Forest Fire Area DetectionUsing Earth Observation Satellites: A Case Study of Ain Marah Al-Jabal Al-Akhdar, Libya.

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Abstract: A forest fire started on June 30th, 2021and was stopped on July 3rd in Ain Marah Al Jabal Al-Akhdar causing damage and casualties. There had not been any official results of the area burnt by the fire. This study is an attempt to provide an accurate burnt space area usingNormalized difference vegetation(NDVI) index, Burned Area Index (BAI), Normalized Burn Ratio (NBR) indices, which was derived from the European satellite Sentinel-2A. the indices were calculated for the displacements of burned and unburned pixels in the pre-/post-fire NIR-MIR and NIR-R bi-spectral spaces. NDVI classified the space of actual vegetation loss by 96.8 ha, while NBR and BAI were calculated for the same images in order to gain the actual burned area which were estimated by 103 and 101.8 ha respectively. The estimated burned area obtained from NBR and BAI were slightly vary that is because the area had already passed through an unusual long hot weather before the fire occurrence, making the part vegetation cover already dry and look as bare land. Additional the land cover is overlapped by low dry vegetations and bare land, that may disturb the calculations.
Keywords: Remote Sensing; Sentinel-2; Fire indices, Burned vegetation, Burn extension.

1.0 Introduction:

Climate change has been representing a critical topic during the last decades. An unusualfires, flooding and other crises have been hitting the whole world with high frequency, causing serious destructionand, in worst cases, crises. As Earth is experiencing higher temperatures with compared to the past supported by heat waves and droughts, fires represent a complex issue to deal with. As in recent years the world has witnessed more wildfires occurring in areas where they had not occur often in past. Almost 330–431Million ha over the world is affected by forest fire every year (Giglio et al. 2010). Wildfire is a natural hazard that can lead to massive destruction of surrounding environment, natural areas and livelihoods. It is simply defined as an uncontrolled fire in a forest area.Forest fires motivations include environmental factors such as weather, fuel (accumulation of biomass), lightning, and topography, or human activities such as agricultural burning and arson (Garza, et al 2018).

Although limited wildfires are essential element of the system that could be beneficial for the whole ecosystem. However, if wildfires are difficult to control, large human settlements, ecosystems, lives and property can be destroyed. The presence of strong winds can make the even more difficult to control and can dramatically increase damage. Satellite imagery contributes to all phases in the risk management cycle by providing information about forest fire occurrence and frequency, in addition to spotting the factors that could lead to high fire danger. Satellite data and the Geographical Information System (GIS) and remote sensing (RS) techniques have been used extensively to detect, assess and predict the fire frequency at all geographic and spatial scales. Remotely sensed satellite data has practically provided an evident understanding of the behavior of forest fire, these factors that contribute to detecting fire behavior using pre and post time series fire date (Erten, E et al 2002).

This study focuses on two main aspects. First, to provide an accurate information about area space affected by Ain Marah forest fire, using modern remotely sensed fire indices. Secondly,

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mapping burnt vegetation using NDVI obtained of the pre-/post-fire Sentinel-2 satellite images.

2.0 Al Jabal Al Akhdar wildfires 2021:

According to the Centre for Research on the Epidemiology of Disasters, “since 1911, wildfires have killed at least 4,545 people, injured 11,379 and affected more than 17 million around the world”.Minnesota’sCloquet fire of 1918 is the deadliest on record, killing an estimated 1,000 people (including those missing). According tothe European Space Agency ESA, fire affects an estimated 4 millionsq kilometers of Earth’s land annually”. that is about half size of the America, larger than India, or approximately four times the size of Nigeria (ESA 2021).

In 2021 A heat-wave across southern Europe and the Mediterranean region, fed by hot air from central Africa, producing droughts, which, have created dry vegetation that fuels larger wildfires across the region. Several major fire incidentshad been reported inGreece, Turkey, Morocco, Tunisia, Algeria and Libyabetween late June to September. Those countries have reported their worst fires in decades, including hundreds of deadly fires across the Mediterranean. The worst was in August in Algeria, at least 90 people have been killed, including 28 members of the People's National Army deployed as firefighters. (European Forest Fire Information System (EFFIS, 2021) (Al Jazeera Media Network 2021).

Libya is not exception, as it has witnessed two massive wildfires in 2021 in the region of Al Jabal Al Akhdarwhich means (The green mountains) in English reflecting to the relative intensive vegetation cover in the region, one on the 30th of June near Ain Marah town approximately 70 km from East-south the biggest city of the region named Al Bida city which is 400,000 population. The other forest fire was on the 12th of August in AL Bayada town which is 60 km West of Al Bida city.

The climate of Libya is combined of Mediterranean coast and Sahara desert in terms of precipitation and temperature. Al Jabal Al Akhdar is classified as moderate to warm climate, with averaged temperature ranges from 10 to 30 degree Celsius. The wind is represented by the North-westerly winds that are 45 % of the total wind affecting the region. In the dry season the “Ghibli” winds (hot and dry) blow from the desert in the south causing desertification of the grain, while the dust borne of these winds representing a real threat on the vegetation cover of the region. According to The Libya Observer news agency on the 2nd of July 2021, Libya is passing through the longest hot wave since 1987 which was for 9 days. The temperature levels have reached the an extraordinary levels in the North-West of Libya to be 45 C^0 and in the North-East in Al Jabal Al Akhdar to record 39 C^0on the 26th of June 2021, that accordingly led to close schools for a week (The Libya Observer 2021), figure (1) shows the temperature of Al Jabal Al Akhdar region in June 2021.

