IMPORTANCE OF SPACE TECHNOLOGY FOR MONITORING AND MANAGEMENT FOREST FIRES (CASE STUDY; SYRIAN COASTAL FORESTS)

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ABSTRACT: Fires is the most important disturbance agent in global vegetation worldwide, affecting between 3 to 4 million square kilometers , annually. Secondary effects of fire include sudden onset disasters such as landslides, mudslides, rock falls, and flashfloods. Creeping disasters triggered by fire include post-fire soil erosion, ecosystem degradation, and reduced carrying capacity for human populations and their livelihood.
Space borne remote sensing technologies has enabled to map and monitor vegetation resources in varying scale and time. These Technologies have improved the capability to identify fire activities at local, regional and global scales by using visible and infrared sensors on existing platforms for detecting temperature anomalies, active fires, and smoke plumes. Geosynchronous satellites such as GOES and polar orbiting sensors such as the NOAA, AVHRR have been used successfully to establish calendars of vegetation state (fire hazard) and fire activities. Other satellites with longer temporal sampling intervals, but with higher resolution, Such as Landsat 8, Ikonos, Quick bird, Geo-eye, sentinel and SPOT, Indian, Russian Chinese satellites and space borne radar sensors, deliver accurate maps of active fires, vegetation state and areas affected by fire.
Providing an effective response to wild land fires by our vision requires four stages of analysis and assessment:
1- Determining fire potential risk
2- Detecting fire starts
3- Monitoring active fires
4- Conducting post-fire degradation assessment
The technological advancement in space remote sensing has been widely experimented in last years to obtain the desired information.
In result: the Maryland dataset indicates that nearly 20% of Syria's forests have been lost since 2000. During the summer of 2020 and especially from July to October, Hundreds of wildfire incidents have been reported in Syria. By interpretation of space data at October 2020a grand total of approximately 30,000 hectares of agricultural and forested land across NW Syria is estimated to have been burned during the wildfire incidents in the period September 1st to October 15th, 2020 . Forest fires Assessment that took place in Syrian coastal area and Lebanon from late August (27) till 17 October 2020 using Sentinel satellite, has been indicated that the affected areas in Lebanon were around 1652 Hectares. The NBR and the ΔNBR indices were applied on sentinel images dated 23 August, 27 September, 7 and 17 October 2020. The severity of damage varied between Moderate to low, Moderate-High and High.
In Conclusion: Space remote sensing technologies gives accurate results for monitoring, management and assessment forest fires impacts.

1-INTRUDUTION

Fire is the most important disturbance agent in global vegetation worldwide, affecting between 3 to 4 million square kilometers , annually. Secondary effects of fire include sudden onset disasters such as landslides, mudslides, rock falls, and flashfloods. Creeping disasters triggered by fire include post-fire soil erosion, ecosystem degradation, and reduced carrying capacity for human populations and their livelihood. Haze and smoke from wildfires are major threats to aviation, limiting visibility and leading to engine failure. These days world Fire caused by Human pressure on the Environment, it was noted that about 5 % of forest fire in Europe are natural origin (San – Miguel Ayanz et.al.2005).
Fires have an immense impact in all Countries which have forests, most of them, Australia , Indonesia, Brazil, Mexico, Canada, USA, France, Turkey, Greece, India and Italy. Mongolia, Eastern parts of the Russia and north east of China. The assessment of the forest fire and degradation is one of the important factors to be considered for better management of the forest resources. Global vegetation fires, including burning of peat lands, constitute a significant source of greenhouse gases and aerosols. Approximately 20% of CO_2 emission into the atmosphere is caused by forest fires.(Kührt E., Knollenberg J., et al.2001) Wildfire has many serious negative impacts on human safety, health, regional economies, and global climate change
Space borne remote sensing technologies have improved the capability to identify fire activities at local, regional and global scales by using visible and infrared sensors on existing platforms for detecting temperature anomalies, active fires, and smoke plumes. Geosynchronous satellites such as GOES and polar orbiting sensors such as the NOAA AVHRR have been used successfully to establish calendars of vegetation state (fire hazard) and fire activities. Other

satellites with longer temporal sampling intervals, but with higher resolution, Such as Landsat, Ikonos, Quick bird, Geo-eye and SPOT, Indian, Russian Chinese satellites and space borne radar sensors, deliver accurate maps of active fires, vegetation state and areas affected by fire.(Rukieh M. 2016)

2-STAGES OF ANALYSIS WILD LAND FIRES

Providing an effective response to wild land fires requires four stages of analysis and assessment (Rukieh 2016)
1- Determining fire potential risk
2- Detecting fire starts
3- Monitoring active fires
4- Conducting post-fire degradation assessment
The technological advancement in space remote sensing has been widely experimented in last three decades to obtain the desired information.

