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| **PROJECT TITLE** | **DETERMINING HOW WEATHER CONDITIONS AFFECT MALARIA OCCURRENCE AND MAIZE YIELDS IN HOMABAY, KENYA USING NDVI.** |
| **NAME OF SCHOOL** | **Shree Swaminarayan Academy, Mombasa.** |
| **STUDENTS NAME** | **MANAL G. AHMED & MOHAMMED HAJI** |
| **INTRODUCTION** | Normalized Difference Vegetation Index (NDVI) is a remote sensing technology that is used to determine the amount of vegetation cover on the earth's surface. It is important to determine vegetation cover on the earth's surface because any changes on vegetation cover affects our health, economy and environment. In an effort to monitor major fluctuations in vegetation and understand how they affect the environment, 20 years ago Earth scientists began using satellite remote sensors to measure and map the density of green vegetation over the Earth. Using NOAA's Advanced Very High Resolution Radiometer (AVHRR), scientists have been collecting images of our planet's surface.<br>NDVI is useful for farmers as it helps them monitor and manage their farms remotely, and can predict climate changes such as drought. Since NDVI determines vegetation cover, it can also be correlated with incidences of vector borne diseases such as malaria, which is transmitted by the mosquito.<br>In this study, normalized data from the weather station located at Homa Bay High School (0.5379° S, 34.4600° E), in Homa Bay County, was used to determine whether there was a correlation between NDVI and malaria occurrence with weather conditions (precipitation, humidity and temperature) in Homa Bay County during the period between January, 2017 and February, 2018.<br>NDVI is calculated by near-infrared radiation (NIR) minus visible radiation (Red) divided by near-infrared radiation plus visible radiation (Earth observatory, NASA, 2000). The result generates a value between -1 and +1.<br>A value of zero means no vegetation (e.g. tundra or desert) and close to +1 (0.8-0.9) indicates the highest possible density of green leaves (e.g. forest).<br>NDVI technology is therefore a very useful tool for monitoring health of crops by farmers and also to monitor incidences of vector borne diseases such as malaria in malaria endemic regions. |
| **METHOODS** | **2.1 Data collection for NDVI, weather parameters and malaria occurrence.**<br>Raw and normalized data from the weather station located at Homa Bay High School (0.5379° S, 34.4600° E) between January 2017 and February 2018 was obtained from the Regional Centre for Mapping of Resources for Development (RCMRD). The data included temperature, humidity, precipitation, pressure, radiation, wind speed, NDVI and malaria occurrence.<br><br>Raw data is presented in Table 1 while the normalized data is presented in Table 2 (see project report). |

**Table 1**: Raw data of weather parameters and malaria occurrence collected from the weather station located at Homa Bay High School. (Source: RCMRD)

| Automatic Weather Station Data(aggregated to Montly) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DateTime | Site | Name | huHidity | Precipitation | Pressure | Radiation | Temp | Windspeed | Malaria |
| 2017 Jan | TA00031 | Homa Bay High School | 57.96236559 | 0.62365591 | 87.89954 | 239.8129 | 24.8296 | -12.286976 | 48195 |
| 2017 Feb | TA00031 | Homa Bay High School | 65.13541667 | 0.61160714 | 87.91533 | 248.9524 | 24.57853 | -102.99347 | 35020 |
| 2017 Mar | TA00031 | Homa Bay High School | 68.78734859 | 1.04306864 | 87.92402 | 262.3542 | 24.59635 | -510.12552 | 32924 |
| 2017 Apr | TA00031 | Homa Bay High School | 69.58333333 | 0.65694444 | 87.96872 | 239.3051 | 24.06767 | -360.02821 | 32599 |
| 2017 May | TA00031 | Homa Bay High School | 77.07795699 | 1.61962366 | 88.10966 | 221.1212 | 22.85399 | -200.73246 | 52231 |
| 2017 Jun | TA00031 | Homa Bay High School | 68.58888889 | 0.41111111 | 88.11208 | 229.3145 | 23.59654 | -165.5884 | 31620 |
| 2017 Jul | TA00031 | Homa Bay High School | 71.64516129 | 0.04973118 | 88.19539 | 200.9733 | 22.80532 | -429.14035 | 25961 |
| 2017 Aug | TA00031 | Homa Bay High School | 69.74596774 | 0.25672043 | 88.08913 | 216.3381 | 23.20805 | 0.8769086 | 17897 |
| 2017 Sep | TA00031 | Homa Bay High School | 72.66527778 | 0.67083333 | 88.08786 | 219.7303 | 22.90224 | -818.48678 | 20148 |
| 2017 Oct | TA00031 | Homa Bay High School | 71.67607527 | 0.36424731 | 87.98101 | 238.0995 | 23.62642 | -509.85464 | 17773 |
| 2017 Nov | TA00031 | Homa Bay High School | 75.1625 | 0.75 | 87.95803 | 213.1151 | 22.51647 | -485.09922 | 30703 |
| 2017 Dec | TA00031 | Homa Bay High School | 66.25541667 | 0.34408602 | 36.41874 | 241.1095 | 24.24499 | -39.116156 | 25341 |
| 2018 Jan | TA00031 | Homa Bay High School | 63.68426075 | 0.15860215 | 46.54321 | 207.7534 | 23.697 | -2364.1936 | 44842 |
| 2018 Feb | TA00031 | Homa Bay High School | 58.80205357 | 0.4389881 | 63.53458 | 239.578 | 25.60705 | -9998 | 33645 |