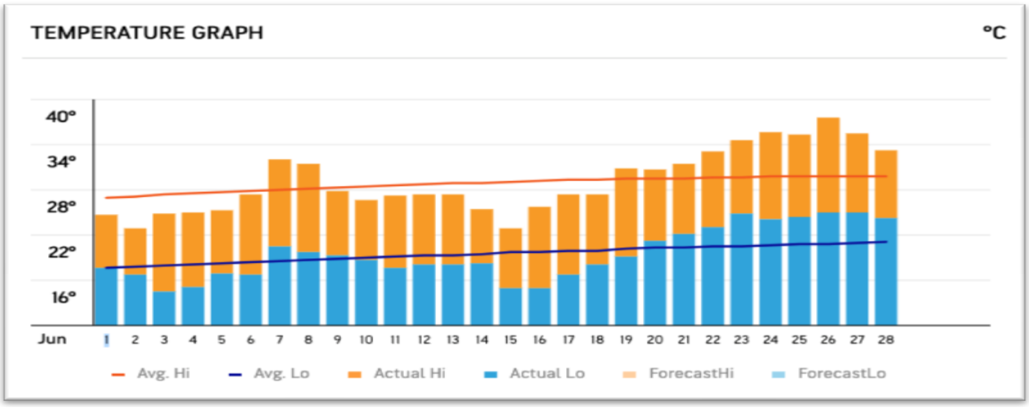

Fig 1: Temperature levels in Al Jabal Al Akhdar in June 2021, (climate-data.org).

Thisheat wave has led to several wildfires in an agricultural palm project far near the city of Ghat south of Libya, which took the safety and security authority 9 hours to be stopped. The worst wildfire wasin the North-East of Libya4 km away from a rural town named"Ain Marah" Al Jabal Al Akhdar in 2021, which was In the early morning of the 30th of June 2021 when the local citizens of Ain Marah woke up to see smoke cloud few kilometers of the town, they started trying to stop the fire for the whole day, but they were not able to stop it. The preceding dry monsoon spell left plenty of flammable material in the under-story of the forest ranges. The fire kept spreading till the second day went out of control, they started asking the civil defence to send firefighters to stop the fire, the support arrived on the 1stof July and kept fighting the fire till the following day. The high temperature and the harsh topography of the area, had made it difficult to control the fire easily. However, the fire had been stopped on the 2nd of July by the great constant effort by the safety authority supported by the local civilians from all cities and towns of the region (figure 2). However, the fire sparked again to nearby ranges on the 3rd of July fed by moderate winds just few meters of the power station of the area, that made it very dangerous and destroying. The fire was officially stopped at the end of the same days leaving hectares of burnt environment including natural vegetations, farms and animals. Till the time of writing this research, there are not any official information or data about the fire nether its severity or actual destroyed area.

Fig 2: Ain Marah wildfire, 02/07/2021(Local photographer).

2.1Satellite Data:

The energy obtained from the elements on the surface of the earth has unique properties. These spectral signatures allow you to study a variety of ground processes. Optical remote sensing equipment and techniques uses visible and infrared sensors located on high-resolution earth observation satellites to investigate forest fires. Near-infrared NIR, mid-infrared, and thermal bands are susceptible to changes in vegetation health. These are commonly used to accurately assess fire-affected areas and burn severity to support forest management activities. Healthy green vegetation reflects near-infrared range (NIR) radiation. Absorbs red light in the visible part of the electromagnetic spectrum. Burnt areas, on the other hand, use more energy in the visible and shortwave infrared (SWIR) length, while absorbs energy in the NIR region (figure 3).

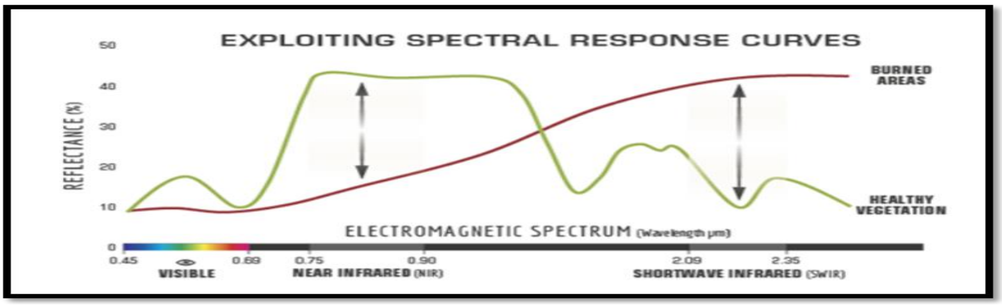

Fig 3: Comparison of the spectral response of healthy vegetation and burned areas.

(US Forest Service).