2-1 Fire Detection

Satellite-borne sensors can detect fires in the visible, thermal and mid infrared bands. Active fires can be detected by their thermal or mid-infrared signature during the day or by the light from the fires at night. For their detection the sensors must also provide frequent over flights, and the data from the over flights must be available fast. Satellite systems that have been evaluated for fire detection include AVHRR, [NOAA 2012], which has a thermal sensor and makes daily over flights, the Defense Meteorological Satellite Program , Optical Lines System (OLS) sensor, which makes daily over flights and routinely collects visible images during its nighttime pass, and the NOAA Geostationary Operational Environmental Satellite (GOES) sensor, which provides visible and thermal images every 15 minutes over the United States and every 30 minutes elsewhere. And the moderate resolution imaging Spectroradiometer (MODIS), launched in 1999, have been used [NASA,"MOIDS 1999, K.Nakau, 2006]. Therefore AVHRR and MOIDS has been used most extensively for detecting and monitoring wildfires. Nowadays, two different types of sensor networks are available for fire detection, camera surveillance and wireless sensor network.
Different types of detection sensors can be used in terrestrial systems:
(1) video-camera, sensitive to visible spectrum of smoke recognizable during the day and a fire recognizable at night,
(2) Infrared (IR), thermal imaging cameras based on the detection of heat flow of the fire,
(3) IR spectrometers to identify the spectral characteristics of smoke.
(4) Light detection and ranging systems - LIDAR (detection of light and range) that measure laser rays reflected from the smoke particles.
A new technology called wireless sensor network (WSN) is nowadays receiving more attention and has started to be applied in forest fire detection. The revolution of WSN technology in recent years has made it possible to apply this technology with a potential for early forest fire detection.

2-2 Fire Monitoring

Fire monitoring differs from fire detection in timing and emphasis rather than in the methods used to process the satellite image information. Satellite sensors typically provide coarse resolution fire maps which show the general location and extent of wild land fires. Detailed fire suppression mapping requires the use of higher resolution thermal infrared sensors to accurately map small fire hot-spots and active fire perimeters. Higher-resolution fire maps are needed to deploy fire suppression crews and aerial water or retardant drops.

2-3 Fire Assessment

Once fires are extinguished, a combination of low resolution images (AVHRR) and higher-resolution images can be used to assess the extent and impact of the fire. Radar has proved effective in monitoring and assessing the extent and severity of fire scars in the boreal forests, for quantifying biomass regeneration in tropical forests and for modeling ecosystem recovery in Mediterranean climates (Rukieh M. 2016). Multi-resolution studies incorporating both AVHRR and Land sat images reveal the scale-related influences of analyzing post-fire vegetation regeneration (R.S. ROY 2004 ,). Satellite images have a considerable value for mapping forest fire and degradation assessment. It helps in decision making processes for the proper establishment of the green cover over the affected areas. Extensive areas are burnt and deforested every year, leading to widespread environmental and economic damage. Małgorzata M.D. 2004, pointed to, three classes Forest danger: 1 – high fire danger, 2 – moderate fire danger, 3 – low fire danger.

3-AN EARLY WARNING SYSTEM FOR FOREST FIRES

To mitigate fire-related problems and costs, forest and land management agencies, as well as land owners and communities, require an early warning system to identify critical periods of extreme fire danger in advance of their potential occurrence. Early warning of these conditions allows fire managers to implement fire prevention, detection, and pre-suppression plans before fire problems begin. Fire danger rating is commonly used to provide early warning of the potential for serious wildfires based on daily weather data. Fire danger information is often enhanced with satellite data, such as hot spots for early fire detection, and with spectral data on land cover and fuel conditions. Normally, these systems provide a 4- to 6-hour early warning of the highest fire danger for any particular day that the weather data is supplied. However, by using forecasted weather data, as much as 2 weeks of early warning can be provided.(Rukieh M. 2016)

There are so many Early warning Systems for forest fires; some of them are:

Fire watch system. This system a terrestrial, digital, remote surveillance system which is capable of observing larger wooded regions, and to analyze, evaluate, link and store the collective data. Due to its sensitivity, accuracy and reliability the system enables an early recognition of forest fires. The system is able to evaluate and classify the incoming data in multiple ways, connected to a central station.

