IVSS REPORT - 2020

THE RELATIONSHIP BETWEEN WEATHER PARAMETERS, NORMALIZED DIFFERENCE VEGETATION INDEX (NDVI), LAND COVER AND MOSQUITO BORNE DISEASES.

PREPARED BY

ST. SCHOLASTICA CATHOLIC SCHOOL – RUARAKA

(SCIENCE CLUB)

Chaperoned by:

Amos Vundi Kaui

and

Eric Nzioka Maweu

STUDENTS

Evelyne Nyambura, Jemima Kanini, Barnarbas Mutuku, Junior Mayaka, Sharon Makhoha and David Muhia

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ABSTRACT

Global Learning and Observation to Benefit the Environment (GLOBE) Program, is meant to equip students with necessary knowledge and skills about their immediate environment, their distant environment and the world at large to environmental degradation, climate change and its drivers.

We shall be analyzing data we collected from Automatic Weather Station (AWS) - TA00031 at Homa Bay High School, malaria cases in Homa Bay County Hospital in Western Kenya and NDVI MODIS data recorded from the region.

This report computes monthly trends in **precipitation, humidity** and **temperature**, **NDVI, land cover** against **MALARIA OCCURRENCE** computed data. This data was collected between January 2017 and February 2018.

This report identifies the link between the **weather parameters**, and **malaria prevalence** in the region.

The report also includes use of data collected using the **GLOBE Observer** app to show how different **GLOBE protocols (Clouds, Land cover)** can be linked with the **Mosquito protocol** to determine mosquito seasons and favorable climatic conditions for the growth of mosquitoes. This can help to develop mitigation measures before the disasters like outbreak of mosquito borne diseases strike.

With the growing need to apply STEM science to address environmental challenges in our day to day life, we delve into this expansive field by looking into these parameters of interest and relevance for the benefit of the community within and without our reach.

We live in a society that is a direct recipient of emerging trends of environmental changes. The different parameters have been carefully selected to provide a fair environmental administration of the analysis and for the benefit of the learners in both elementary and ordinary levels.

Figure 1.0: A map of Kenya.

1.0 THE RESEARCH QUESTION

What is the relationship between weather parameters and Normalized Difference Vegetation Index (NDVI), land cover and mosquitoes?

2.0 HYPOTHESIS

Owing to the altitude of the site of research, there is expected overall parameter variations. Homa Bay region experiences convectional rainfall which may influence the trend of the parameters of study. Using the satellite map (figure 1.0), it shows that there is **green vegetation cover** which suggests that the **NDVI** should be above **o.4**. Additionally, the area will **record high number of mosquitoes and malaria occurrence** at different times of the period of study owing to rainfall occurrence and due to its nearness to a large water body (Lake Victoria).

3.0 LITERATURE REVIEW

Malaria still remains a major public health problem in Kenya and accounts for an estimated 16% of outpatient consultations based on data from the routine health information system. Malaria transmission and infection risk in Kenya is determined largely by altitude, rainfall patterns, and temperature. The variations in altitude and terrain create contrasts in the country's climate, which ranges from tropical along the coast to temperate in the interior to very dry in the north and northeast. The two rainy seasons are the long rains occur from March to May and the short rains from October to December. Temperatures are highest from February to March and lowest from July to August. Therefore, malaria prevalence varies considerably by season and across geographic regions. All four species of Plasmodium that infect humans occur in Kenya. **Plasmodium falciparum,** which causes the most severe form of the disease, is the most common accounting for over 99% of all malaria infections in the country. The major malaria vectors in Kenya are from the **female anopheles mosquitoes**. The malaria vector distribution in the country is not uniform due to variation in climatic factors, particularly temperature and rainfall.

Approximately 70% of the Kenyan population is at risk for malaria. For the purposes of malaria control, the country has been stratified into four epidemiological zones to address the varied risks:

• **Endemic areas**: Areas of stable malaria with altitudes ranging from sea level in the coastal region to up to 1,300 meters around the Lake Victoria basin in western Kenya. Transmission is intense throughout the year with Plasmoduim falciparum prevalence historically greater than 20% The five coastal counties now have malaria prevalence ranging from 5–20%. 29% of the total population live in a malaria-endemic zone, with an estimated 9.6 million in the eight lake endemic counties.