2.3 Sentinel-2:

Sentinel-2 is the first earth observation satellite in European Copernicus program, that. Was built and developed by industrial leadership of Airbus defence and Space for the European Space Agency (ESA). its mission with a wide range of uses for exploration of the global environment,that was developed by an industrial consortium led by Astrium GmbH (Germany), Astrium SAS (France) is responsible for the Multi-Spectral Instrument (MSI), which was officially launched on 23 June 2015 Consisting of twin satellites with an advanced multispectral imager(MSI), which provides global high resolution optical imagesin 13 spectral bands ranges from (443 to 2190 nm) at 5 days revisit frequency (ESA 2021), illustrated at Table (1).The mission will be an essential data source for land-use and land-cover monitoring. The mission is dedicated to complete and systematic coverage of the land surface, including the world's most important islands, with the aim of providing cloud-free products throughout Europe and Africa, typically every 15-30 days. Sentinel-2A satellite data is set to support, land cover, land use, and change detection maps, besides mapping geophysical variables for leaf area index, leaf chlorophyll content, and leaf water content. In addition to providingconstant update of globally consistent maps to be applied for impact assessments. That supports data for various application such as, monitoring land-use change that triggers erosion, forest and wildfires, and the onset of floods.

As the SWIR band is sensitive to water content in the vegetation and soil, while the NIR is strongly sensitive the vegetation wellbeing (photosynthetic activity), the SWIR and NIR bands combination enables to produce accurate maps of burned areas. In addition to, the radiance measured by a spaceborne sensor in the SWIR wavelengths increases if the surface is hot. As a consequence, SWIR/NIR/Red Bands composition colour appears as a stunning view of burnt areas and highlights ongoing fire areas if the smoke is not cloudy, (Gascoin, S. 2016).

Sentinel-2 Bands	Central Wavelength (µm)	Resolution (m)
Band 1 - Coastal aerosol	0.443	60
Band 2 - Blue	0.490	10
Band 3 - Green	0.560	10
Band 4 - Red	0.665	10
Band 5 - Vegetation Red Edge	0.705	20
Band 6 - Vegetation Red Edge	0.740	20
Band 7 - Vegetation Red Edge	0.783	20
Band 8 - NIR	0.842	10
Band 8A - Vegetation Red Edge	0.865	20
Band 9 - Water vapour	0.945	60
Band 10 - SWIR - Cirrus	1.375	60
Band 11 - SWIR	1.610	20
Band 12 - SWIR	2.190	20

Table 1: Sentinel-2 Bands, with their spatial resolution, (Satellite imagining corporation).

2.4 Literature review:

In a study aimed to compare the accuracy assessment of using NDVI, NBR and BAI indices derived from both Landsat and Sentienal-2 Images to obtain the fire extension and severity of the fire accrued in the forest area in Muğla Province, Menteşe District, Zeytinköy District, Turkey on the 7th of September 2017. resulting in massive destruction of the Zeytinköyneighborhood and the forests surrounding villages. The outcome results of these indexes were compared with that of published by the official Turkish General Directorate of Forestry (GDF), In general it has been indicated that the indices provided by multi-temporal Sentinel-2 data were more accurate than that of Landsat-8 satellite images for determining Turkish red pine forest fired areas. As the outcome results of the Sentinel-2 were very close to the that which published by the official authorities, while the Landsat`s were relatively differ from the official results, in terms of burned area extension and the fire severity (Bahadir, K et al 2019).

Another study aimed at assessing the ability of the derived indices commonly used to detect burnt areas derived from (NDVI and NBR) Sentinel-2A satellite to delineate burnt areas of the wildfire accrued in the Sierra deGata region of the province of Caceres in North-Eastern Spain between the 5th and 10th of August 2015. It tended that using the Sentinel-2 instead of (Landsat-8, MODIS) for the higher spatial, spectral and temporal resolution than most current orbiting sensors of Sentinel-2. According to the study authors the outcome results of the study showed that it is possible to separate burned and unburned regions in order to delineate burned areas using (NDVI and NBR) indices. They stated that computing the pre/post fire indices dNDVI and dNBR has been very susceptible to burnt areas and provided comparable results to the higher resolution reference data. It finally highlighted that the use of different of classification methods to produce the burn extension map have aided in improved accuracy. However, it suggests that the obtained results concern the current study only, thus further studies in other regions (using the same dataset types and methods) should be implemented before generalizing the results (Craig, A et al 2018).

In a study undertaken by Mpakairi, K. S., Ndaimani, H., &Kavhu, B on (2020), aimed to test the variation of Sentinel-2 nine spectral indices to assess the extension of four randomly selected study sites located in various landcover types in four different parts of the world, the selection was based on their fire history that makes them suitable for use in wildfire studies. The 1st site was in (Tenterfield, Australia), which includes patches of forest and farmlands. Site 2 was in (Pedrógão Grande, Portugal), which has been frequently burned and the wildfires are largely driven by climate and thermo-dynamical changes which is in a human-dominated landscape. Study site 3 California, United States of America) is an area characterized by frequent fires. Study site 3 is within a wildfire hotspot in (Hwange, Zimbabwe), which is an area that frequently burns from poaching related fires. NDVI, NBR and BAI were among the nine indices calculated to map the burned areas for all the mentioned study sites. The findings of the study highlighted that, in terms of accuracy BAI outperformed the NDVI and NBR to map burned areas with high accuracy in open shrublands, evergreen and semi-deciduous forest, and could efficiently be used for Mediterranean ecosystems. Besides, the study observed that there was a difference of ~15% between BAI and (NBR), in burned area mapping of savannah ecosystems, with high burn severity.

