OPEN ACCESS International Journal of Agriculture & Sustainable Development

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IJASD ISSN:2618-1193

Demarcation of Vulnerable Site for YSB Based on Variable Temperature Values in Rice Fields using Remotely Sensed Thermal Datasets

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Citation | Sohail A[1], Akhtar A[1], Ahmad H[1], Tanveer M.U[1], "Demarcation of Vulnerable Site for YSB Based on Variable Temperature Values in Rice Fields using Remotely Sensed Thermal Datasets". International Journal of Agriculture & Sustainable Development, Vol 02 Issue 01: pp 24-32, 2020.
Received | May 14, 2020; **Revised** |May 24, 2020; **Accepted |** June 10, 2020; **Published |** June 11, 2020.

Rice has become a regular food for 3 billion people of this world which is around half of the global population. Rice contributes healthy for boosting the regional Gross Domestic Product (GDP) and per capita income. About 89% of total global rice production is obtained from south Asian countries. The contribution of China is the highest by producing 148 million metric tons which accounts for 30% of total rice produced globally while India was second with 166.42 million metric tons. Rice crop is very sensitive to climatic hazards and may be attacked by a large variety of insects e.g., yellow, white, pink stem borers, plant hoppers and buttles which finally leads to severe decline to productivity. The pest attacks are highly dependent upon local environmental factors e.g., temperature, humidity and rainfall etc. We incorporated temperature to examine the behavior of Yellow Stem Borer (YSB) at various temperature levels and demarcated hotspots which required pesticides throughout the life cycle of YSB. We obtained thermal datasets of Landsat 8 satellites and computed pixel-based temperature values to demarcate zones likely to be under pest attacks. These zones were mapped on the basis of real-time field observations obtained by installation of light trap into the rice fields. The results show that farmer need to adopt new technologies which will reduce the cost of pesticides by their application in vulnerable sites only. Remotely sensed dataset provided promising results.
Keywords: Landsat 8, YSB, Plant hopper, GDP, and USGS.

Introduction.

Rice (Orayza Sativa) has become an essential part of food supply to humans around the globe. About 3 billion people are eating rice as regular food because it is easy to cook and digest. Asian countries are producing about 88% of the annual global rice productions and China is the leading country with a production of 210 Million tons whereas Pakistan is producing only 6 Million tons [1].

Rice plant is very sensitive to environmental factors including temperature, pressure, humidity and rainfall etc. An optimum rang of temperature is required for each growth stage of rice crop for its proper development. Beyond this range, the overall yield is degraded (Raza S.M.H 2018) [2] has defined optimum temperature ranges for the rice crop in its each growth and development stage. Being a water baby, rice require huge amount of water during its complete life cycle, therefore clayish soil type is essential for plantation of rice crop because clay has high water holding capacity while sand absorb the water so, it is not considered good for rice cultivation [3].

As being sensitive enough, rice crop is easily attacked by a number of insects e.g., Yellow Stem Borer (YSB), White Stem Borer (WSB), Pink Stem Borer (PSB), plant hoppers and buttles etc. These pests are the main cause of yield degradation which must be killed on emergency ground to ensure the promised yield [4].

About one decade ago, “Crop Calendar” was considered as final document to follow while incorporating all the crop related matters e.g., provision of water to crops, applications of insecticide and the removal of herbs from crop fields [5]. Crop calendar has become obsolete now due to phenological changes. Weather events have been shifted therefore, we get rainfall and sunny days at the times “when and where” these are not needed actually e.g., we get rainfall in the ripening period and sunny days at the time of transplantation. These weather events affect the insect population. Insect population changes with variation in temperature, pressure, humidity and the rainfall etc. Temperature has a profound impact on insect population. Raza. S.M.H 2018 [6] investigated YSB population in its growth stage and concluded that high temperature zones are favorable for YSB in any development stage e.g., egg laying, egg hatching, larva and pupa stages Raza S.M.H 2018 [4] demarcated favorable zones for YSB which concludes that “Crop Calendar” provides rough estimates about the existence of insect pest while recent remotely sensed datasets provides the exact estimates about “when and where” to apply the insecticide in crop fields. Humidity plays a vital role for increasing the insect population. The insect population get double at 90% humidity in comparison to population at 70% humidity. Similarly, the impact of rainfall on insect population is considerable. Rainfall water enters into the insects holes and they come out therefore, the insect population get many folds after rainfall [7,8].

