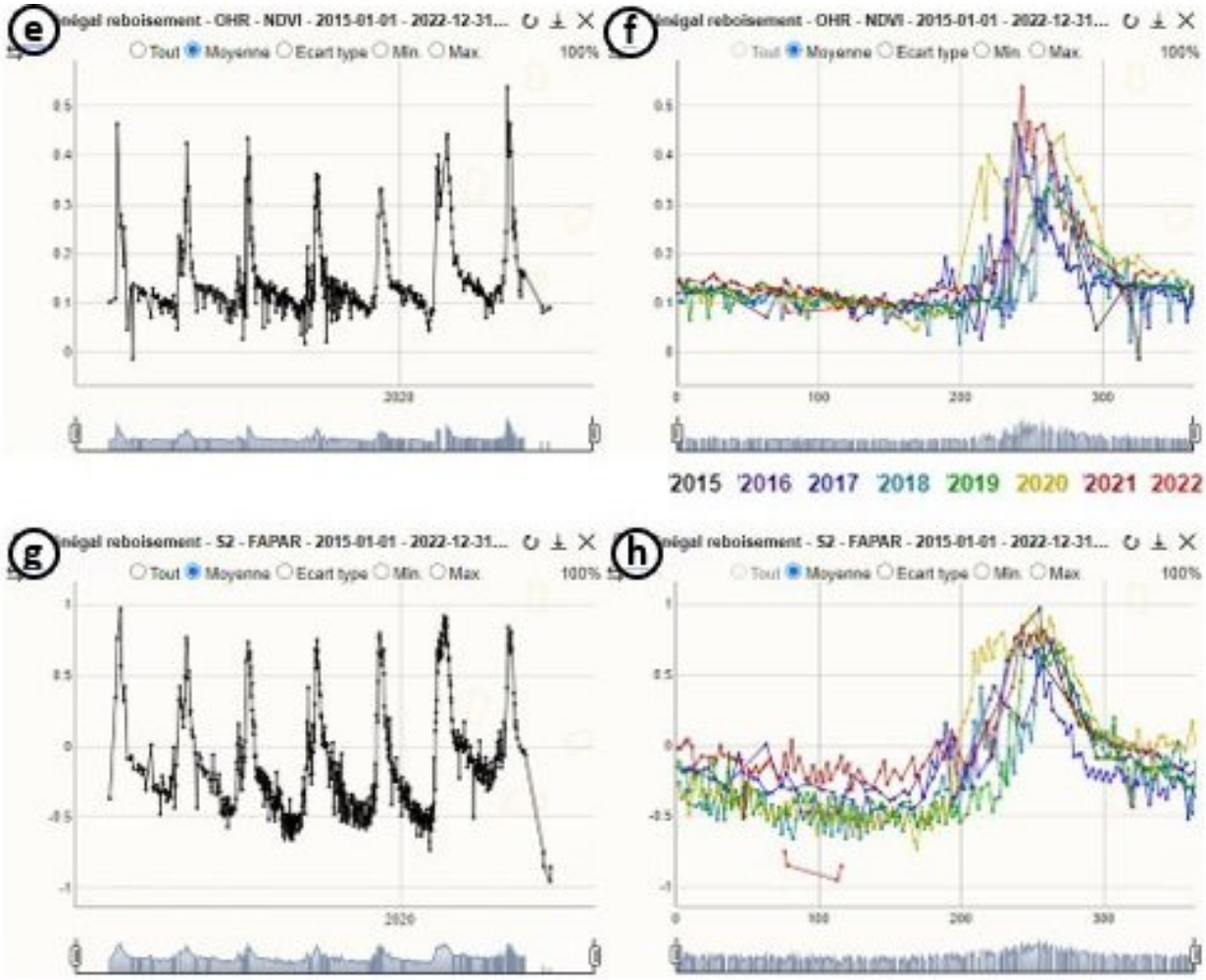


Fig. 10 - S2 (09 & 21.09.2021) - Same location five years later, the area is almost entirely covered by vegetation. 2D view





Time series analysis performed over several reforesting parcels in Senegal using precipitations, a Sentinel-2 soil moisture index and two Sentinel-2 vegetation indices.

