Pakistan Geographical Review, Vol.73, No1, June. 2018, PP 13-24

SPATIO-TEMPORAL EVALUATION OF PRODUCTIVITY OF AN URBAN PARK, USING BIOMASS AND VEGETATION INDICES TECHNIQUES OF REMOTE SENSING

AISHA SIDDIQUI *, ATIF SHAHZAD*, SAIMA SHAIKH** AND MOIZ KHAN**
Department of History, University of Karachi
Department of Geography, University of Karachi
Corresponding Author e-mail: saima-ku@uok.edu.pk

ABSTRACT

The human habitation since the Palaeolithic time has been along with horticultural activity. In the earlier time horticulture was practiced for various needs and with indigenous methods, which is well documented in historical records. Later during the Neolithic period humans developed advanced techniques to grow and manage plants. Since then settlements evolved into towns and towns evolved into cities across the world in different civilizations. After industrial revolution in 1750s the cities swelled into Megalopolises and urban agglomerations.

In the modern world every Mega city of the world needs to have healthy Green Index to maintain its ecological habitats. The quality of life of the populations of such places heavily depends upon it. Today there have been huge issues of Smog which has taken serious turn in the Mega cities of the world. Lahore is an example of Smog affected city. Karachi needs to be given special attention in this regard. Karachi being the largest city of Pakistan is also the most industrialized city as well. The natural environment of Karachi does not support vegetation because of the aridity. The fertility of soil is not so great and the sources of fresh water are located far away.

HISTORICAL OUTLINE

British colonized Karachi in February 1843. Since there occupation they planned the city along the lines a coastal trading post for their trade in the sub-continent and to the West. The parks and gardens started to emerged in the city with British occupation. Important Parks like Jahangir Kothari, around Frere Hall, Bin Qasim Park etc. are reminiscing of that time. The balance of parks and gardens to the residential area was positive until the independence of Pakistan. Since 1947 the population of Karachi has swelled from 0.435 million to over 20 million within 70 years. The later years have witnessed significant imbalance of the vegetation to the built-up land.

Currently there are scores of parks; gardens and sports complexes across Karachi however there are three major concerns regarding these interventions. First their ratio is much less than the population. Secondly very few of them are maintained properly and are green to their true potential. Thirdly, many parks are partially are completely encroached by political parties and pressure groups. Lastly the biomass index of these parks is not up to the mark and needs to be considered to make them more productive. Hence, a remote sensing based evaluation is requested

This paper focuses on the biomass assessment of a particular park as an empirical study to follow suit for others. The current situation of parks all over Karachi is not satisfactory. The study of Master Plans of Karachi 1956, 1974 and others reveal the fact that the administration has failed to accomplish the tasks they set for themselves and address the issue.

The air quality of Karachi is according to US Air Quality Index is 139, with PM2.5/51.2ug/m3. One particular reason for comparatively better air quality of Karachi is the sea breeze. Heavy sea breeze takes all the pollutants away from the city. Non-the less it is high time to study the biomass to make Karachi a better place.

Parks are neither forest nor grass land so they are taken in the category of savanna land (Herte, Kobriger, & Stearns, 1971). These open green spaces are the only recreational source in urban compact cities of concrete jungle that connect dwellers with the nature and provide fundamental ecosystem services that contribute significant part in sustainable development (Atiqul Haq, 2011). This cultivated ecosystem is generally dominated with 2 distinct green biotic life form i.e. Trees and grasses. An active and functional green space must be productive and with good facilities to maximize the effectiveness of green space and planting.

Biomass assessment has become very important to assess the productivity of an urban park. Generally parks that contain more vegetation are considered more productive. Grass biomass under the large canopy trees are dense due to process of hydraulic lift (Moustakas, Kunin, Cameron, & Sankaran, 2013) while grass cover is low in playing areas, near canteens and along the tracks due to direct interaction of human activities.

Estimation of biomass based on field measurement is the most accurate method but consume more time and laborious task. Remote sensing and GIS combined to provide more efficient methods to quantify the Grass biomass through monitoring and mapping of vegetation (Lu, 2006). Correlation analysis between grass biomass with vegetation indices is helpful to understand the proximity and accuracy of the remotely sensed data for monitoring and mapping of natural and cultivated vegetation (Das & Singh, 2012).