3 Materials and analysis:

3.1 Methodology:

In this study, a forest fire that occurred in Ain Marah Town in Al Jabal Al Akhdar region, where natural trees, shrubs and agricultural lands are located. The forest fire started on 30th of June 2021 at an early morning hours and was taken under control on the 3rdof July at late evening. During this period, extension of burning area has not been given by an official authority. While the Maximum temperature reached to 39C° in the area. Sentinel-2 satellite data used for this study was obtained from Copernicus Open Access Hub, to develop the fire affected areas, two images acquired one before the fire break in June the 24th2021, and post-fire was two days after fire-control on the 4thof July 2021 (figure 4). In this study, three spectral indices (NDVI, NBR and BAI) were calculated using the following equations in

(Table 2) to distinguish between burned and unburned surfaces for Sentniel-2 images. The indices were calculated using the bands wavelengths: NIR, R and SWIR for each spectral region, burning area and burning intensity were determined and the differences in the detection of burning area were compared.

Spectral Index	Abbreviation	Formula
Normalized Difference Vegetation Index	NDVI	$NDVI = \frac{NIR-R}{NIR+R}$
Normalized Burn Ratio	NBR	$NBR = \frac{NIR-SWIR}{NIR+SWIR}$
Burned Area Index	BAI	$BAI = \frac{1}{(0.1-R)^2+(0.06-NIR)^2}$

Table 2: Spectral indices used in this study (NIR: Near Infrared, R: Red, SWIR: Short Wave Infrared)Key & Benson (2006)

Figure 4: True colour composition of pre/post fire sentinel-2 images of Ain Marah forest fire position (*Copernicus 2021****).***

3.2 Study area:

Al-Jabal Al-Akhdar is an upland area. It is located between 32° 00’- 32° 58’N and longitudes 19° 56’- 23° 09’E. The total area of the region is about 7,800 km^2, which extends for a distance of over 300 km along the Libyan coast including the most vegetated part of the country. The wide region is characterized by a variety of natural environments that are caused by variation in geology, topography, climate, water resources, soil and natural vegetation. Distance from the sea and altitude cause important variations in climate. The natural vegetation in region varies between forests, shrubland, coastal plain and low vegetation in the semi-arid areas. (Ben Khaial and Bukhechiem, 2005, Al Mukhtar, 2005).

Various activities are run in the region mainly agriculture, traditional industries, grazing and the services sector. Furthermore, livestock breeding is carried out in private farms as well as grazing. In 2011 the political situation changed in Libya and these changes impacted on state policy regarding agriculture and other activities. In the absence of controls, the agricultural and urban areas were expanded after 2012 to areas having natural vegetation. Overgrazing was also rampant while deforestation and fires were also on the increase due to lack of control by the government. Several cities and towns in the region, surrounded by farms and natural vegetations, Ain Mara location as shown in figure 5 is located at the East-North of the region,60 km to the East of AlBida and 23 km the West of Derna City.

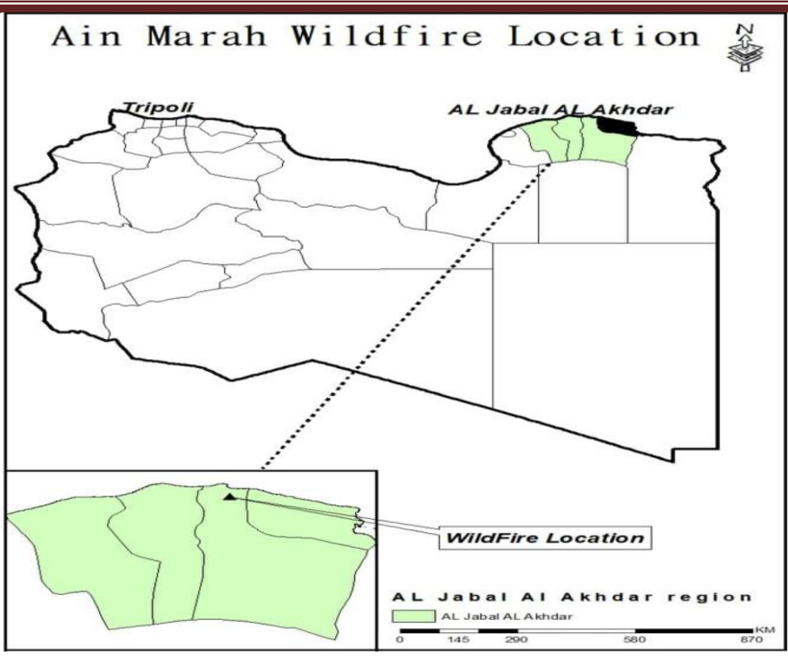

Figure 5: Map of Ain Marah wildfire location.

4.2 Dataprocessing:

When comparing satellite data for the same area at two different times, Atmospheric correction is an essential pre-processing part for determining true surface or Bottom of Atmosphere (BOA) reflectance values. Since April 2017 all Sentinel-2 available products had atmospherically corrected. The area of study was clipped from the Pre/post fire Sentinel-2 images, in order to run the Algebra spectral indices calculation process. The cloud shadow pixels should was removed from images and bidirectional reflectance distribution function (BRDF) should be minimized to enable reliable mapping of surface features, detection of surface change and to provide consistent sensor data comparison.