• **Highland and epidemic-prone areas**: Malaria transmission in the western highlands is seasonal with considerable year-to-year variation. The entire population is vulnerable and case-fatality rates during an epidemic can be greater than in endemic regions. In highland epidemic counties, malaria prevalence ranges from 5–20%.

• **Seasonal malaria transmission areas**: This epidemiological zone includes the arid and semiarid areas of northern and central parts of the country, which experience short periods of intense malaria transmission during the rainy seasons. In seasonal risk counties, malaria prevalence is between 1–5%.

• **Low malaria risk areas**: This zone covers 10 counties in the central highlands of Kenya including Nairobi. Approximately 34% of the population lives in this zone.

At risk populations

Anyone can get Malaria but some people are at higher risk they include:

- Pregnant women
- Children under age 5
- Immunocompromised individuals e.g. those living with HIV/AIDS
- Migrants/Travellers from non-endemic regions

Signs and Symptoms

- Fever
- Chills
- Headache
- Vomiting
- Muscle aches
- Joint pains
- Nausea
- Diarrhoea
- Abdominal pain
- Loss of appetite

Most people begin to present with symptoms from 10-15 days and in some instances even up to 4 weeks. They may occur singly or in combination.

In severe cases, when malaria becomes advanced, symptoms may include:

- Prostration – inability to sit upright, stand or walk without support
- Severe Anaemia
- Jaundice (very common in adults) – yellow discoloration of skin and whites of the eyes
- Convulsions - also known as seizures
- Cerebral Malaria (very common in children)
- Hypoglycaemia – low blood sugar
- Kidney failure
- Respiratory distress

- Alteration in level of consciousness – from drowsiness to coma

Prevention

Malaria is preventable and one should take preventive measures when travelling to high burden areas. In Kenya, high burden areas include:

  - the western/ Lake Victoria region of Kenya – this includes Kisumu, Migori, Homa Bay, Siaya, Kakamega, Busia
  - the coastal/ Indian Ocean region – this includes Mombasa, Kilifi, Malindi, Lamu,Kwale, Diani, TaitaTaveta

Nairobi is a low risk area and according to WHO, fewer than 1% of people in Nairobi harbor the Malaria-causing parasite. This therefore means that one does not require Malaria prophylaxis when travelling to or residing in Nairobi.

Preventive measures include:

- Getting Malaria prophylaxis before travel – This is available at the UN clinics. It is also available at local hospitals and pharmacies. Drugs used in prophylaxis include:

  - Mefloquine
  - Atovaquone-Proguanil
  - Doxycycline

- Using long-lasting insecticide treated bed nets (LLINs)
- Using mosquito repellent on skin that is exposed.
- Leave as much skin unexposed as possible when outside from dusk to late hours. This can be through, wearing long-sleeved clothes, and clothes that cover the legs.
- Environmental management – this involves drainage of stagnant pools of water as they tend to be breeding sites, larvicide treatment of habitats, and clearing bushes around the home
- Indoor Residual Spraying (IRS) for those residing in high transmission areas. This can be effective for 3 months and even up to 6 months depending on the insecticide formulation.
- If one has travelled to the high burden areas listed above, if or when symptoms begin to be present, it is advised that you visit a health facility as soon as possible

Diagnosis and Treatment

Suspected Malaria cases should be confirmed using parasite-based diagnostic testing i.e. microscopy or Rapid Diagnostic Test (RDT) before commencing treatment. However, treatment on the basis of symptoms may be considered in the absence of diagnostic tests.Treatment is done using Artemisinin-based Combination Therapy (ACT). Prompt treatment is necessary not only for the health of the patient but also for the prevention of transmission to those around them.