MATERIAL AND METHODS

Study Area

This study was conducted in the Zamzama Park, lies in the category of Community Park located in DHA and established in 2001 (Fig 1). It covers an area of 26 acres and the management is under the governance of Cantonment Board Clifton. The park is well developed with healthy vegetation. Proper arrangements of seating and lighting, jogging track of about 100 kms. A place is confined for the parking and canteen. In morning time, most of the visitors are regular and reside nearby the park or come from walking distance. Visitors were satisfied with the security and facilities provided in the park. For vegetation maintenance they have a head gardener with supporting staff who decide what to plant. Water is regularly supplied by CBC and other necessary equipment is also provided.

Trees and shrubs are well planted in order to enhance the aesthetic beauty of the park that attracts the visitors. Higher vascular trees are planted along the park boundary similarly trees are found along the tracks. While shrubs are planted in scattered pattern.

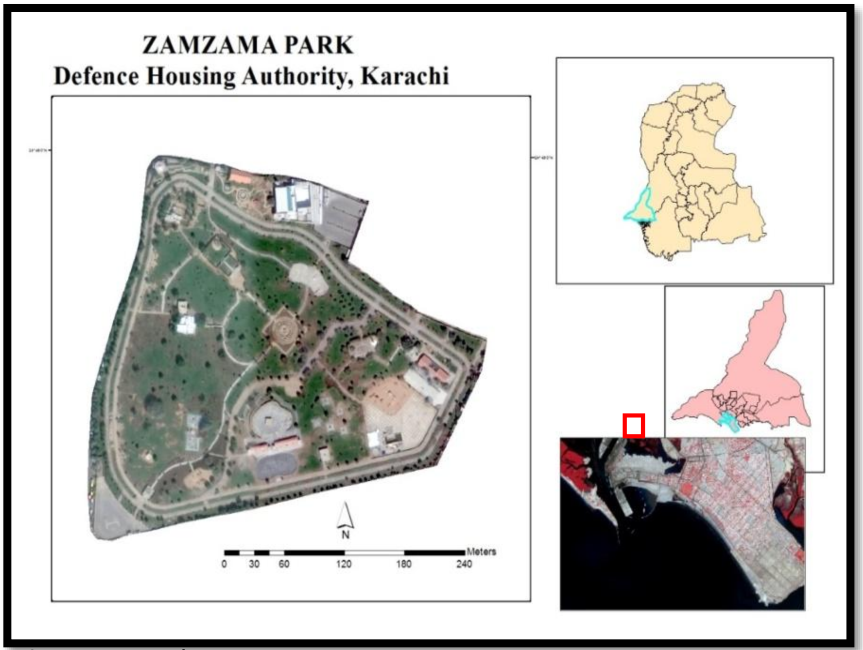
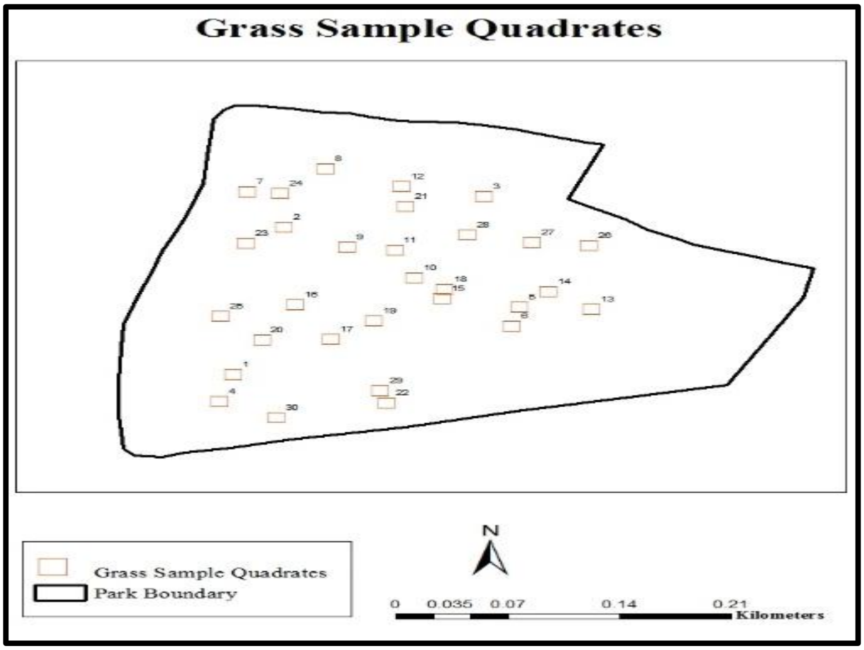


Figure1: Study area.