4.3Burn extension:

To monitor the fires severity, two S-2 satellite images of the Ain Marah fire. The image acquired closest in time to the fire event is termed the master image and the one most recently after as the slave image. By computing the dNDVI, dNBR and the dBAI for the master image and subsequent slave images, the impact of fires can be analyzed [2]. Based on the difference between the master NDVI, dNBR and the BAI image and same indexes of the slave image, the total burned area of the fire event is determined

4.3.1 Normalized Difference vegetation index (NDVI) :

The normalized difference vegetation index, abbreviated NDVI,quantifiesvegetationby measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs). Chlorophyll (a health indicator) strongly absorbs visible light, and the cellular structure of the leaves strongly reflect near-infrared light. When the plant becomes sick, dehydrated, afflicted by disease. It is an effective index for quantifying the state of vegetation health based on how plants reflect light at certain wavelengths. The value range of the NDVI is -1 to 1. Negative values of NDVI (values approaching -1) correspond to water. Values close to zero (-0.1to 0.1) generally correspond to barren areas of rock, sand, or snow. Low, positive values represent shrub and grassland (approximately 0.2 to 0.4), while high values indicate temperate and tropical rainforests (EOS 2021). As shown below, (NDVI) uses the NIR and red channels in its formula (1) below:

$$\text{NDVI} = \frac{NIR-R}{NIR+R}$$

Formula (1).

As it clearly illustrated in chart (1) below, the NDVI of the vegetation cover of the area was significantly affected by the fire the mean NDVI values ranged from 0.48 at the beginning of June to be 0.47 on the 20th of June. After the heat wave starting slight decline has accrued to reach 0.38. on the 30thof June NDVI mean value was 0.4 but due to the fire a significant decrease had started to reach 0.02 on the 4th of July. That is a clear evidence of the of the destruction of the fire on the vegetation health and states.

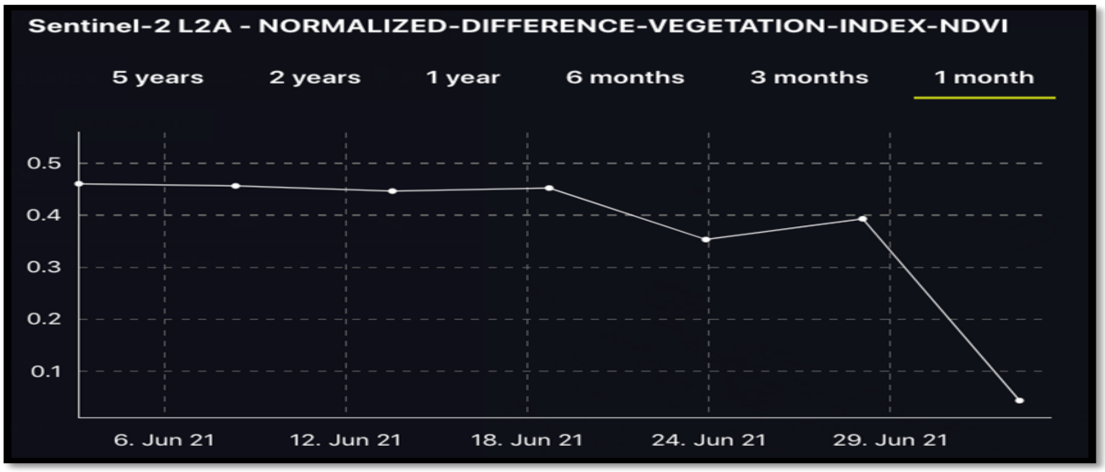

Chart (1) NDVI of the burned area, from the 1st of June to 4th of July (*Copernicus 2021*).

The NDVI formula (1) was applied for the two sentinel-2 pre/post Ain Marah wild fire on the 24th of June 2021, and the 4th of July in order to make a calculation of the change accrued in the vegetation cover that was affected during the fire action. All the affected vegetations cover is represented by the changed pixels of the image was examined for the post fire images on the 4th of July, and was compared with that which of the pre fire image on the 24th of June (dNDVI) Figure (6). Based on the sentinel 2- derived NDVI the total burned vegetation cover area, between the 24th of June and the 4th of July is estimated to be 0.968 km² or 96.8 hectares. However, although the area is mostly vegetation cover but there are other burned land-uses should beexamined, therefore it was vital to apply the NBR and BAI to gain the actual Ain Marah burned extension.