The Global Early Warning System for Wild land Fire (Global EWS) , the Global EWS provides a means of comparing relative fire danger conditions between countries, continents, and biomes ,and the 1-7 day Forecast identifies the expected future fire danger trend. This type of information is often useful for large-scale fire management decision-making such as planning cross-border Suppression resource exchanges. This system has many Indexes, like general indicator of fire danger, Fire Weather Index (FWI) ,which has 6 components that represent fuel dryness and potential fire behavior at the landscape level. Now day many Countries have their Early Warning Systems for Forest Fires

4- FOREST FIRES IN SYRIAN COASTAL AREA

The coastal region is located in the north-western part of Syria , bordered in the west by the Mediterranean Sea with the coastline of about 220 km. The coastal region of Syria covers about 4,190 km2 (2% of the national territory). The region is divided into two main districts; Lattakia district in the north with 2,300 km2 total area and Tartous district in the south with 1,900 km2 area.(Fig.1)

This area covered by trees forests ,which affected from 2000 to wildfire especially in 2020 ,as shown in fig. 2and fig.3..

The fig. 2 shows the extent forests in Lattakia Governorate in 2000,forest loss 2000-2018, forest loss in 2019 and in 2020, by Maryland dataset. The Maryland dataset indicates that nearly 20% of Syria's forests have been lost since 2000. A recent study confirms the Maryland data, also finding that between 2010 and 2020 nearly a quarter of the coastal forests were lost, amid a significant decline in forest density .In turn, there was an increase in agricultural and desert areas. The rate of forest loss has accelerated in recent years and was found to be associated with proximity to the population

In the fig.3 TM Space Image shows affected Basset area and situation of Basset forest in Lattakia before and after fire happened in 28/10/2004.which covered (30 km2)

4-1 Fire Events in 2020

During the summer of 2020 and especially from July to October , Hundreds of wildfire incidents have been reported in Syria . With the objective being to monitor the extension and magnitude of the events and conduct an initial assessment on the potential impact of the fires on WFP operations, , It was used satellite imagery and remote sensing tools in order to conduct an analysis and map the affected areas and created maps designed to track and monitor over time the frequency, impact and spread of these fires (RBC and SYR CO VAM Units 2021).

By interpretation of space data at October 2020 a grand total of approximately 30,000 hectares of agricultural and forested land across NW Syria is estimated to have been burned during the wildfire incidents in the period September 1st to October 15th, 2020 (fig.4) as follow. Lattakia 18848 hectares, Hama 5075, Tartous 4053, Homs 1379, Idleb 508 hectares , 4,470 hectares of cropland, including orchards, olive trees, and greenhouses. it is reported that half a million olive trees have been destroyed since March 2018.

Local authorities report that up to 28,000 houses are directly affected, with a number of victims hospitalized for smoke inhalation. while up to 25,000 people are said to have been displace

4-2 Analysis Methodology

Analysis and maps have been generated using space Images. Sentinel-2 data has been extracted and classified using Normalized Burned Ratio Index (nBRI). Pre and post event imagery have been used for the September and October analysis; results are shown as cumulative hectares of burned land. nBRI takes advantage of the near infrared and short wave infrared spectral bands, which are sensitive in vegetation changes, to detect burned areas and monitor the recovery of the ecosystem