Processing of Grass Samples

In laboratory all the samples were washed to remove the soil attached with roots and dried at room temperature then mass has been measured. After that the sample was kept in the oven for 4 hours at 80°C and again mass has been measured by using digital laboratory weigh machine. Same process was followed for all the remaining 29 samples. Table 1 showed the recorded tabulated data for the further analysis.

Table 1: Tabulated field data

Sample No	Normal_Weight	Dry_Oven Weight	Biomass gm/m²
1	176.3200073	170.0700073	1830.678227
2	165.4299927	157.75	1698.062433
3	101.0400009	94.1600037	1013.563001
4	25.9899998	23	247.5780409
5	55.8800011	51.4199982	553.498366
6	78.3099976	72.9000015	784.7147632
7	88.9800034	83.0199966	893.6490484
8	62.3400002	58.2299995	626.8030086
9	191.1699982	180.0200043	1937.782608
10	110.7799988	97.9300003	1054.144244
11	106.1100006	98.2300034	1057.373557
12	150.6600037	138.2599945	1488.266895
13	76.5400009	70.5199966	759.0957653
14	87.9899979	82.1699982	884.4994424
15	79.6500015	73.6600037	792.8956265
16	188.0099945	178.4499969	1920.882636
17	145.5200043	138.3099976	1488.805141
18	84.9000015	79.9400024	860.4951819
19	87.2200012	82.4300003	887.2981733
20	136.8600006	131.2900009	1413.24005
21	112.6600037	103.0699997	1109.472548
22	93.2799988	87.5899963	942.8417255
23	106.9400024	98.0400009	1055.32832
24	94.6699982	89.4199982	962.5403466
25	26	24.3400002	262.002155
26	172	164.3800049	1769.429547
27	155.25	148.4799957	1598.277672
28	149.7700043	142.1100006	1529.709371
29	66.0400009	61.5200005	662.2174435
30	29.0599995	27.0900002	291.6038773

REMOTE SENSING ANALYSIS

Image Acquisition

High resolution image data has been acquired through USGS Earth Explorer. Sentinel Image of April, 2018 having spatial resolution of 10 meters has been downloaded with its complete bands.

Pre-processing of satellite image

- Atmospheric correction
- Band composite
- Image enhancement

Image Analysis

Study area has been extracted by using polygon shape file of the park. Extracted part was go through with different vegetation indices by using the relevant band combinations in Arc Map 10.3.

Land use land cover classification was performed by using the technique of supervised classification.

RESULTS AND DISCUSSION

Species Composition in the Park

Plant composition in the park was dominated with exotic non indigenous plant species. Along the boundary wall of the park *Conocarpus eractus* is dominated followed by *Guaicum officinale* and *Azardicita indica*. An area is separately designed for xerophytes plants having variety of cactus species. Palm species especially Date Palm is found along the tracks while some trees of coconut palm are also found.

Vegetation Indices relation with Grass Biomass

A comparative correlation analysis was done to check the relationship between vegetation indices and Grass biomass data measured in field (table 2). The results shown in figure 3,4 &5 indicate that that all vegetation indices NDVI, EVI and SAVI have significant positive correlations with above ground Grass biomass. In linear model the most significant relations was seen in SAVI& NDVI with R^2value of 0.7175 as visible (Figure 3 & 4). The next closer fit was obtained for EVI. The R^2value was 0.7122as shown in figure 5. From the given analysis and results we can conclude that all three vegetation indices are useful for biomass estimations.

Table 2: Vegetation indices

Biomass(gm/m²)²)	SAVI	NDVI	EVI
1830.678227	0.496008	0.330702	0.550379
1698.062433	0.52452	0.34971	0.587594
1013.563001	0.384294	0.256218	0.411131
247.5780409	0.171223	0.114158	0.171455
553.498366	0.271864	0.181259	0.280719
784.7147632	0.280601	0.187084	0.290528
893.6490484	0.299631	0.199773	0.312076
626.8030086	0.273889	0.182609	0.282988
1937.782608	0.588816	0.392577	0.67419
1054.144244	0.373362	0.248929	0.398039
1057.373557	0.39114	0.260782	0.419376
1488.266895	0.346772	0.231202	0.366574
759.0957653	0.284453	0.189652	0.294869
884.4994424	0.295496	0.197014	0.307371
792.8956265	0.294204	0.196153	0.305904
1920.882636	0.593913	0.395978	0.681218
1488.805141	0.277642	0.185113	0.287199
860.4951819	0.294204	0.196153	0.305904
887.2981733	0.340786	0.22721	0.359564
1413.24005	0.440477	0.293679	0.47989
1109.472548	0.302602	0.201753	0.315462
942.8417255	0.340399	0.226953	0.359111
1055.32832	0.193058	0.128716	0.194596
962.5403466	0.309758	0.206524	0.323647
262.002155	0.264807	0.176553	0.272836
1769.429547	0.409358	0.272931	0.441496
1598.277672	0.390397	0.26029	0.418479
1529.709371	0.431222	0.287507	0.46839
662.2174435	0.250428	0.166967	0.25688
291.6038773	0.200849	0.133911	0.202927