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Fig. 11 - S2 (10 & 27.09.2016) - In 2016, MSAVI2 values found on this image were low to average. 2D view

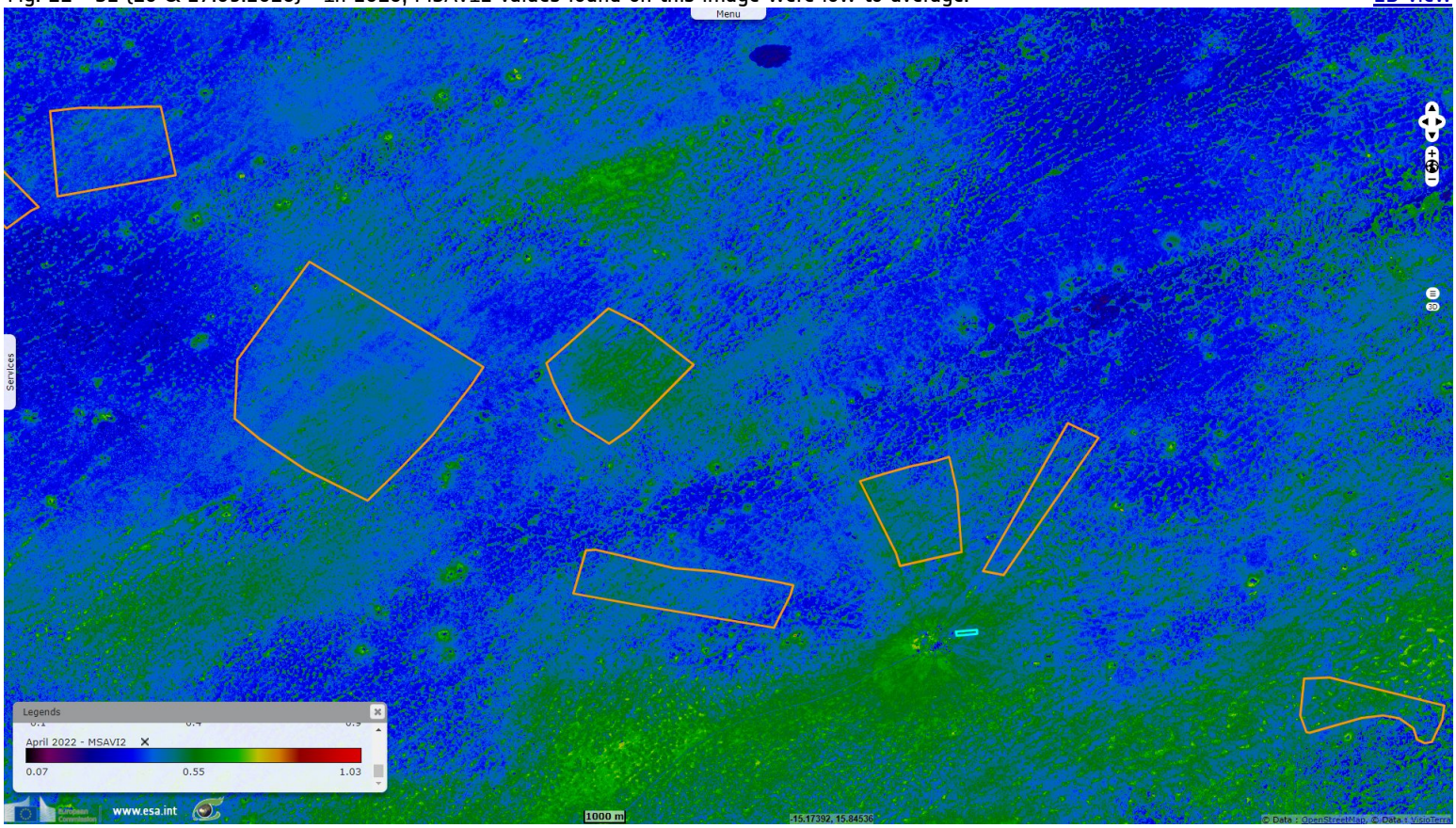
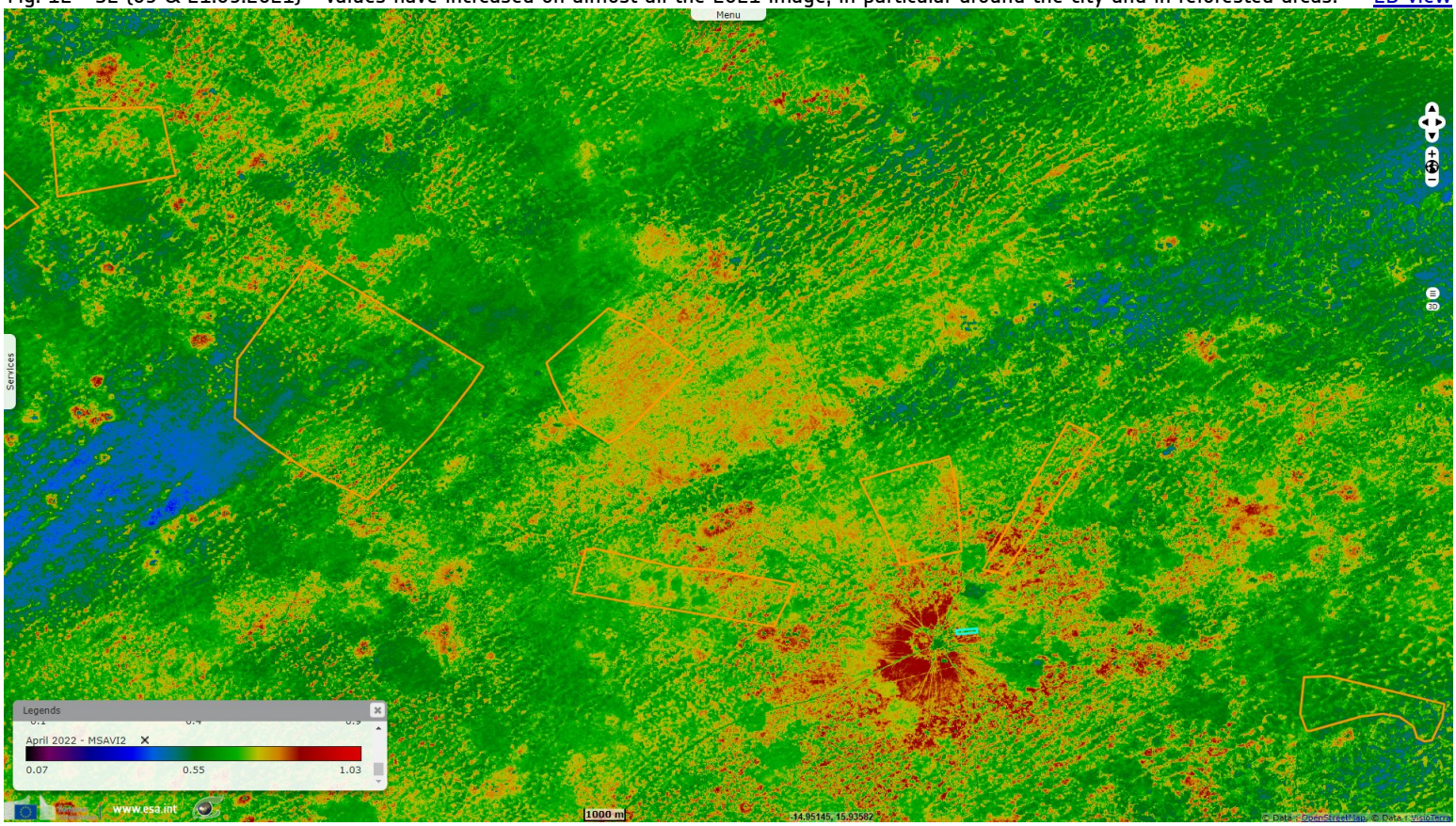
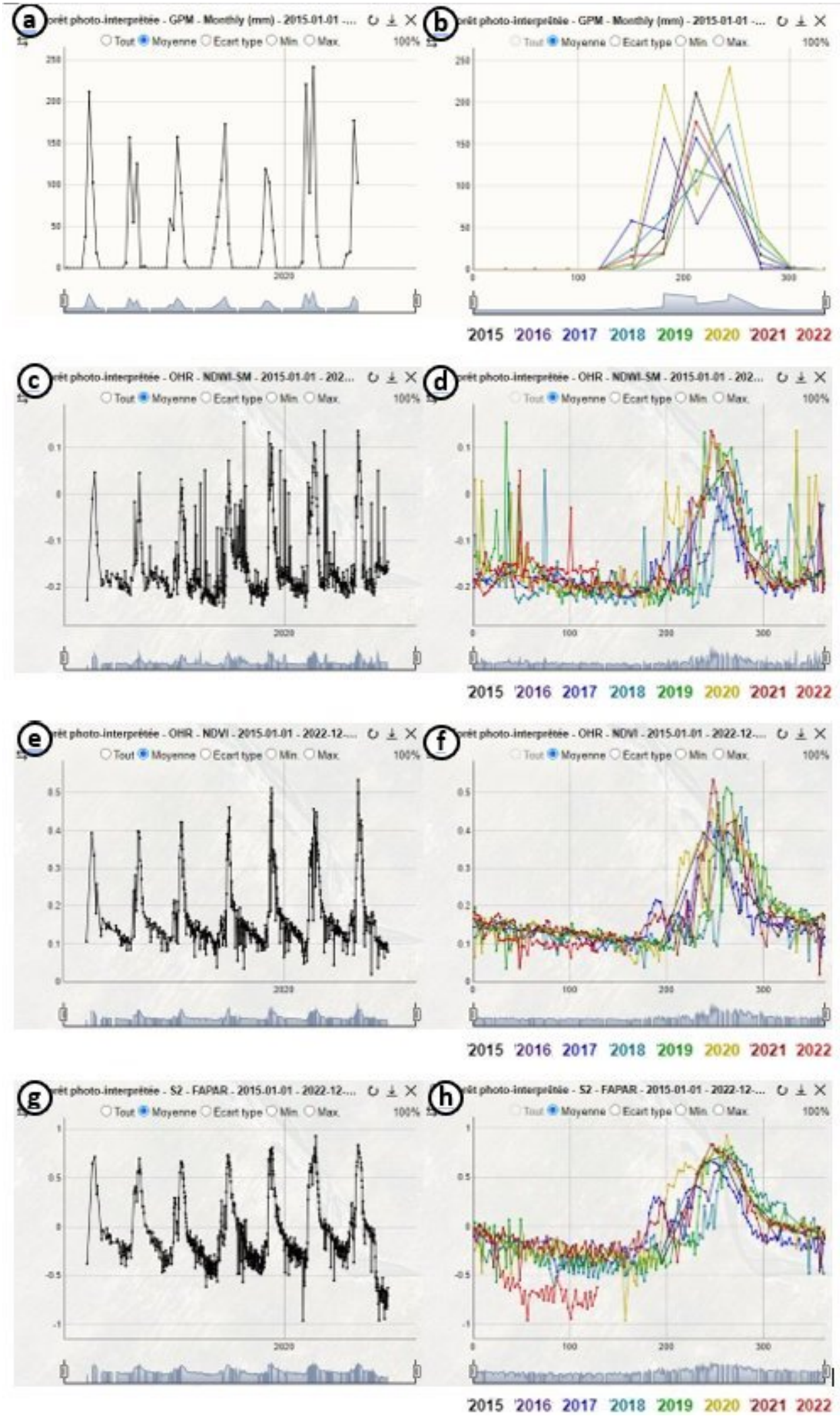