After a quiet period, the peak was reached from 04 to 11 September, when the fires began again.(fig.5) With the goal to understand the impact of the fires on the land, a change detection analysis has been performed in order to compare the situation pre and post fire events. This remote sensing analysis allows to detect the most recent event and to measure the portion of the land that has been impacted. A new round of wildfires – October In the period from 08 to 11 October, there was a new series of wildfires in the governorates of Lattakia, Tartous and NW Homs. Notably, during the same period fires hit Lebanon forest Land . In total, as on date more than 95 fires have been registered across Lattakia and Tartous in one day , Satellite imagery clearly depict a pattern to these fires and it seems evident that many fires were in some way connected and clustered in few specific areas; Temperatures have been registered as extremely high during these days, and the hot air mass made even more difficult to extinguish the fires, it has also been reported that the smoke coming from Lattakia reached to Cyprus which is 100+ Km away. The fires also caused humanitarian suffering and damage to critical infrastructure, with the large smoke plumes emitting toxic air pollutants, as clear in (Figure 6). Although the meteorological conditions caused extreme fire danger.

Forest fire Assessment that took place in Lebanon and Syrian coastal area from late August (27) till 17 October using Sentinel satellite, has been indicated that the affected areas in Lebanon were around 1652 Hectares. The NBR and the ΔNBR indices were applied on images dated 23 August, 27 September, 7 and 17 October 2020 by Dr. Chadi Abdallah 2020. The severity of damage varied between Moderate to low, Moderate-High and High.

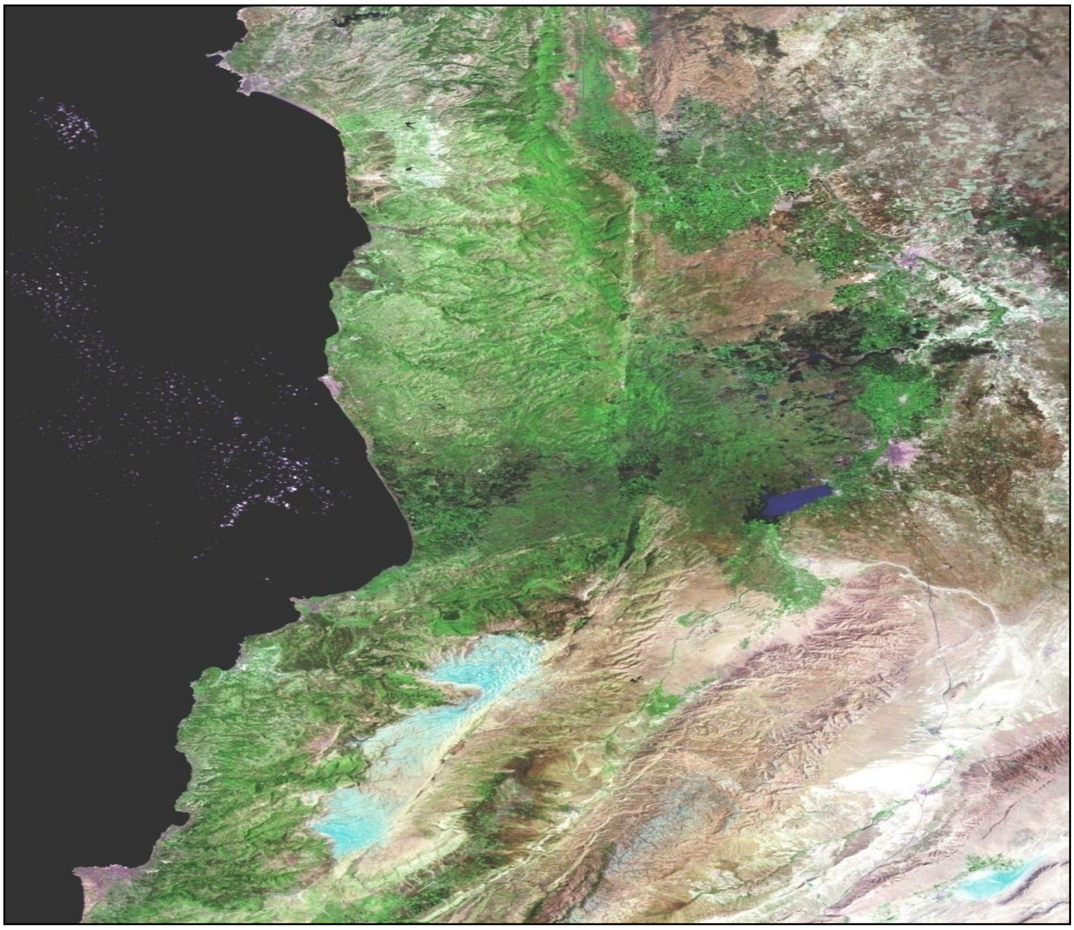


Fig1.TM space Image show Syrian –Lebanese Coast from Beirut in the south till Lattakia in the north