The raw data was normalized using the formula: Normalized = (x-min)/(max-min) where:
x is the value to be normalized within a particular data set
min is the minimum value within the data set and max is the maximum value within the data set.

## 2.2 Data collection on maize yield

Data on annual maize yield was collected from Homa Bay High School and six (6) farmers randomly sampled from around the school's environs, which included three small villages, namely, Kananga Lakeshore, Katuma & Nyalkinyi. Data on field-observed maize yields of four growing seasons (2017–2018) were collected in 2019 by means of interviews with the selected farmers who had records of their production. Maize yield was calculated as Kg/ha.

## 2.3 Data analysis

**Table 2**: Normalized data of weather parameters, NDVI and malaria occurrence in Homa Bay county (Source: RCMRD)

| Normalized (x-min)/(max-min) | | | | | |
|---|---|---|---|---|---|
| DateTime | Humidity | Precipitation | Temperature | Malaria Occurence | NDVI |
| Jan, 17 | 0 | 0.365582192 | 0.748443185 | 0.882871902 | 0.401 |
| Feb, 17 | 0.3752461 | 0.35790729 | 0.667206048 | 0.500522375 | 0.391 |
| March, 17 | 0.56629077 | 0.632742353 | 0.67297384 | 0.439694701 | 0.413 |
| April, 17 | 0.60793137 | 0.386786529 | 0.501910247 | 0.430262929 | 0.437 |
| May, 17 | 1 | 1 | 0.109209136 | 1 | 0.446 |
| June, 17 | 0.55590869 | 0.230194064 | 0.34947129 | 0.401851529 | 0.424 |
| July, 17 | 0.71579243 | 0 | 0.093461497 | 0.237622613 | 0.414 |
| Aug, 17 | 0.61643932 | 0.131849315 | 0.223769829 | 0.003598584 | 0.442 |
| Sept, 17 | 0.76915811 | 0.395633561 | 0.124819199 | 0.068924488 | 0.437 |
| Oct, 17 | 0.71740965 | 0.200342466 | 0.359140364 | 0 | 0.431 |
| Nov, 17 | 0.89979609 | 0.446061644 | 0 | 0.375239422 | 0.456 |
| Dec, 17 | 0.43383701 | 0.1875 | 0.559284531 | 0.219629694 | 0.444 |
| Jan, 18 | 0.29933132 | 0.069349315 | 0.381976831 | 1 | 0.386 |
| Feb, 18 | 0.04392686 | 0.247951321 | 1 | 0.70076699 | 0.3 |

The normalized data from RCMRD (Table 2) and data on crop yields from the selected farmers was used to plot line graphs using MS Excel in order to determine the following:
Whether there is a correlation between the weather conditions and NDVI,
Whether there is a correlation between the weather condition and malaria occurrence, and,
Whether there is a correlation between the NDVI and crop yield.
The normalized data (Table 2) was also used to compute a correlation matrix using CORREL formula in MS Excel.