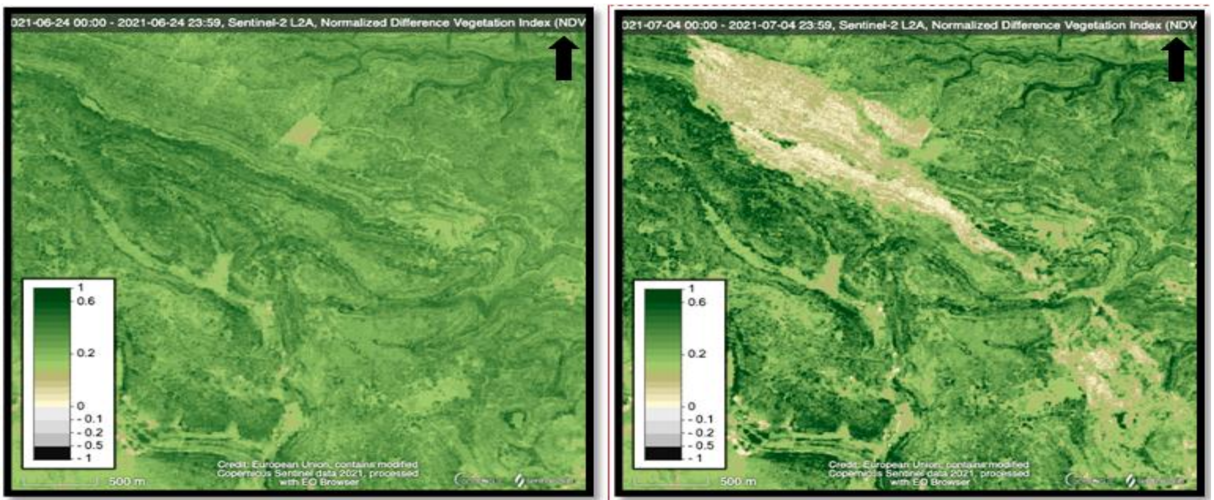

Figure 6: NBR of Pre (24th June) & post (4th July) Ain Marah wildfire (*Copernicus 2021*).

4.3.2 Normalized Burn Ratio (NBR):

The Normalized Burn Ratio (NBR) is one of the most accurate indexes to measure the delineating burned areas, as it is designed to highlight burnt areas in most scales fire zones. It measures the fire severity by distinguishing areas that have been virtually transformed in their spectral signature after a wildfire. The NBR difference has successfully been applied in several studies to map the burn severity (Cocke et al. 2005; Adagbasa et al. 2018).

As shown in figure (3) healthy vegetation gives a very high reflectance in the NIR, and low reflectance in the SWIR portion of the spectrum, the opposite of what is seen in areas devastated by fire. Recently burnt areas indicates a high reflectance in the SWIR and low reflectance in the NIR. Therefore the difference between the spectral responses of healthy vegetation and burnt areas reach their peak in the NIR and the SWIR wavelength bands from the remotely sensed satellite imagery.

NBR benefits from the magnitude of spectral difference, As it uses the ratio between NIR and SWIR bands according to formula (1) shown below. The NBR index is expressed in values between -1 and +1. A high NBR value indicates healthy vegetation while a low value illustrates bare ground and recently burnt areas. Non-burnt areas are normally attributed to values close to zero (Mallinis et al. 2017) . NBR for Sentinel 2 data is calculated as:

$$NBR = \frac{(NIR - SWIR)}{(NIR + SWIR)} = \frac{(Band\ 8 - Band\ 12)}{(Band\ 8 + Band\ 12)}$$ *Formula (2) Key & Benson (2006).*

To estimate the difference between the pre-fire and post-fire NBR conductedfrom the images is used to calculate the *delta* NBR (dNBR), which accordingly can be used to measure the recently burned areas. A higher value of dNBR indicates more severe damage, while areas with negative dNBR values may indicate regrowth following a fire. The formula used to calculate dNBR is below:

dNBR or ΔNBR = PrefireNBR - PostfireNBR *Formula (3) Key& Benson (2006), Keeley, J. (2009).*

The United States Geological Survey (USGS) proposed a classification table to interpret the burn severity, which can be seen below (Table 1).

Severity Level	dNBR Range (scaled by 10^3)	dNBR Range (not scaled)
Enhanced Regrowth, high (post-fire)	-500 to -251	-0.500 to -0.251
Enhanced Regrowth, low (post-fire)	-250 to -101	-0.250 to -0.101
Unburned	-100 to +99	-0.100 to +0.99
Low Severity	+100 to +269	+0.100 to +0.269
Moderate-low Severity	+270 to +439	+0.270 to +0.439
Miderate-high Severity	+440 to +659	+0.440 to +0.659
High Severity	+660 to +1300	+0.660 to +1.300

Table 3: Burn severity classification criteria table** (USGS)**.

In order to compare NBR with the reference spectral indices used for burned area mapping, NBR was computed according to formula (2).