Malaria is curable but **remember prevention is better than cure.**

Normalized Difference Vegetation Index (NDVI) quantifies vegetation by measuring the difference between near-infrared - which vegetation strongly reflects - and red light - which vegetation absorbs.

NDVI always ranges from -1 to +1. But there isn't a distinct boundary for each type of land cover. For negative values, it's highly likely that it's water. On the other hand, NDVI value close to +1 indicates a high possibility that it is dense green leaves.

In practice, the absence of vegetation in bare soil conditions typically result in a value close to zero while areas of dense vegetation will have values close to +1

If the NDVI is close to zero, there isn't green leaves and it could even be an urban area. Normalized Difference Vegetation Index (NDVI) uses the NIR (Near Infra-Red) and red channels in its formula.

$$\boldsymbol{NDVI = \frac{NIR-RED}{NIR+RED}}$$

Healthy vegetation reflects more near-infrared (NIR) and green light compared to other wavelengths, but it absorbs more red and blue light. This justifies why our eyes see vegetation as the color green. Near-infrared would be strong for vegetation too. Satellite sensors like Landsat and Sentinel-2 both have the necessary bands with NIR and red.

NDVI is a standardized way to measure healthy vegetation. When you have high NDVI values, you have healthier vegetation. When you have low NDVI, you have less or no vegetation. Generally, if you want to see vegetation change over time, then you will have to perform atmospheric correction.

When you apply the formula, bright green indicates high NDVI. Whereas red has low NDVI. So it's quantifying vegetation by measuring the difference between near-infrared (which vegetation strongly reflects) and red light (which vegetation absorbs).

For example, in agriculture, farmers use NDVI for precision farming and to measure biomass. Whereas, in forestry, foresters use NDVI to quantify forest supply and leaf area index.

NDVI is a good indicator of drought. When water limits vegetation growth, it has a lower relative NDVI and density of vegetation.

There are hundreds of applications where NDVI and other remote sensing applications is being applied to in the real world in agriculture, forestry and environment to name a few.

The NDVI helped scientists develop things like famine alarm systems and it was used to improve climate models.

Conversely, their cell structure causes them to reflect a lot of near infrared (NIR) radiation. By comparing the reflectance of visual and NIR radiation, therefore, one can get a good idea of how dense the vegetation in an area is. This led to the now ubiquitous equation.

From its beginnings as a tool developed for use in satellite remote sensing, the NDVI is an integral part of precision agriculture because of the level of insight it provides. Apart from its ability to discern the density of vegetation, the NDVI is correlated to key agricultural outcomes such as crop yield, crop identification, leaf area index and even plant health.

Weather is simply the current state of the atmosphere at a specific location at any given point in time. Weather can change very rapidly at times, varying hour to hour or even minute to minute.

There are five factors that determine the state and condition of the atmosphere and, therefore, influence and determine the weather. They include: temperature, air pressure, humidity, cloudiness and wind. These factors can cause different properties in sections of the atmosphere or air masses.

Temperature is the amount of heat contained in an object, in this case, the air. The amount of heat in the air determines the speed of the molecules in the air. The more heat, the faster the molecules move, raising the temperature. The heat in the atmosphere comes from the sun and varies at different levels in the atmosphere. The layers of the atmosphere are determined generally by their temperature. Near the surface of the Earth, the temperature is a factor of how much sunlight an area receives, how much is changed into heat at the Earth's surface and how much of that heat is held near the surface by greenhouse gases or cloud cover. The higher the elevation above the ground, the cooler the air is. Temperature is measured using a thermometer in degrees Fahrenheit or Celsius.

Humidity is a measure of the water content of the air mass. The amount of moisture in the air can vary widely depending on the conditions. In the winter, air is generally cooler and drier, whereas in the summer when air is warmer, it can hold more moisture. The amount of moisture can be seen when it condenses as fog. Humidity is measured using a hygrometer and is measured as a percentage.

Weather forecasts provide critical information about future weather.

4.0 RESULTS.

In this section, the data used from the weather station at Homa Bay High School will be indicated.