# RESULTS

## Trends between NDVI and weather parameters

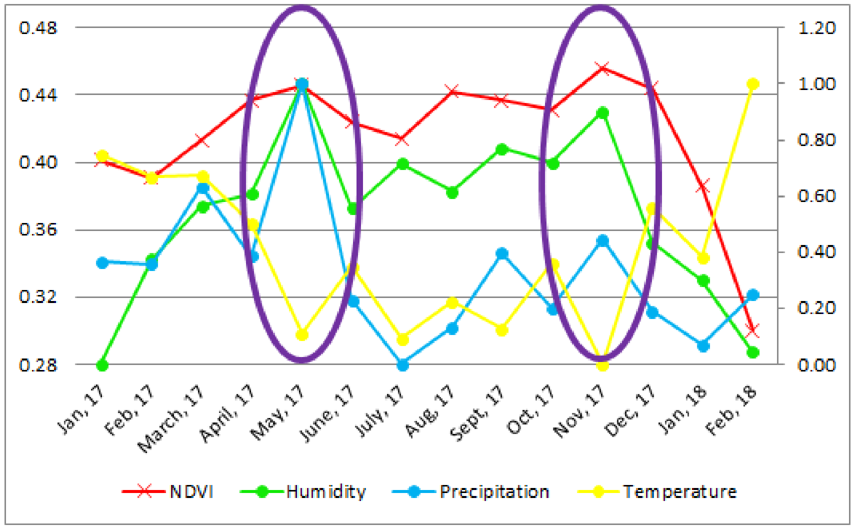


**Figure 2**: Graph showing trends between NDVI and weather conditions. The months of May and November, 2017 are circled in purple.

Maize, the staple food crop in Homa Bay, is usually planted just before the rainy seasons of February to March and September to October.

From our results (Figure 2), we can see that, the highest recordings of NDVI obtained were in May, 2017 (0.45) and November, 2017 (0.46). This is because, during this time, the maize plants are growing and appear very green in colour. During these months humidity and precipitation were also high (1.00).

Between May and July, 2017, NDVI precipitation and temperature decreased from 0.45 to 0.41. The low NDVI is because Maize is harvested in June, and in July, the maize stalks are left to dry, and they turn yellow in colour. The average maize yield for the year 2017 was 722 kg/ha.

## Trends between malaria occurrence and weather conditions

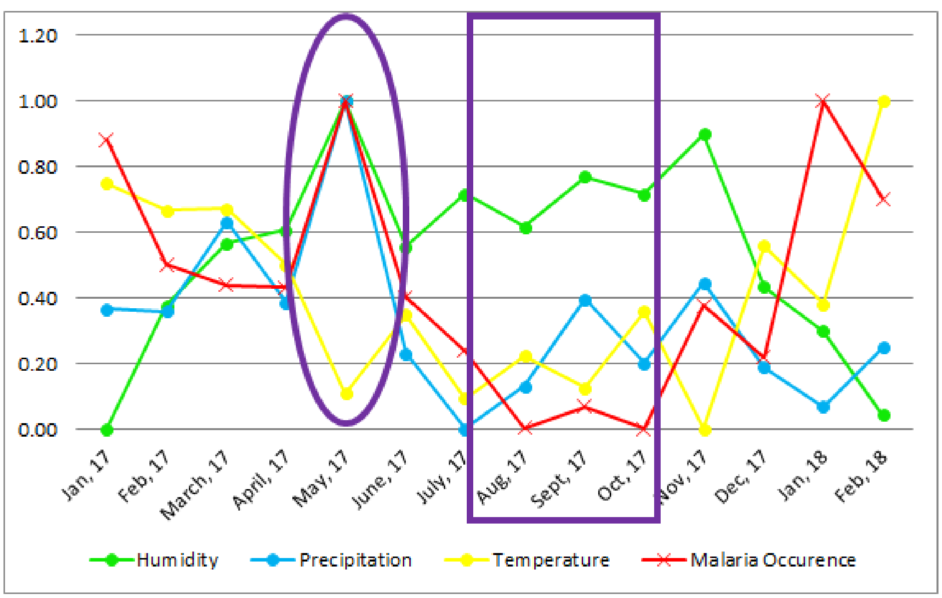


**Figure 3**: Graph showing correlation between malaria occurrence and weather conditions. The months of May, 2017 and August-October, 2017 are highlighted in purple.

Malaria is transmitted by the Anopheles mosquito, which breeds in stagnant water during the rainy seasons. It is clear from our data that, there was high vegetation cover

and precipitation in May (Figure 2 and 3) which could have increased mosquito population.
Between August and October, 2017, malaria occurrence was at its lowest (Figure 3). This could be due to low vegetation cover, since this is the period that harvesting of the first season and planting of the second season of maize is taking place. The NDVI values during these months are also lower (0.44-0.43), indicating less healthy crop (yellowed maize stalks during harvesting) and less vegetation cover following harvesting.