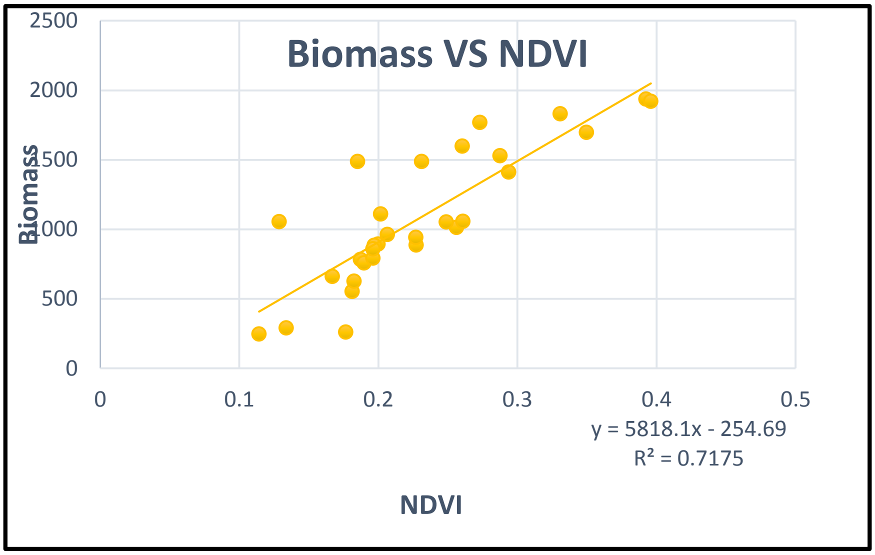


Figure 2: Correlation between Grass Biomass and NDVI

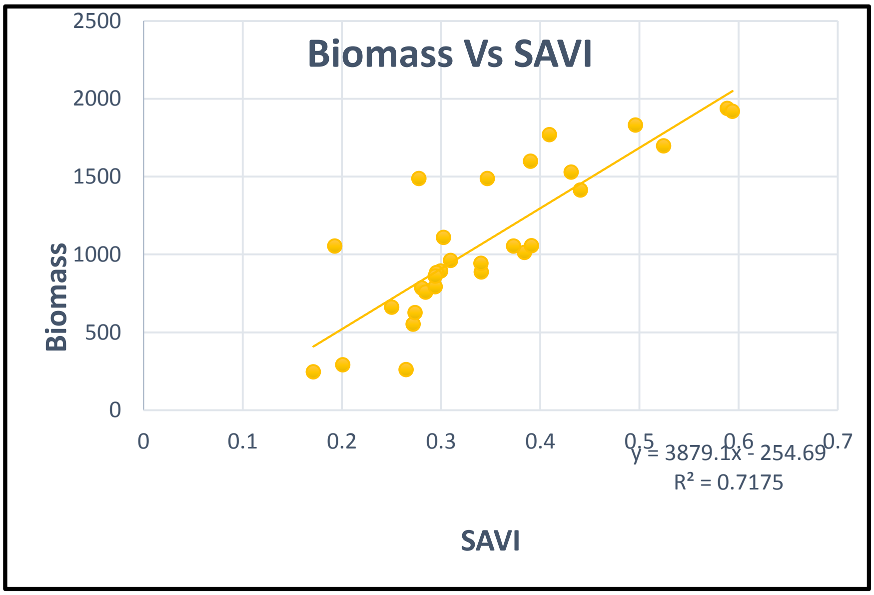


Figure 3: Correlation between Grass Biomass and SAVI

Correlation among the vegetation indices

Correlation analysis was conducted between the indices and it has been observed that SAVI and NDVI have strong correlation with R^2 value of 1 (Fig 6). Further the comparative relation between EVI and NDVI is also very positive with R^2 value of 0.998. Similar results were seen between the SAVI and EVI as shown in figure 7 & 8.