Tables

Homa Bay School Automatic Weather Station Data(aggregated to Monthly)					
dateTime UTC	humidity	precipitation	pressure	radiation	temperature
2017 Jan	57.96236559	0.623655914	87.89954	239.8129	24.82959677
2017 Feb	65.13541667	0.611607143	87.91533	248.9524	24.57852679
2017 Mar	68.78734859	1.043068641	87.92402	262.3542	24.59635262
2017 Apr	69.58333333	0.656944444	87.96872	239.3051	24.06766667
2017 May	77.07795699	1.619623656	88.10966	221.1212	22.85399194
2017 Jun	68.58888889	0.411111111	88.11208	229.3145	23.59654167
2017 Jul	71.64516129	0.049731183	88.19539	200.9733	22.80532258
2017 Aug	69.74596774	0.25672043	88.08913	216.3381	23.20805108
2017 Sep	72.66527778	0.670833333	88.08786	219.7303	22.90223611
2017 Oct	71.67607527	0.364247312	87.98101	238.0995	23.62642473
2017 Nov	75.1625	0.75	87.95803	213.1151	22.51647222
2017 Dec	66.25541667	0.344086022	36.41874	241.1095	24.24498656
2018 Jan	63.68426075	0.158602151	46.54321	207.7534	23.69700269
2018 Feb	58.80205357	0.438988095	63.53458	239.578	25.60705357

Table 1.1: Homa Bay School Automatic Weather Station Data (aggregated to Monthly)

NDVI MODIS DATA		
Month (2017)	NDVI pixel values (16bit raster)	Rescaled NDVI values
Jan-17	401	0.401
Feb-17	391	0.391
Mar-17	413	0.413
Apr-17	437	0.437
May-17	446	0.446
Jun-17	424	0.424
Jul-17	414	0.414
Aug-17	442	0.442
Sep-17	437	0.437
Oct-17	431	0.431
Nov-17	456	0.456
Dec-17	444	0.444
Jan-18	386	0.386
Feb-18	300	0.3

Table 1.2: NDVI MODIS DATA for Homa Bay region.

Homabay County Malaria Occurance (Confirmed Malaria data was used)						
	2017			2018		
Period	Confirmed Malaria (only Positive cases)	Malaria in pregnancy	Suspected Malaria	Confirmed Malaria (only Positive cases)	Malaria in pregnancy	Suspected Malaria
January	48195	623	11572	44842	439	19981
February	35020	722	12316	33645	635	18551
March	32924	590	11232	23268	334	15505
April	32599	488	10834	14210	321	9397
May	52231	396	18573	21340	485	22088
June	31620	348	9168	18465	355	22803
July	25961	300	8193	19661	195	23315
August	17897	269	6660	13179	204	16302
September	20148	460	7961	12500	308	18296
October	17773	297	6715	10661	193	17942
November	30703	1977	13050	7423	303	14509
December	25341	310	13198	8948	154	11055

Table 1.3: Homabay County Malaria Occurance.

	Normalized (x-min)/(max-min)				
	Humidity	Precipitation	Temperature	Malaria Occurrence	NDVI
2017 Jan	0.00	0.37	0.75	0.88	0.40
Feb	0.38	0.36	0.67	0.50	0.39
Mar	0.57	0.63	0.67	0.44	0.41
Apr	0.61	0.39	0.50	0.43	0.44
May	1.00	1.00	0.11	1.00	0.45
Jun	0.56	0.23	0.35	0.40	0.42
Jul	0.72	0.00	0.09	0.24	0.41
Aug	0.62	0.13	0.22	0.00	0.44
Sep	0.77	0.40	0.12	0.07	0.44
Oct	0.72	0.20	0.36	0.00	0.43
Nov	0.90	0.45	0.00	0.38	0.46
Dec	0.43	0.19	0.56	0.22	0.44
2019 Jan	0.30	0.07	0.38	1.00	0.39
Feb	0.04	0.25	1.00	0.70	0.30

Table 1.4: Normalized data.