Correlation between NDVI, malaria occurrence and weather conditions

**Table 3: Correlation matrix**

| | **Humidity** | **Precipitation** | **Temperature** | **Malaria Occurrence** | **NDVI** |
|---|---|---|---|---|---|
| **Humidity** | **1** | | | | |
| **Precipitation** | **0.386** | **1** | | | |
| **Temperature** | **-0.855** | **-0.073** | **1** | | |
| **Malaria Occurrence** | **-0.378** | **0.392** | **0.311** | **1** | |
| **NDVI** | **0.767** | **0.271** | **-0.752** | **-0.378** | **1** |

From the correlation matrix (Table 3) generated using normalized data, we observed that:
1. NDVI had a positive correlation with humidity (0.767) and precipitation (0.271), while it had a negative correlation with temperature (-0.752).
2.NDVI had a negative correlation with malaria occurrence (-0.378)

## CONCLUSION

The results presented show that there is a correlation between:
a) NDVI and weather conditions
b) Malaria occurrence and weather conditions

In summary:
1. NDVI generally has a strong positive correlation with precipitation and humidity, while it has a moderately negative relationship with temperature.
2. Malaria occurrence has a moderately positive correlation with precipitation, humidity and also a negative relationship with temperature.
3. NDVI can be correlated with malaria occurrence because it is dependent on weather conditions and gives a good indication of vegetation cover. High vegetation cover encourages mosquito breeding.
4. Direct correlation between NDVI and crop yield was limited by insufficient data on crop yield and NDVI. This study was limited by data that was available for the year 2017. To generate a comprehensive correlation matrix, large sets of data that have been collected over longer periods of time are required.

High NDVI also implies good vegetation cover, contributed by the healthy staple crops such as maize.
NDVI technology is therefore a very useful tool for monitoring health of crops by farmers and also to monitor incidences of vector borne diseases such as malaria. This is important, as, a healthy community will result in increased agricultural productivity.

**RECOMMENDATIONS**

**-** Information on NDVI and malaria occurrence of a given area can be used by the government to help its citizens on best agricultural and health practices, help in prediction of drought, floods and disease epidemics.
-Adopting NDVI technology in Kenya, which relies on agriculture for economic

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| | growth, will help to improve agricultural yields and improve food security, minimize food shortage in the country, resulting in a more healthy and productive nation.<br>-There is need to collect NDVI data with weather parameters and crop yields for at least three years or longer in order to determine the correlations more confidently. |
| **REFERENCE** | GoK. 2013. Homa Bay County First County Integrated Development Plan (CIDP) 2013-2017. Government of Kenya, Nairobi, Kenya.<br>GoK. 2014. Agricultural Sector Development Support Program (ASDSP). Ministry of Agriculture Livestock and Fisheries, Nairobi, Kenya.<br>https://earthobservatory.nasa.gov/features/MeasuringVegetation/measuring_vegetation_1.php<br>https://earthobservatory.nasa.gov/features/MeasuringVegetation/measuring_vegetation_2.php<br>https://earthobservatory.nasa.gov/features/MeasuringVegetation.<br>https://www.gislounge.com/measuring-vegetation-satellite-imagery-ndvi/<br>https://sentera.com/what-is-ndvi/<br>MoALF. 2016. Climate Risk Profile for Homa Bay County. Kenya County Climate Risk Profile Series. The Ministry of Agriculture, Livestock and Fisheries (MoALF), Nairobi, Kenya. |
| **ACKNOWLEDGMENTS** | In the present world of competition there is a race of existence in which those who have will, come forward to succeed. Project is the bridge between theoretical and practical working. With the will, we joined this particular project.<br>First of all, we would like to thank the Supreme power, the Almighty Allah, who has always guided us to work on the right path of life. Without His grace this project could not become a reality. Next to Him are our supportive parents, Prof. Suhaila Hashim and Mrs. Khadija Haji whom we are greatly indebted for bringing us up with love and encouragement to this stage.<br>Secondly, we feel obliged in taking this opportunity to sincerely say a word of 'thank you' to our School Principal Mrs. A. Lazar and special heartfelt gratitude to our worthy supervisor Mr. Kennedy Otieno for his patience, belief in us and the enthusiasm that inspired us throughout the project.<br>Thirdly, we pay our deep sense of gratitude to Ms. Beatrice Oyange of Globe program, Mr. Charles Mwangi of Kenya Space Agency and Laurence Ochieng Okello of Regional Centre for Mapping of Resources for Development (RCMRD) for their provision of normalized NDVI data and remote sensing techniques that made our research more meaningful and complete.<br>Last but not least, our project mentor, Ms. Nancy Kinyua and fellow students for their elevating inspiration, encouraging guidance and kind mentorship in the completion of this project |