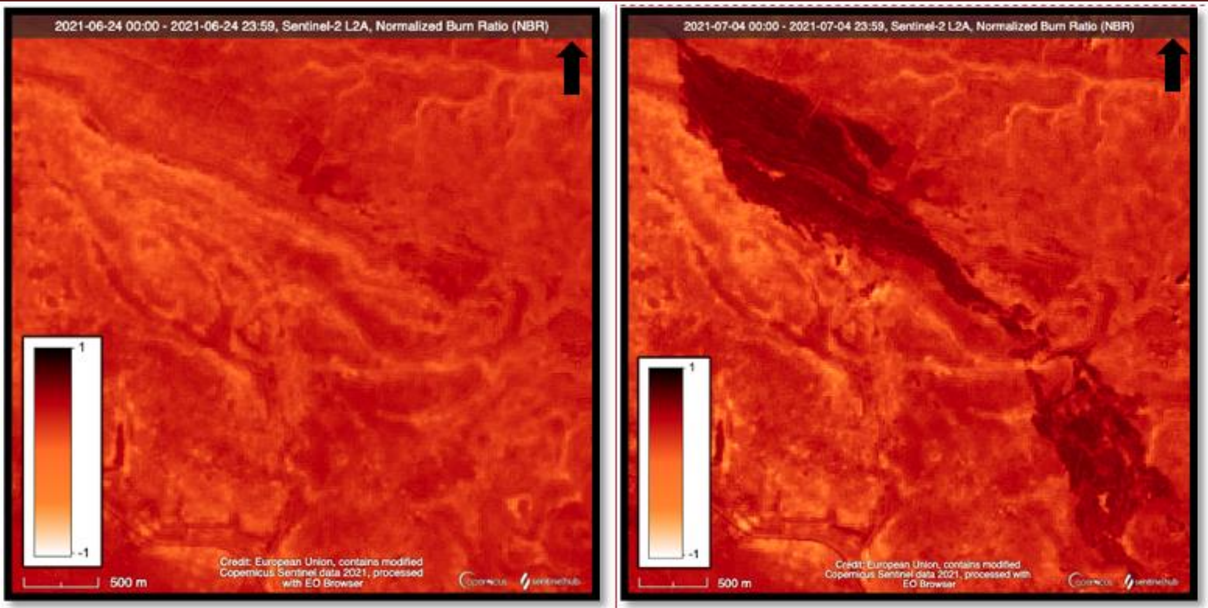

Figure 7: NBR of Pre (24th June) & post Ain Marah wildfire (4th July) (*Copernicus 2021*)**.**

Analyzing the post-fire NBR image, it could be clearly seen that burned areas are visualized in darker, almost black color and it is now easier to distinguish them from the rest of areas.

At this point, we have two NBR bands each corresponding to the pre-fire (June 24th), which is 5 days before the fire, and post-fire date (July 4th) just two days of the fire stop. To identify recently burned areas, dNBR was calculated by differencing the post-fire NBR from the pre-fire NBR. For Ain Marah data the NBR values ranges mostly from – 0.22 to 0.534. pixels in the dataset have a value close to 0 (mean value is 0.04) which corresponds to unburned areas. The burn scar showing fire-affected areas is clearly visible on the right image in figure (7) and is illustrated by pixels with dNBR values above 0.1. Within the affected area, quite a large number of pixels have been classified to a low severity burn zone. dNBR index conducted from the Sentinel-2 data of Ain Marah fire has illustrated the recently fire affected area by1.03 km2(103 ha).

4.3.3 Burned area index (BAI):

In order to reduce burned areas classification errors, the use of difference indices is preferred, hence Ain Marah burned area was investigated using (Burned area index BAI). Sentinel-2 BAI adapts the traditional BAI for Sentinel-2 bands (BAIS2), taking advantage of the wider spectrum of Visible, Red-Edge, NIR and SWIR bands.Values description: The range of values for the BAIS2 is -1 to 1 for burn scars, and 1 - 6 for active fires. Different fire intensities may result in different thresholds, the current values were calibrates, on mostly Mediterranean regions. it take advantagesof vegetation properties described in the red-edge spectral domains and the radiometric response in the SWIR spectral wavelength, widely recognized to be efficient in the determination of burned areas. The use S-2A spectral information allows to map burned areas at 20 m resolution and to identify small burned areas(Filipponi, F2018).

BAI formula (4) was applied for each pixel in the image and the result is as follows:

$$BAI = \frac{1}{(0.1-R)^2 + (0.06-NIR)^2}$$

Formula (4) (Mpakairi, K et al 2020).

The outcome dBAI results obtained from both pre/post Ain Marah indices shows the actual burned area scars in figure (9). The BAI values for the post-fire image ranged from – 0.53 to –

0.85 according to the fire severity for the burned areas, The total burned area estimated from the Sentinel 2-derived BAI between 24th June and 4th July, 2021 is approximately 1.018 km² or (101.8ha).

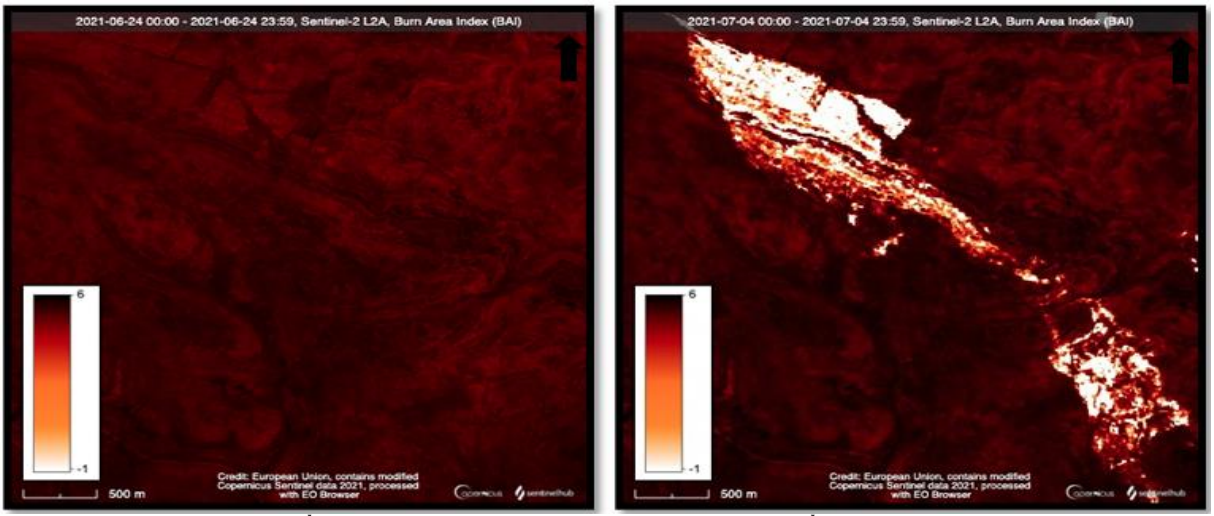

Fig 9: BAI of Pre (24th June) & post Ain Marah wildfire (4th July) (**Copernicus 2021**).