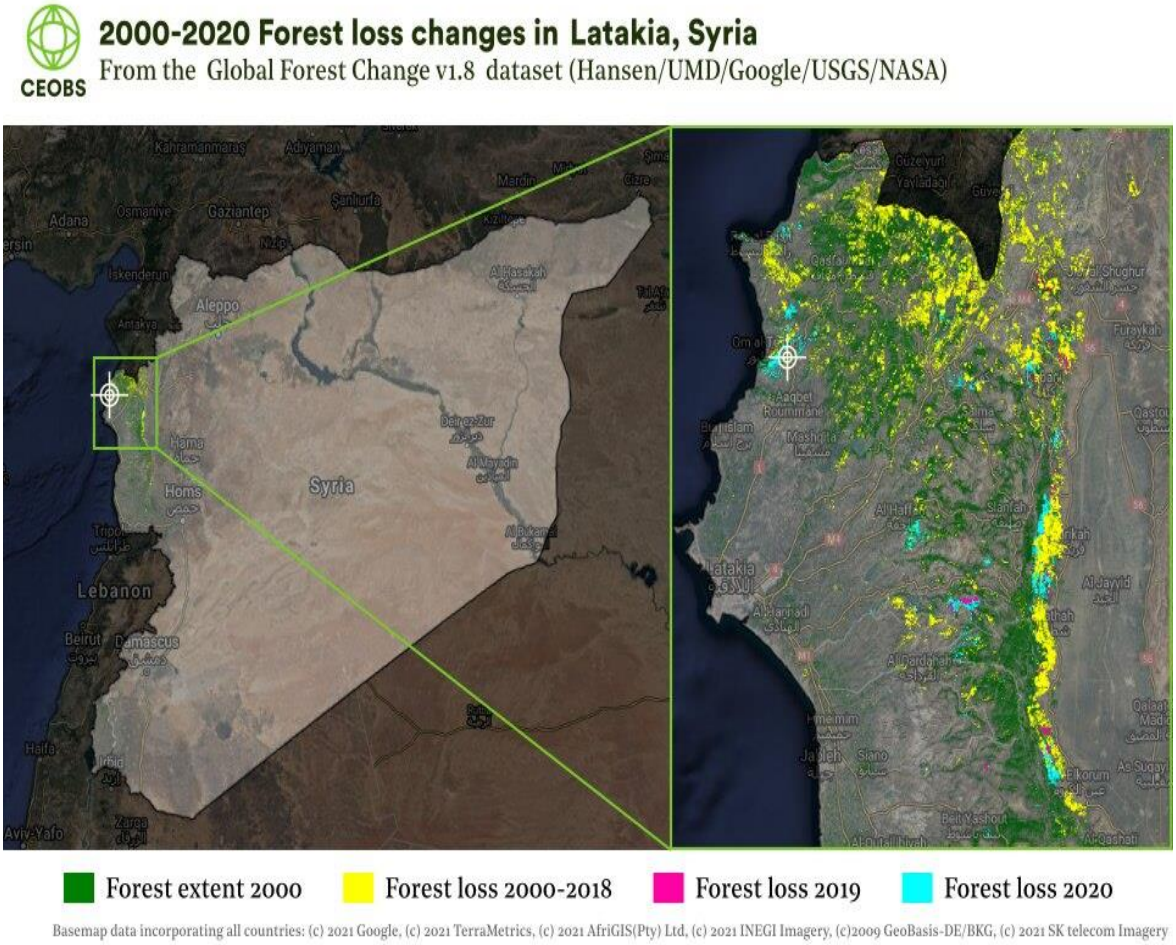


Figure 2. Forest loss in Lattakia governorate at 2000- 2020 based on the Maryland dataset.