GRAPH

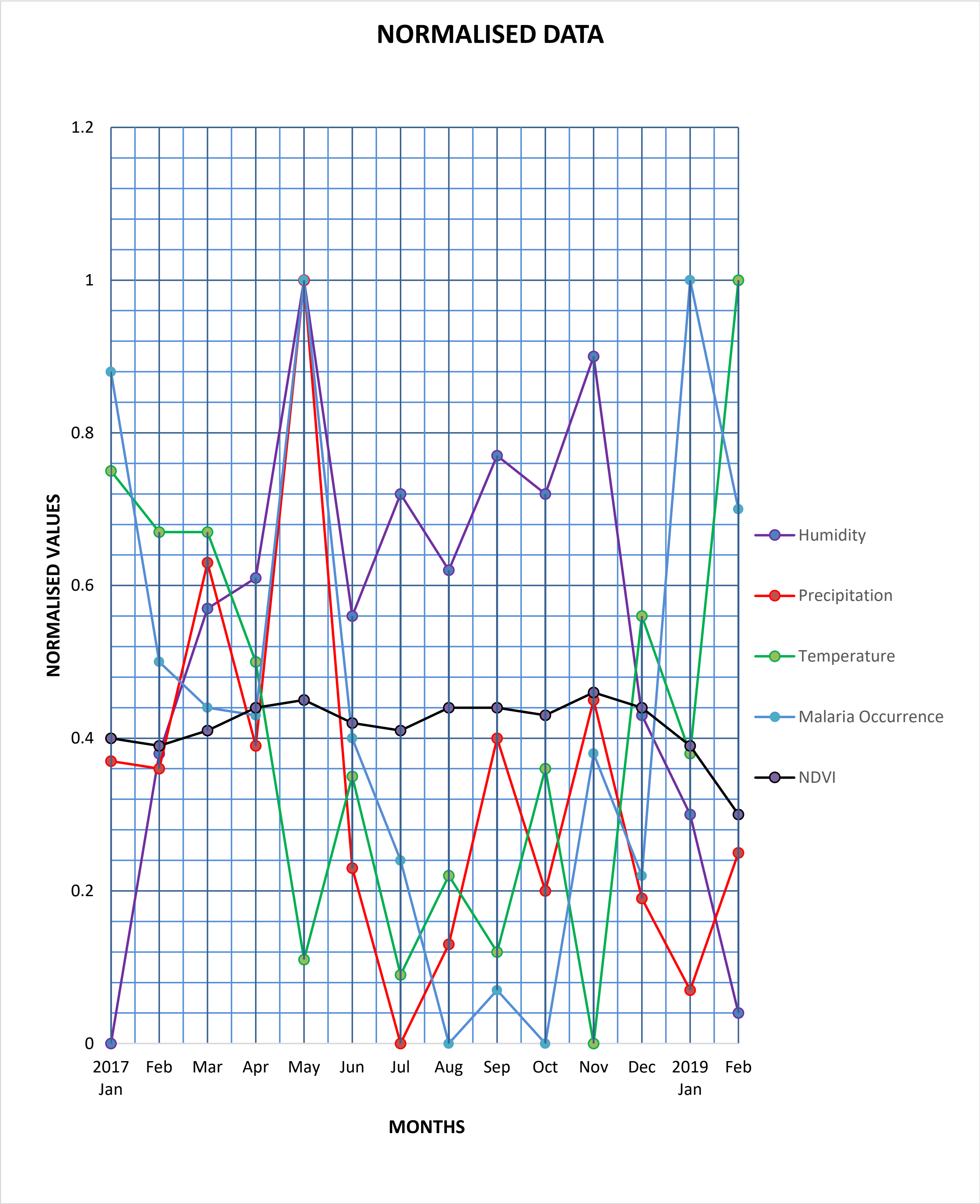

Figure 2.1 combined weather and NDVI data.