The main objective of this research was to investigate the YSB behaviors at variable temperatures. It also aim at recognition of YSB friendly areas throughout its life cycle using remotely sensed datasets. This research will demarcate the areas “when and where” to apply the insecticide.

Study area.

We selected district Sheikhupura as investigation site. Sheikhupura is located in Punjab province of Pakistan, which is famous around the world to produce high quality rice.

Water provision to rice crops is executed using a cemented network of drainage lines which are maintained by Punjab Irrigation Department (PID). PID appoints a "Nehri Patwari" who ensures equal distribution of water to crops against a little price which farmer pay him on hourly basis. Nehri Patwari collects the detailed information about crops which is useful for crop estimates i.e., yield estimation from a certain area. The study area is mapped in Figure 1 as below,

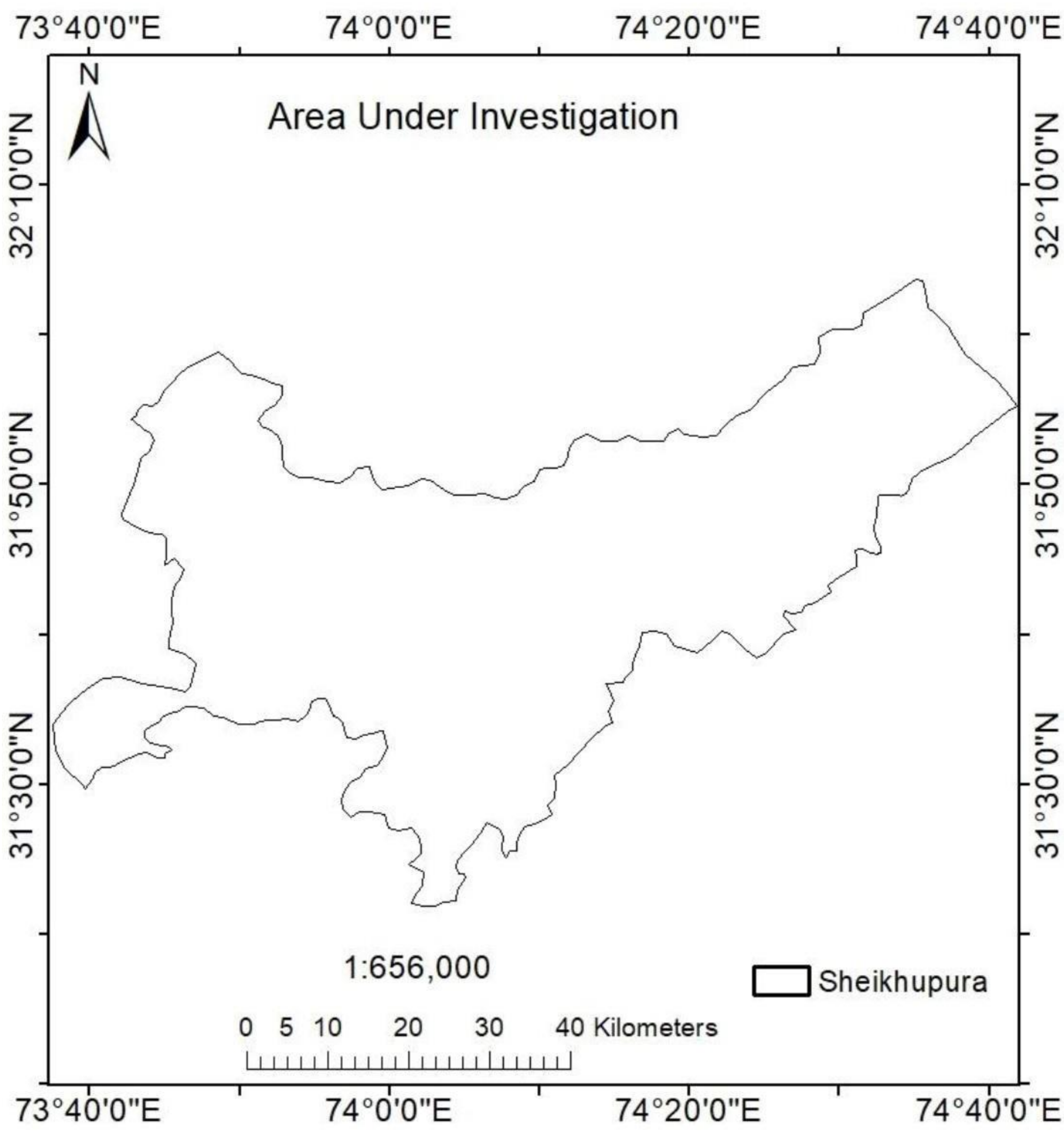

Figure 1. Study area.

Material and Methods.

Temperature plays a vital role in all agro-climatic processes. Every specie needs an optimum range of temperature to grow properly. Similarly, temperature affects the insect's population [9, 10]. The regions having high temperature are considered more favorable for insects to attack. In previous times, there were only two temperature values (high and low) recorded by local meteorological station, available to examine temperature-based processes but now thermal datasets are available which provided pixel-based temperature values. Therefore, it has become more flexible to examine crop related issues in detail using pixel-based temperature values.