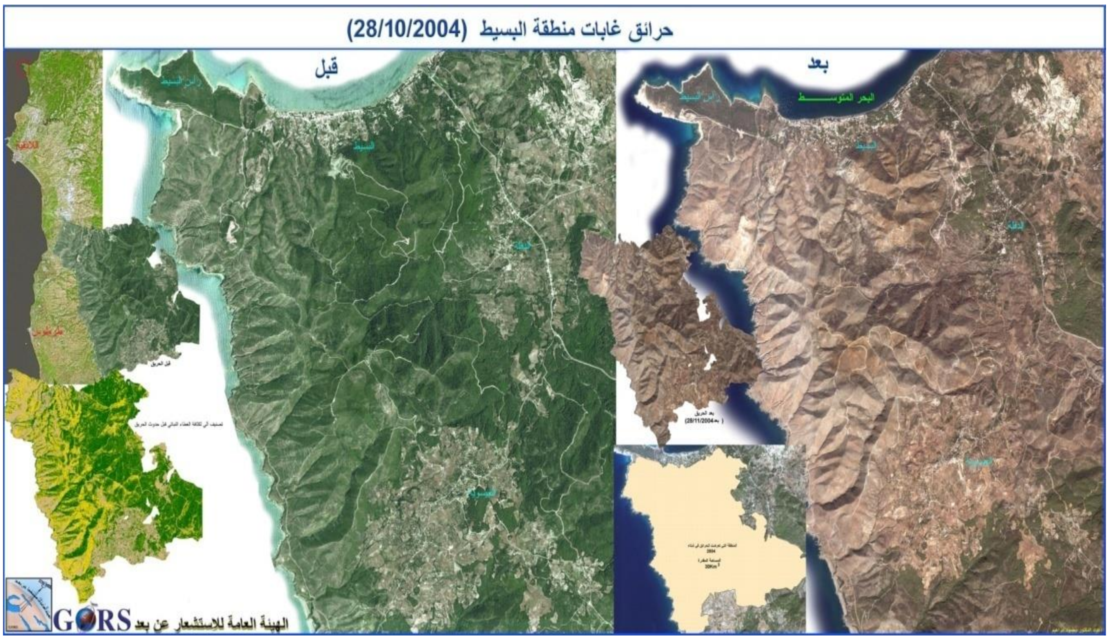
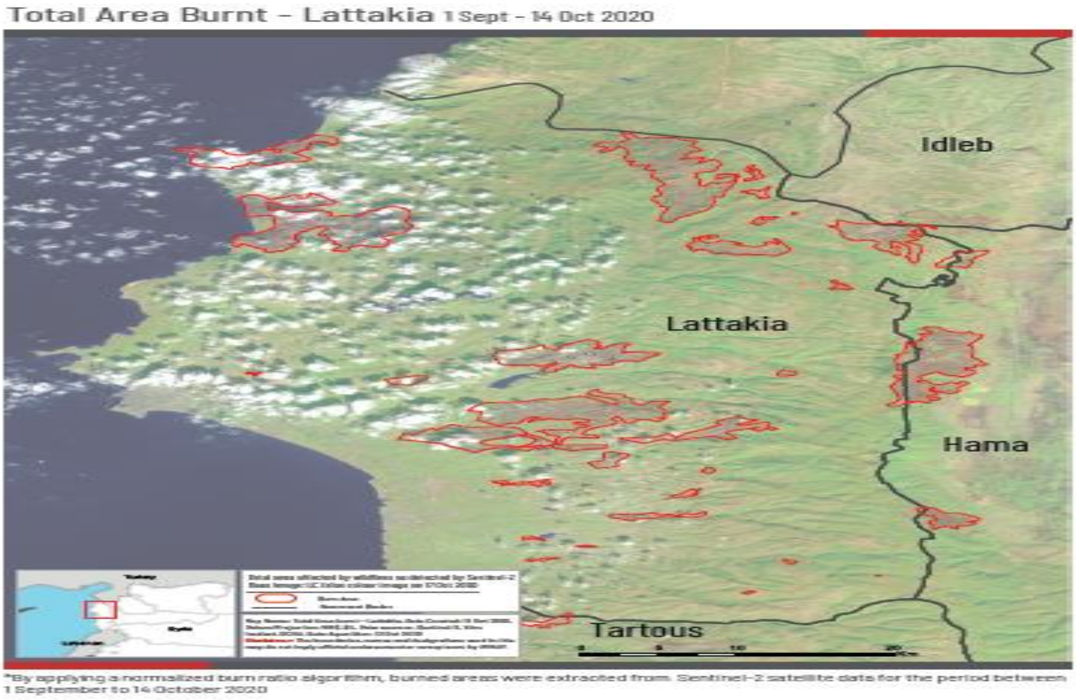