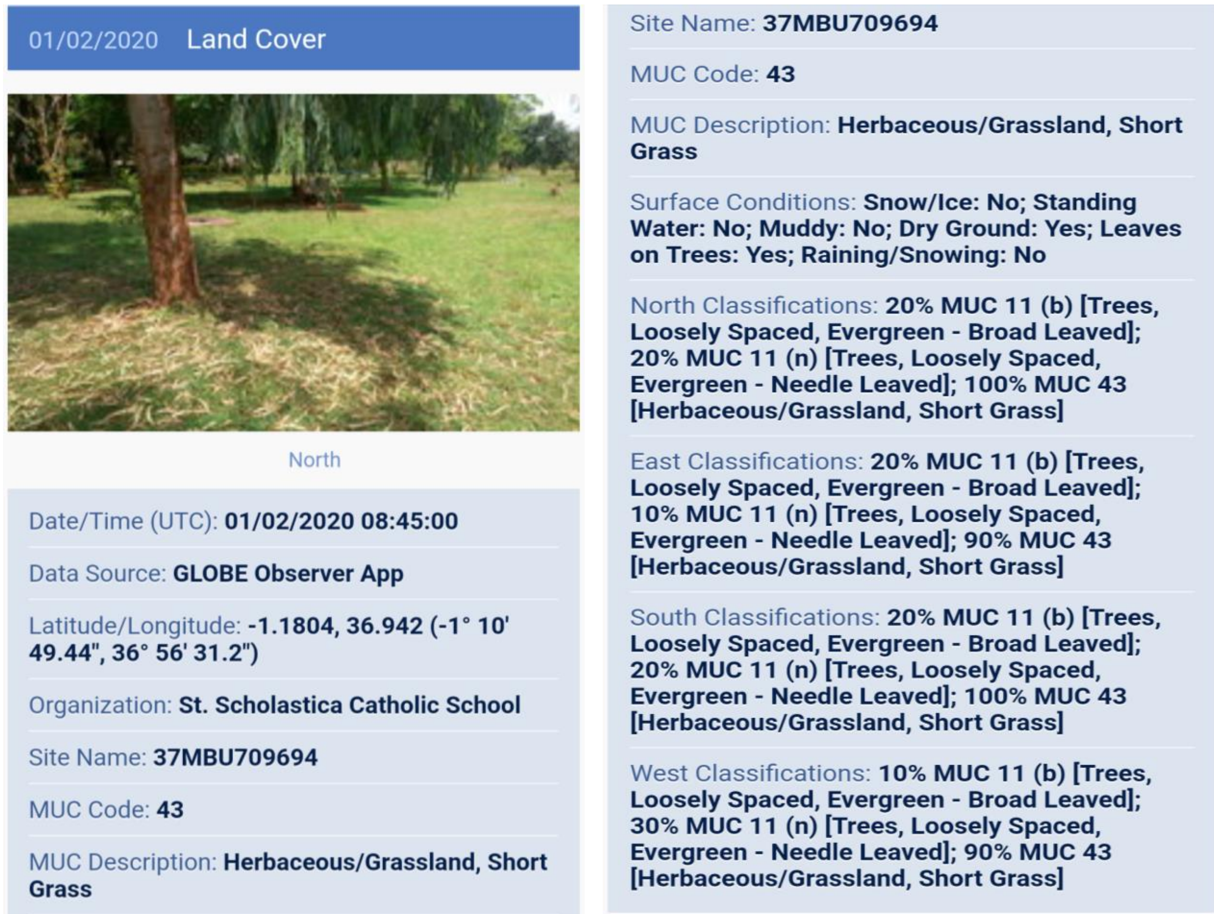

Figure 2.2: GLOBE Observer app screenshot with NDVI value of about 0.3 with some mosquito hiding places.

Figure 2.3: Land cover photo with NDVI value of about 0.6 which creates more hiding places for mosquitoes.