Landsat satellite series provide us thermal datasets. We acquired the thermal bands (Band 10, Band 11) of Landsat 8 from United States Geological Survey (USGS) website [11] for the complete life cycle of YSB. The dates of thermal dataset acquisition are mentioned in Table 1.

Table 1: Land sat Image acquisition dates.

Sr. No	Land sat Series	Date	YSB Stages
1	Landsat 8	March 29, 2018	Egg Laying
2	Landsat 8	April 14, 2018	Egg Laying
3	Landsat 8	April 30, 2018	Egg Hatching
4	Landsat 8	May 16, 2018	Larva
5	Landsat 8	June 01, 2018	Pupa

Each pixel of thermal dataset is comprised of brightness values. These brightness values were converted to irradiance using the following algorithm in Equation 1,

$$\text{Irradiance} = (3.342\text{x}10^{-4} \text{ x Thermal band}) + 0.1 \quad (1)$$

The irradiance-based datasets were further processed to compute pixel level temperature values using the equation as under,

$$T = \left(\frac{K_2}{\ln(\varepsilon K_1 / \text{Irradiance} + 1)}\right) - 273 \quad (2)$$

In Equation (2) K_1 and K_2 represents the calibration constants and their values are fixed as 607 and 1206 respectively.

Subsetting.

Subsetting is a process of extraction of a defined area from a large dataset. “Extract by mask” utility of Arc GIS 10.1 was used to extract the study site from a large [12] Landsat 8 image.

Results and Discussions.

The egg spots were found in the early April in the investigation site. We demarcated most vulnerable sites under YSB attack using field observations through satellite image. Satellite images of date March 29, 2018 and April 14, 2018 were used to map these sites as shown in the Figure 2.