Fig. 3, Space image shows situation of Basset forest in Syria before and after fire happened in 28/10/2004. (30 km2)



Fig,4. space image interpretation for fire forest in Lattakia district at 1septamber by 14 October 2020 (IMMAP Geoinformatic Unit)

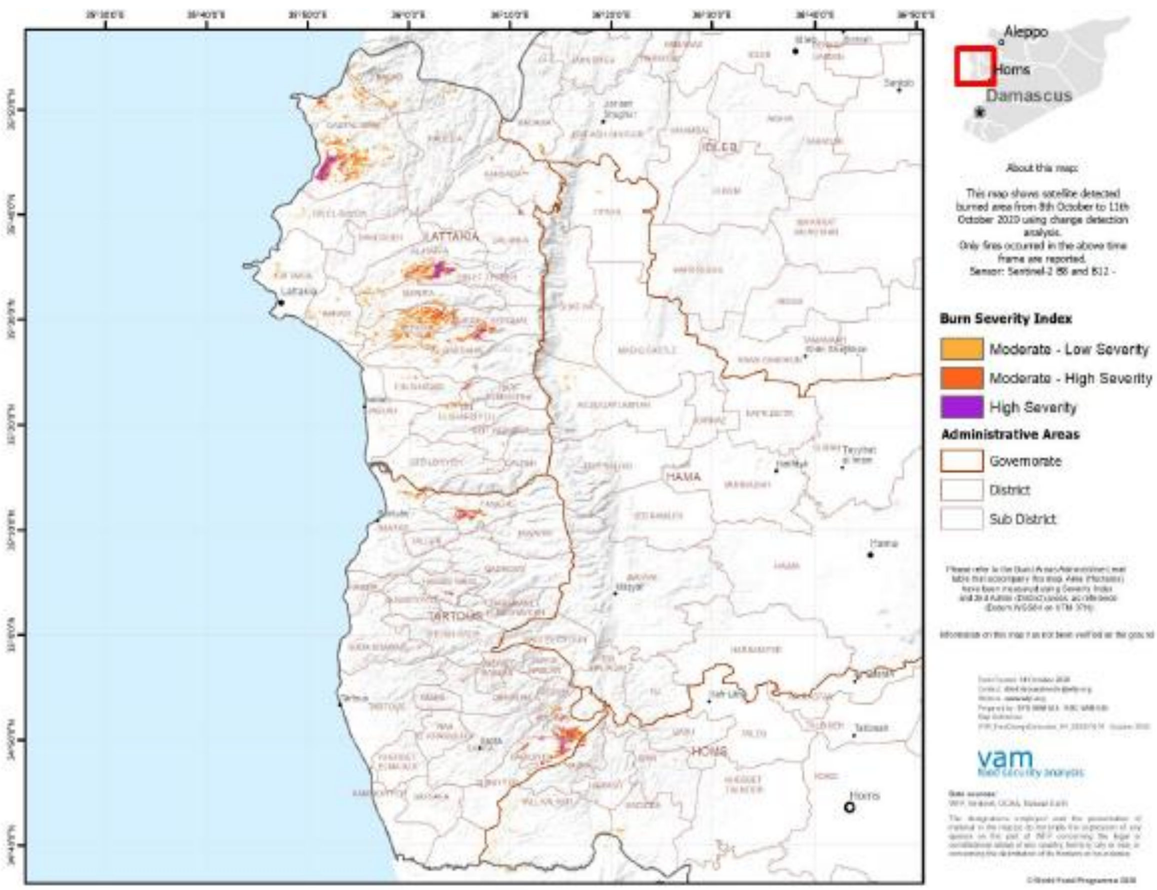


Fig.5 Map shows Fires in Syrian Coastal Area at 8-11 October 2020 by interpretation of space images