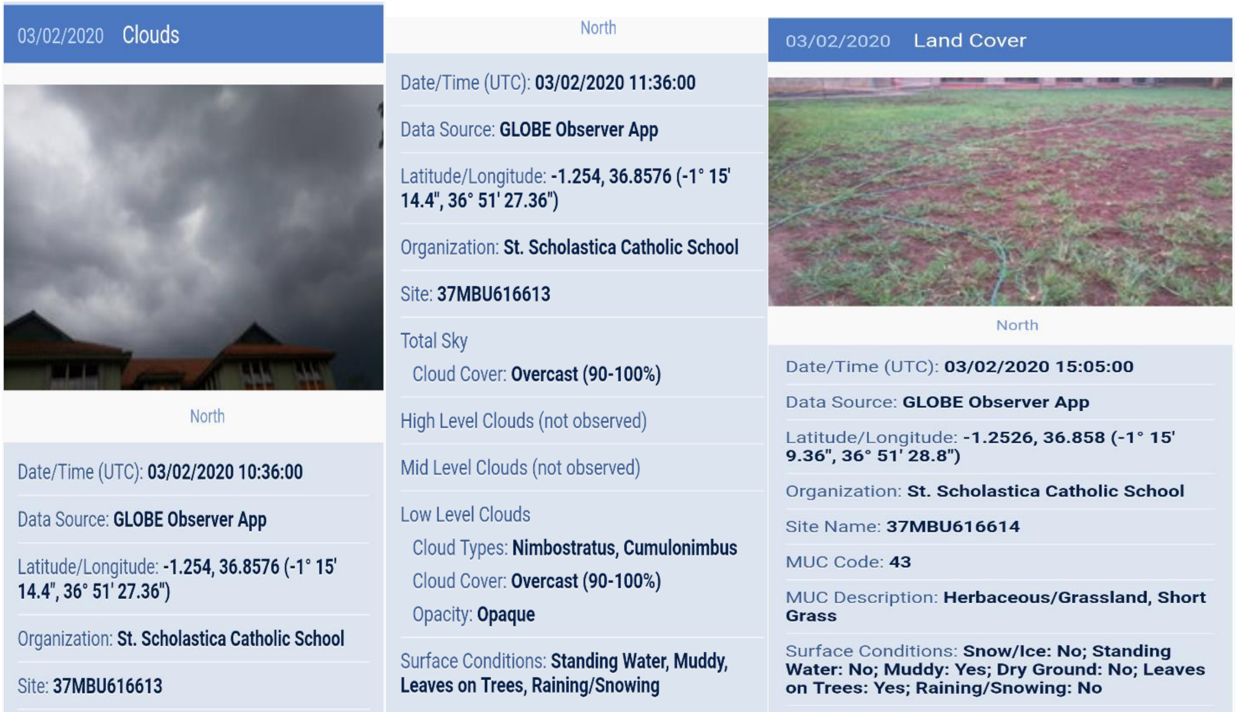

Figure 2.4: Cloud data indicating rainfall and standing water which provides mosquito breeding habitat. Land cover indicating muddy ground.

Figure 2.5: mosquito data collected at the same time with clouds and land cover matched on comparison.

5.0 DISCUSSION.

From the **graph** in figure 2.1 we observe the:

Temperature.

The region has high temperatures at the beginning of 2017 in January as in figure 1.2 but it gradually falls throughout the months with the lowest in May and July. June is hotter than may and July. It rises from July gradually but drastically falls to the lowest of the selected period of study in November. Unusually or unexpectedly it rises to the highest levels in February of 2018. Seemingly, this region has two weather patterns: i.e. Highest temperatures at the beginning of the year and lowest in the middle of the year. November has the lowest temperature recording.

Humidity

At the beginning of 2017, humidity is very low but gradually rises to hit the highest record in may. It is relatively high throughout the following months though in November it falls through the following year to February. From the foregoing, it appears that the region has two low humid seasons in the year.

Precipitation

Attitudinally this area receives convectional rainfall. It has one heavy season in may. The other months are average though the lowest is July 2017 followed by January of 2018.