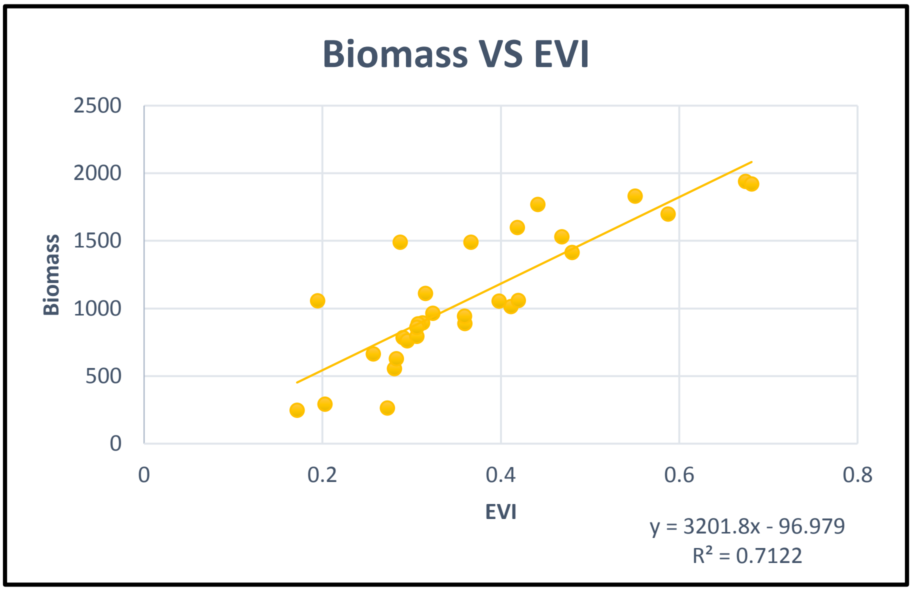


Figure 4: Correlation between Grass Biomass and EVI

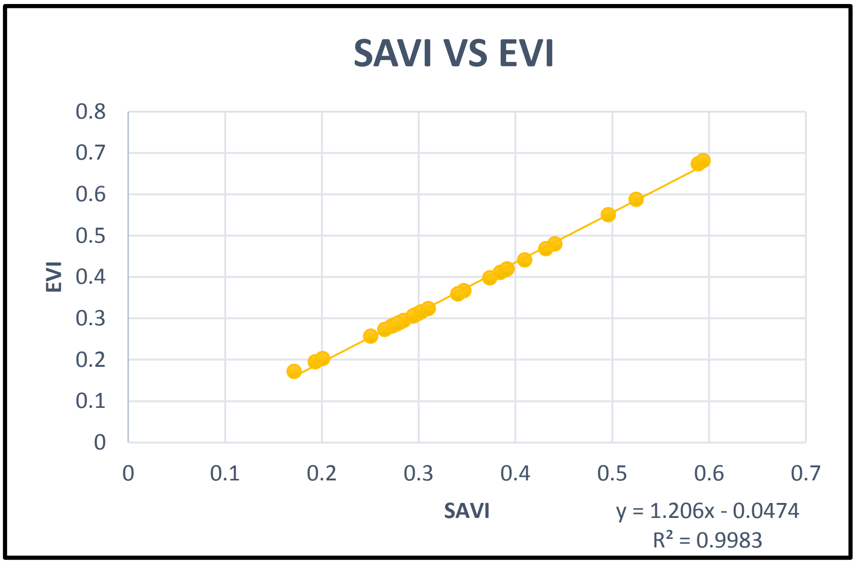


Figure 5: Correlation between SAVI VS EVI

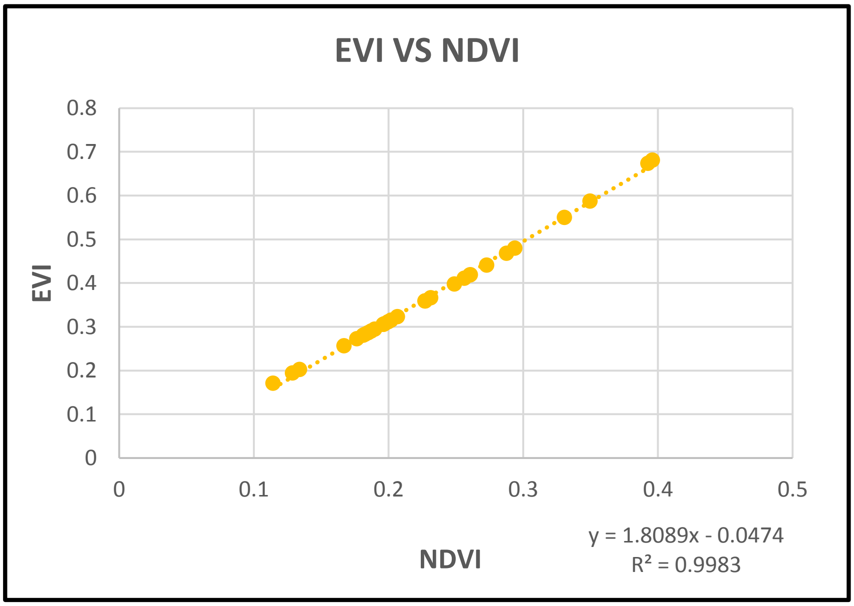


Figure 6: Correlation between EVI VS NDVI

CONCLUSION

The satellite remote sensing methods provides a rapid, efficient and timely estimates of biomass as compared to traditional approach of biomass assessment based on field measurements which are labour intensive and time consuming. A significant correlation was found between Grass biomass and vegetation indices. The result of this research shows that SAVI and NDVI has the most significant correlation with biomass and is the most appropriate vegetation index for above ground biomass estimation in parks. These sites most likely had large amount of photo-synthetically active vegetation and NDVI was more sensitive to the contrast between red and infra-red reflectance.

REFERENCES

Atiqul Haq, S. M. (2011). Urban Green Spaces and an Integrative Approach to Sustainable Environment. *Journal of Environmental Protection, 2*, 601-608.

Breuste, J., & Qureshi, S. (2011). Urban sustainability, urban ecology and the Society SURE. *Urban Ecosystem, 14*(3), 313-317.

Das, S., & Singh, T. (2012, july). Correlation analysis between biomass and spectral vegetation indices of forest ecosystem. *International Journal of engineering Research and Technology, 1*(5), 1-13.

Herte, M., Kobriger, N., & Stearns, F. (1971). Productivity of an Urban Park. *Field Station Bulletin*,14-18.

Ko, D. W., Kim, D., Narantsetseg, A., & Kang, S. (2017). Comparison of field- and satellite-based vegetation cover estimation method. *Journal of Ecology and Environment, 41*(5), 1-11.