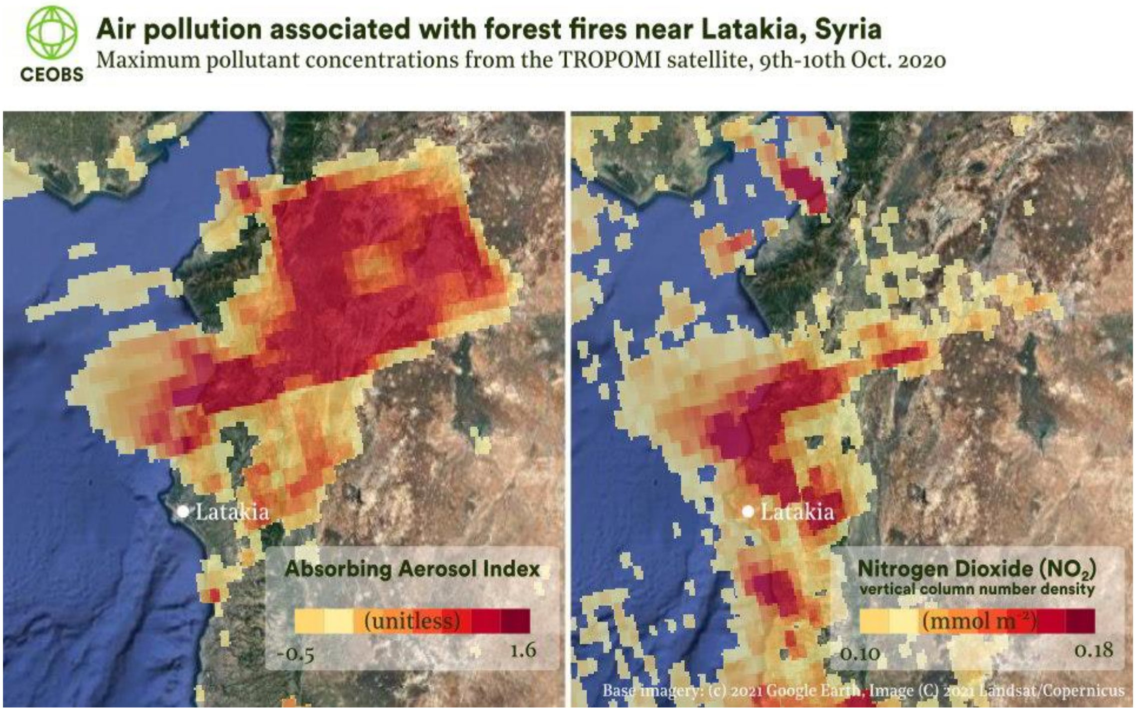


Figure 6. Smoke plumes associated with fire activity near Lattakia, Syria in mid-October 2020. a) Maximum values of the absorbing aerosol index and NO2 concentrations over the 9th and 10th October, from the TROPOMI instrument onboard Sentinel-5P, processed in Google Earth Engine. Credit: Copernicus Sentinel data (2021). b) Satellite imagery of smoke plumes from forest fires on the 9th and 10th October 2020, from the MODIS instrument onboard the Terra satellite. Credit: NASA Worldview.

5- RESULTS

1- The Maryland dataset indicates that nearly 20% of Syria's forests have been lost since 2000.

2- During the summer of 2020 and especially from July to October , Hundreds of wildfire incidents have been reported in Syria. By interpretation of space data at October 2020 a grand total of approximately 30,000 hectares of agricultural and forested land across NW Syria is estimated to have been burned during the wildfire incidents in the period September 1st to October 15th, 2020 .

3- Forest fires Assessment that took place in Syrian coastal area and Lebanon from late August (27) till 17 October 2020 using Sentinel satellite, has been indicated that the affected areas in Lebanon were around 1652 Hectares. The NBR and the ΔNBR indices were applied on sentinel images dated 23 August, 27 September, 7 and 17 October 2020. The severity of damage varied between Moderate to low, Moderate-High and High.

4- The fires also caused humanitarian suffering and damage to critical infrastructure, with the large smoke plumes emitting toxic air pollutants by Aerosol index and NO2

6- CONCLUSIONS

The usage of remote sensing and GIS allows to monitor the situation and estimate the impact of the ongoing fires, it means Space remote sensing technologies gives a good results for monitoring, management and assessment forest fires impacts.

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