NDVI

The normalized difference vegetation index is average from the beginning of 2017 to the end of the same year. However, it falls in the month s of January and February in 2018. May and November have high NDVI compared to the other months.In general, all the parameters combined priovide a different corelation with the vegetation cover at different times of the year.

Malaria Occurrence

Cases of malaria occuurrence begin at a high record but reduce gradually in the first quota of 2018. In May, surprisingly, they rise to their highest at normalised +1. May to October records low occurrence with August and October being the lowest months of this occurrence. The last two months of 2017 record relavely below average occurrence. January and February of 2018 have higher occurrence. Generally, January, May and the next January are the peak months of occurrence. In a year, the first half has higher occurrence than the second half. **Malaria** occurrence was directly proprtional to precipitation, temperature and to some extend NDVI.

From the **GLOBE Observer** data as show in the photographs in figures 2.3, 2.4 and 2.5 we observe that:

Cloud show presence of heavy rainfall at the period when there was green vegetation cover. At the same time heavy rainfal was recorded. When mosquito data was collected it showed presence of mosquioes at the same site. This shows that water provided beeding habitat for mosquitoes and the vegetation cover was the hiding places for those mosquitoes.

6.0 CONCLUSION.

The effects of these changing parameter patterns include irregular rain patterns in different parts of the region. By extension, they change plant cover, animal migration and life cycles. Water in large water bodies warms further raising humidity levels. This way it damages water life animals, plant and crop cycles are also adversely affected and in case of storms then they become rather stronger and cause more harm than good to the locals and the society at large.

Temperature records are to a greater percentage proportional to **malaria occurrence**. In May, there is **high humidity, high malaria occurrence, high precipitation and high NDVI.** It is only temperature which is low, surprisingly.

Arguably, this **high rainfall** leads to **expansive vegetation cover** around this area, a possible **high breeding of mosquitoes**. **Mosquitoes** need **high temperatures**. The presence of high rain means that the water stagnates in rather clean environment. This provides suitable environment for mosquito eggs habitation, their incubation and hatching into larvae.

This region receives high rainfall within the first six months of the year. This should be good time for people to be educated on **preventive measures of malaria**. They should also be provided with mosquito nets and repellants. Additionally, they should consider the two seasons and decide on the **suitable mosquito preventive measures** so as to prevent malaria outbreaks during these two periods of the year. Finally, all the above show that the is a direct relationship between **Mosquito mapper app, Clouds app** and **Land cover app** in the **GLOBE observer app**.

<u>7.0 RECOMMENDATIONS</u>

1. On the field, the NDVI works best as a part of a robust agricultural data stack, one that brings together important information on various data points like plant height, soil type, soil moisture, and yield expectation. In this regard we recommend that the Ministry of Agriculture in liaison with its counterpart ICT seeks to share this knowledge with the farmers within this region for better and improved agricultural practices.
2. The NDVI serves as a useful supplement or even substitute to traditional scouting. Imagine being able to quickly determine problem areas in the field based on regions with low NDVI values instead of relying on time-consuming practices that are also prone to human error. This then serves as a strong insight on why today's health practitioners and the wider society should embrace technology in disease outbreak prediction and risk control especially **mosquito borne diseases**.
3. The ease and availability of data also means that scientists can then quickly deploy teams to examine specific mosquito affected areas, allowing them to diagnose issues more efficiently rather than spending time and resources looking for answers with no avail.
4. This NDVI knowledge makes time-sensitive events like the onset of certain diseases such as **malaria** much more manageable. In the end, all these will benefit the bottom line - less time and less resources are spent while getting as much or even more insight than traditional methods.
5. Having conducted this research as a founding for others to come, we feel there is need to do further study on mosquitoes and their relationship with these selected parameters in this research.
6. It will be prudent to share this information with the agricultural sector, health sector, researchers etc. for better decision making.
7. The government departments of health, agriculture, water and sanitation should be provided with this interpretation for better preparation and control of health epidemics, drought, famine and floods.
8. Finally, using **the mosquito habitat mapper**, which is an element of STEM study, the mosquito prevalence can be studied for identification and decommissioning.

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