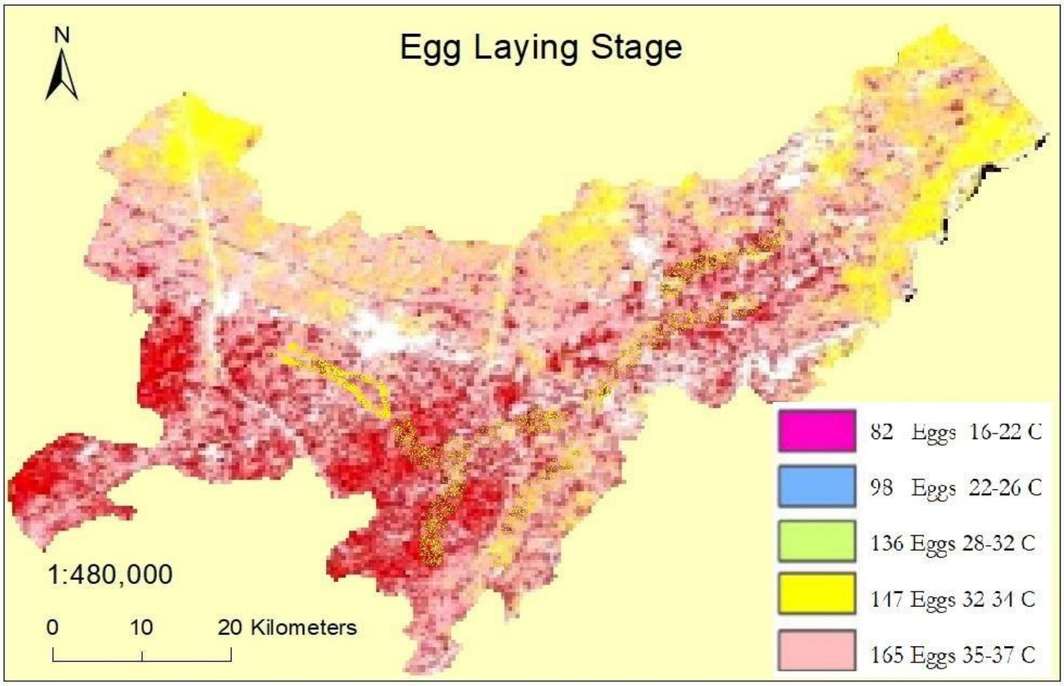

Figure 2. The zones favorable for YSB under egg laying stage.

Figure 2 describes that about 82 eggs were laid by YSB at 16-22 C, 99 eggs at 23-27 C, 138 eggs at 33-35 C and 166 eggs at 36-38 C. It showed that high temperature is favorable for a YSB to lay eggs. Same response of YSB was observed in Figure 3.

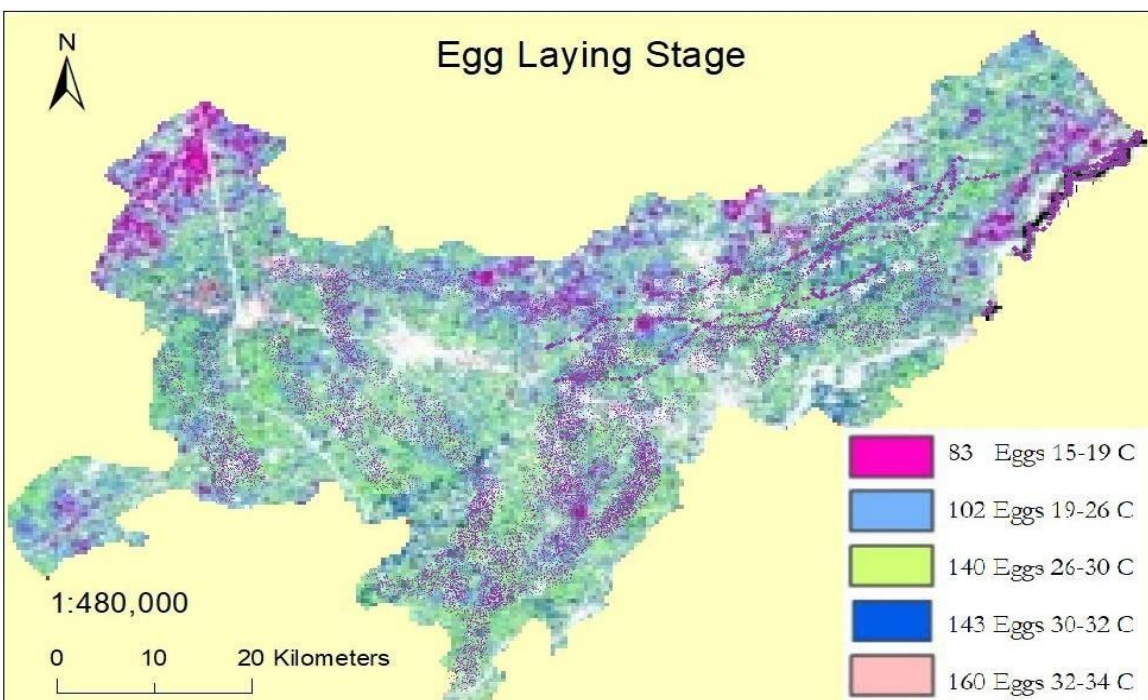

Figure 3. Egg laying zones by YSB at different temperatures.

The egg hatching process was also investigated at different temperatures for which we computed pixel base temperature values for the satellite image of date April 30, 2018 and demarcated vulnerable zones for a YSB to hatch eggs using real time field observations and mapped the results in Figure 4.