5.0 ResultsDiscussion:

The comparison of Sentinel-2 spectral indices shows a high similaritybetween(NIR) and(SWIR) to discriminate between healthy vegetation and burned areas. For this reason, this study uses the differenced Normalized Burn Ratio (NDVI), (dNBR) and (dBAI) which contain information in the NIR and SWIR spectrum regions and it is commonly used in burned areas detection. The NDVI as a vegetation health indicator results have provided a clear evidence of the vegetation destruction at the area of study, since the mean NDVI value was 0.42 before the fire occurrence, but due to the fire this number started to decline significantly to reach to its lowest value 0.02 on the 4th of July,that was illustrated in chart (1). NDVI formula was implemented on the pre/post fire Sentinel-2 images of the study area, in order to map the fire effected vegetation (dNDVI), that was clearly shown on figure (7) the outcome dNDVI results have given an estimation of 96.8 ha as the total burned vegetation cover. As there was not any official data from neither governmental nor scientifical organization for the meant fire to be used as a reference, Adoption of difference indices such as (dNBR and dBAI S2) was demonstrated to gather better results when compared to a multi-temporal observation, the use of difference indices is strongly recommended (Mpakairi, K et al 2020) . NBR and BAI indexes calculation is one of the most efficiently used indices for the fire extension and severity mapping and discrimination of burned extension, therefore it was applied for the pre and post Ain Marah fire Sentinel-2 images, the outcome results of these indices were 103 and 101.8 hectares for the NBR and BAI respectively. Although the obtained results area highly close and convenient. But according to (Filipponi, F 2018) Separation between burned pixels and pixels of overlapped baren and dry vegetation is common, and have been already reported by several studies, that highlighted critical issues related to the existence of extremely dark pixels that can be the source of commission errors in the classification of burned pixels from BAIS2 estimates. Differences among values BAIS2 and NBR , was emphasized through a comparison of the two products. The difference between spectral indices and biophysical estimates suggests further investigation to identify the suitability of using biophysical estimates for the interpretation of fire extension and severity levels in a more comprehensive manner.

6.0 Conclusion:

The study was an attempt to emphasize the importance of remote sensing science in mapping, analysis and detection of forest fires which is unusually complex Issus,instead of using the time and costly-consuming works carried out on the field, remote sensing techniques are modern technology that could present efficient results in a much more economical, fast and safe way. The implementation of NDVI, NBR and the BAI spectral indexes derived from Sentinel-2 images of Ain Marah burned area mapping provided visual and numerical results of the actual burnt area resulted from the fire. The main limitation of the study was the absence of any official data about the fire destruction from the Libyan authorities. Therefore, the study author advises the decision makers to put an effort for the remotely sensed technology in order to gain a comprehensive archive for the wildfires causes, behaviour, severity and consequences in Libya, in order to reach to local awareness knowledge of the fire loss and severity.

المستلخلص: اندلع حريق غابات في 30 يونيو وتوقف في 3 يوليو2021 بالقرب من قرية عين مره بالجبل الأخضر، ليبيا. مما تسبب في أضرار وإصابات جسيمة. ولم ترد أي نتائج رسمية عن المنطقة التي التهمتها النيران. هذه الدراسة هي محاولة لتقدير دقيق للمساحة المحترقة باستخدام مؤشر الغطاء النباتي الطبيعي (NDVI) ، ومؤشر المساحة المحترقة (BAI) ، ومؤشرات نسبة الحرق الطبيعي (NBR) ، والتي تم اشتقاقها من القمر الصناعي الأوروبي Sentinel-2A تم حساب المؤشرات للتمييز بين وحدات البيكسل المحترقة وغير المحترقة في المساحات ثنائية الطيف-NIR وMIR وNIR-R قبل / بعد اندلاع النار. صنف NDVI مساحة فقدان الغطاء النباتي الفعلي بمقدار 96.8 هكتار ، بينما تم حساب NBRو BAI لنفس الصور من أجل الحصول على المساحة المحترقة الفعلية والتي تم تقديرها بـ 103 و 101.8 هكتار على التوالي. كانت المساحة المحترقة المقدرة التي تم الحصول عليها من NBR و BAI متباينة قليلاً وذلك لأن المنطقة قد مرت بالفعل بطقس حار طويل غير عادي قبل حدوث الحريق ، مما يجعل الغطاء النباتي جافًا بالفعل ويظهر فالصورة وكأنه أرض جرداء. يتداخل الغطاء الأرضي الإضافي مع نباتات جافة منخفضة وأرض جرداء ، مما قد يؤثر علي دقة هذه الحسابات.

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