Kundu, A., S, D., & Dutta, D. (2016). Monitoring the vegetation health over India during contrasting monsoon years using satellite remote sensing indices. *Arabian Journal of Geosciences, 9*(2), 1-15.

Lu, D. (2006). The potential and challenge of remote sensing -based biomass estimation. *International Journal of Remote Sensing*, 1297-1328.

Moustakas, A., Kunin, W. E., Cameron, T. C., & Sankaran, M. (2013). Facilitation or Competition? Tree Effects on Grass Biomass across a Precipitation Gradient. *PLOS ONE*, 1-8.

Mugabe, W., Moatswi, B., Nsinamwa, M., Akanyang, L., Dipheko, K., Matthews, N., . . . Shah, A. A. (2017). Dry Matter Biomass Productivity and Composition of Grasses along Grazing Gradient in

Fenced and Unfenced Grazing Areas of the Gaborone North, Botswana. *Journal of Animal Research and Nutrition, 2*(2), 1-6.

Piragnolo, M., Lusiani, G., & Pirotti, F. (2018). COMPARISON OF VEGETATION INDICES FROM RPAS AND SENTINEL-2 IMAGERY FOR DETECTING PERMANENT PASTURES. *ISPRS - International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 43*(3), 1381-1387.

Roy, P. S., & Ravan, S. A. (1996). Biomass estimation using satellite remote sensing data—An investigation on possible approaches for natural forest. *Journal of Biosciences, 21*(4), 535-561.

Shahzad, A., Kazmi, J., Shaukat, S. S., & Farhan, S. B. (2017). Mapping Invasive Plant Species In Karachi Using High Resolution Satellite Imagery: An Object Based Image Analyses Approach. *International Journal of Biology and Biotechnology, 14*(4), 479-484.

Wang, H.-F., Qureshi, S., Knapp, S., Friedman, C. R., & Hubacek, K. (2015). A basic assessment of residential plant diversity and its ecosystem services and disservices in Beijing, China. *Applied Geography*, 121-131.