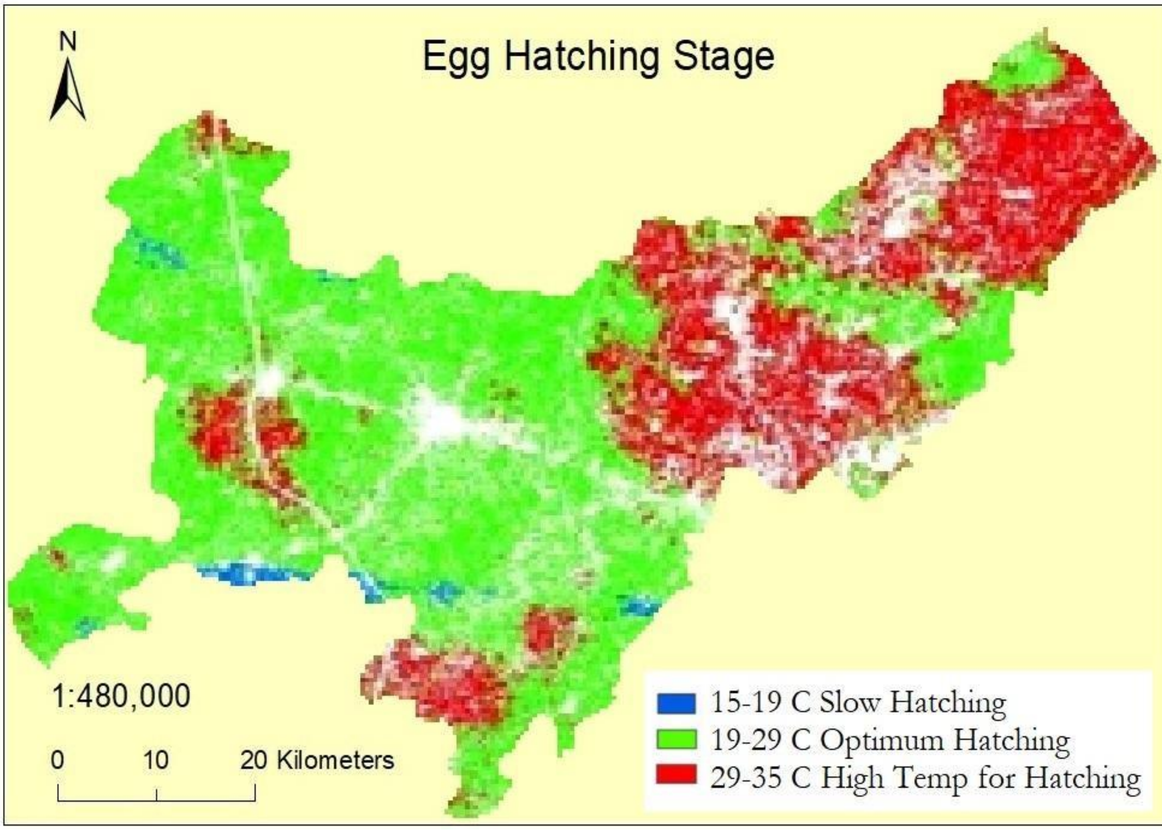

Figure 4. Eggs hatched at variable temperatures.

Figure 4 describes that 14-18 C was observed critically low for YSB to hatch eggs, 18-30 C was observed favorable whereas 30-36 C was found critical high. All eggs were observed destroyed in critical high zone therefore, the red zone in Figure 4 was marked as safe zone where the application of pesticides was not needed. The satellite image of date May 16, 2018 was used to map the vulnerable sites for Larva generation as shown in Figure 5.