Fig. 12 - S2 (09 & 21.09.2021) - Values have increased on almost all the 2021 image, in particular around the city and in reforested areas. 2D view





Time series analysis performed over several control panel forests in Senegal using precipitations, a Sentinel-2 soil moisture index and two Sentinel-2 vegetation indices.

- a: GPM monthly precipitations time series calculated over the parcels from 2015 to 2022, chronological view.
- b: GPM monthly precipitations time series calculated over the parcels from 2015 to 2022, seasonal view.
- c: Normalized Difference Water Index - Soil moisture (NDWI-SM) time series calculated over the parcels from 2015 to 2022, chronological view.
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While the multipurpose gardens and reforesting parcels are assumed to be modified by man since the Great Green Wall initiative began (regarding the addition of vegetation or possibly irrigation and fertilizers), these parcels are expected to follow natural patterns. It has been added to allow the comparison of trends, at least qualitatively.

The soil moisture (figures c and d) computed on the control sample of forests shows a similar pattern of that of the other classes with a decrease of the lower values until 2019 and an increase afterwards. However, its wet season peaks remain between 0 and 0.1 and did not decrease like that of the reforesting parcels. It can be hypothesised that a mature forest has a deeper root system and more reserves to access water even in the bad years of rain.

The NDVI (figures e and f) shows a high regularity from year to year. The FAPAR (figures g and h) is also very similar from one year to the next, it does not reach values as high during the rain season or as low during the dry season as the reforesting parcels do. It can be inferred the forest has already reached its potential which prevent it from benefiting more from the good years but is also more resilient to the bad years.

A positive loop can be hoped for, vegetation allowing water to remain longer where it fell, reducing temperatures while increasing evaporation and precipitations. It is however too soon to see the effect of the Great Green Wall on precipitations. The general increase in soil moisture and vegetation indices in 2020 and 2021 can be attributed in large part to a natural and temporary increase in precipitations but a part of the rise seen in reforested areas is likely the result of the efforts to avoid desertification by the Great Green Wall initiative.