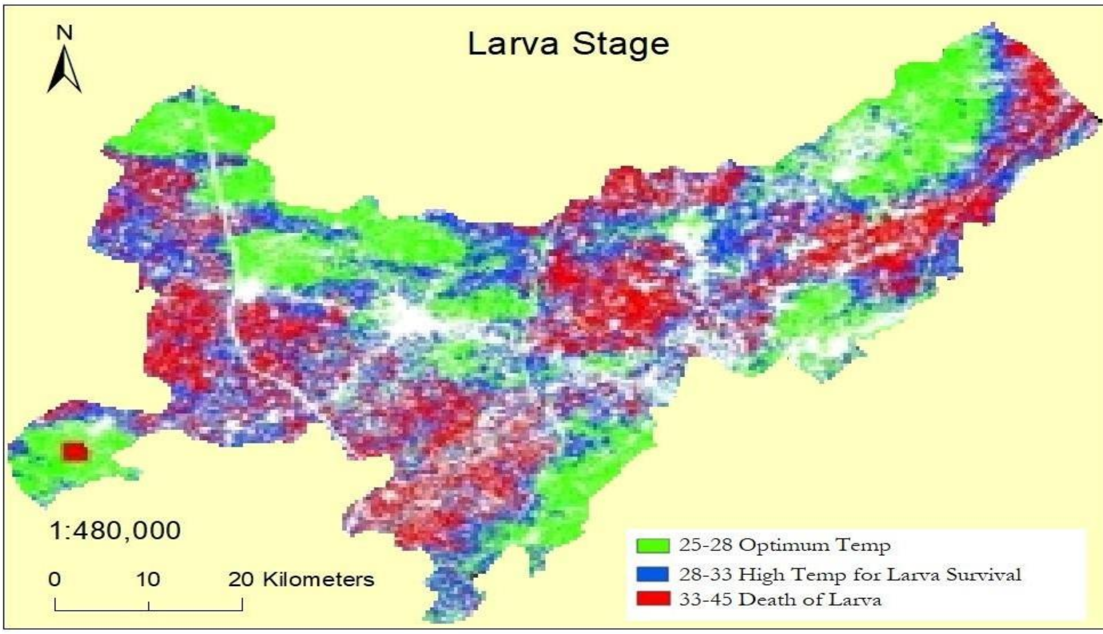

Figure 5. Larva emergence zones.

Figure 5 shows that the critical low temperature for Larva initiation was 26-28 C, while 32-38 C was observed as favorable where the larva population was observed very high. The regions having 32-45 C were observed critical high where all larvas had died. Only favorable site for larva to initiate were marked to apply pesticide.

Pupa is the final stage of YSB which was mapped using the satellite image for the date June 01, 2018. We computed the pixel level temperature values and marked the vulnerable zones for pupa based on real time filed observations as in Figure 6.

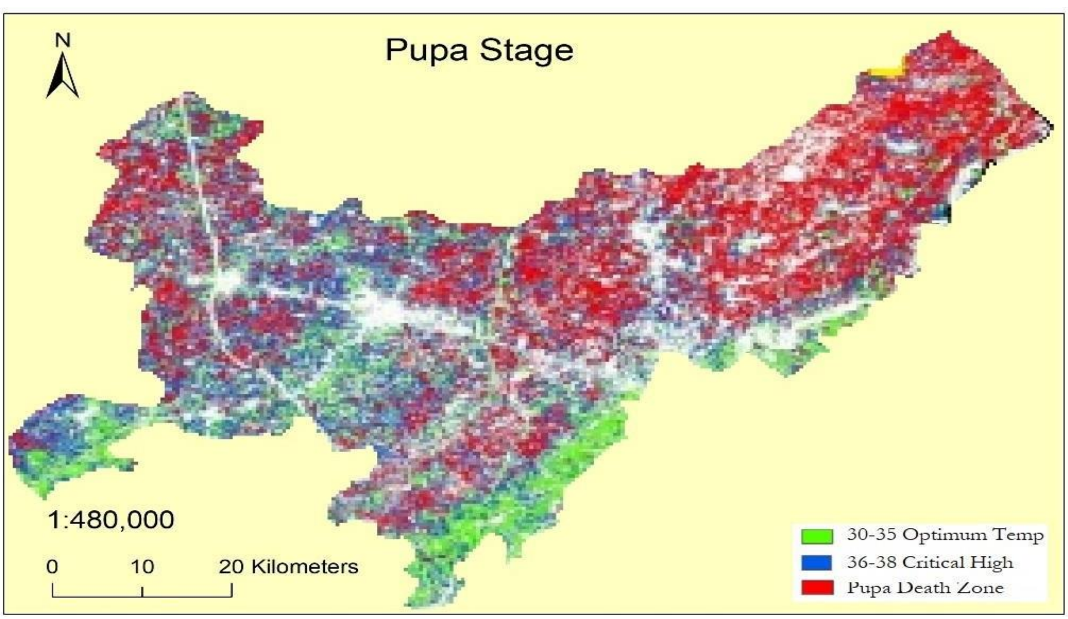

Figure 6. Pupa emergence zones.

Pupa stage in Figure 6 was found very sensitive to temperature where 30-35 C was found vulnerable for pupa evaluation. The zones having temperature above 35 C were found as critical high i.e., safe for pupa to emerge. The red parts of this image were having so much high temperature where pupa was not able to survive.

Ground Validation.

We used light traps to validate our results at various locations. These light traps require a chemical named “Potassium Cyanide” which has ability to make senseless a YSB therefore, it fell down into the chemical and gets die finally. Our results were 85% in coordination with satellite derived results.

Conclusion.

The evaluation of satellite derived datasets proved efficient in demarcation of spatio-temporal variability in the YSB population. The vulnerable sites to any YSB development stage were marked to apply pesticide which save not only the cost but also the time of our farmer. Before this our farmer used to apply the pesticides throughout the fields with no discrimination of areas, which were not under pesticide’s attacks.

References.

1. Mosleh, M.K., Q.K. Hassan and E.H. Chowdhury. 2016. “Development of Remote Sensing Based Rice Yield Forecasting Model” Span. J. Agric. Res. 14(3): 1-10. https://doi.org/10.5424/sjar/2016143-8347
2. Raza, S.M.H., S.A. Mahmood, A.A. Khan and V. Lisenberg. 2018. Delineation of Potential Sites for Rice Cultivation Through Multi-Criteria Evaluation (MCE) Using Remote Sensing and GIS. Int. J. Plant Prod. 12(1): 1-11. https://doi.org/10.1007/s42106-017-0001-z
3. Saifullah M, Islam.B, Rehman.S, Shoaib M, Haq.E, Gillani.S.A, Farooq.N, Zafar.M”. Estimation of Water Stress on Rice Crop Using Ecological Parameters. International Journal of Agriculture and Sustainable Development, Vol 01 Issue 01: pp 17-29, 2019.
4. Raza, S.M.H., S.A. Mahmood, V. Liesenberg, S.S. Hassan. 2018. Delineation of vulnerable zones for YSB attacks under variable temperatures using remote sensing and GIS. Sarhad Journal of Agriculture, 34(3): 589-598.
5. De Castro, A.I.; Six, J.; Plant, R.E.; Peña, J.M. Mapping Crop Calendar Events and Phenology-Related Metrics at the Parcel Level by Object-Based Image Analysis (OBIA) of MODIS-NDVI Time-Series: A Case Study in Central California. *Remote Sens.* **2018**, *10*, 1745
6. Raza, S.M.H. and S.A. Mahmood. 2018. Estimation of net rice production through improved CASA Model by addition of soil suitability constant. Sustainability. 10(6): 1-21.
7. Houghton, L.G., M. Filho, B.A. Callender, N. Harris, A. Kattenberg and K.Maskell. 1995. Climate change: the science of climate change. Contribution of Working Group I to the Second Assess. Intergovernmental Panel Clim. Change.
8. Harrison, J., B. Rascon, A. Kaiser, R.F. Melanie, R.H. Joanna and C.J. Klok. 2006. Responses of terrestrial insects to hypoxia or hyperoxia. Respir. Physiol. Neurobiol.154 (1–2): 4-17. (https://earthexplorer.usgs.gov/)

9. Manikandan, N. 2013. "Effect of Elevated Temperature on Development Time of Rice Yellow Stem Borer" India. J. Sci. Technol. 6(12): 5563-5566.
10. Pathak, M.D. and G.S. Dhaliwal. 1981. Trends and strategies for rice insect problems in tropical Asia, International Rice Research Institute LosBanos. IRRI res. paper series. 64: 1-15.
11. http://landsat.usgs.gov/Landsat8_Using_Product.php
12. https://doi.org/10.1016/j.jinsphys.2005.10.004
13. https://developers.arcgis.com/rest/services-reference/extract-changes-feature-service-.htm