Assessing the Coverage of Urban Green Space in Butwal Sub-Metropolitan City, Nepal: A GIS based Approach

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Abstract

Urban green spaces are integral part of urban infrastructure. Green spaces can offer a number of benefits ranging from inner spiritual to outer materialistic values. Available green spaces in particular area especially in urban places need to be identified and located properly with scientific way and means so that we can use those places in emergency caused by natural or human induced hazards. This study has tried to measure the green space available for people dwelling in Butwal Sub-Metropolitan City of Nepal. An attempt was made to quantify green spaces in urban environments from Landsat 8 OLI imageries using object-oriented approach and field verification. The study concluded that the total green space available in Butwal Sub-Metropolitan City is 86.37 km^2 i.e., around 86% of total municipal area and per capita green space is around 623 m^2.

Key words: remote sensing, green spaces, urban, per person, municipal area

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Introduction

Urban green space can be defined as land and water in urban area that is not covered by buildings or roads or as any undeveloped land in an urban area (Gold 1980). Urban green space include the broad range of urban vegetation including not only parks and open space, but community forests, street trees, residential gardens, agricultural land and in fact any vegetation found in the urban environment whether the vegetation is in public or private ownership or whether it is indigenous or exotic. (Barnett, Doherty, Beaty 2016). These urban green space provide many of ecosystem services, promotes physical activity, psychological well-being, and the economic status of urban residents (Wolch, Byrne, Newell 2014).

In 20th century, experts in Germany, Japan and other countries proposed a standard of 40 square meters (m²) urban green space in high quality or 140 m² sub urban forest area per capita for reaching a balance between carbon dioxide and oxygen, to meet the ecological balance of human well-being. Currently, developed countries have tended to adopt a general standard of green space of 20 m² park area per capita (Wang 2009). International minimum standard suggested by World Health Organization (WHO) and adopted by the publications of United Nations Food and Agriculture Organization (FAO) is a minimum availability of 9 m^2 green open space per city dweller (Kuchelmeister 1998).

Detail study and better understanding of urban green spaces requires update and accurate information of these features. Remote sensing techniques provide an important source of information to automate urban land-cover mapping. Nevertheless, some techniques tend to be more appropriate than others in distinguishing specific categories, such as vegetation, particularly when classifying high resolution imagery in urban environments. The conventional pixel by pixel classification cannot obtain very satisfactory results in urban spaces whereas an object-oriented approach tends to achieved better results using IKONOS and Quick Bird Image (e.g. Barnett, Doherty, Beaty 2016; Laliberte et al. 2007; Firpo 2016; Cleve et al. 2008). This paper aims to assess the per person availability of urban green space in meter square and to map green area versus dense populated area of Butwal Sub-Metropolitan City with Landsat image using object based image classification followed by field verification.

Materials and Methods

Site description

Butwal covers an area of 101.69 sq. km. from latitude 27^{0}36'55"N - 27^{0}44'55''N and longitude 83^{0}21'40"E- 83^{0}30'20''E in Rupandehi district of Lumbini zone in the southern Terai of Nepal (Fig. 1). The climate is subtropical monsoon type. Daily mean monthly temperature ranges from 17^{0}C to 31.4^{0}C with average of 25.9^{0}C. Maximum absolute temperature reaches to 42.5^{0}C and the minimum absolute remains 7.5^{0}C. The annual precipitation is about 2600 mm. The altitude ranges from 100 m in the south west to 1,229 m in the north. Butwal have a total population of 138,742 with annual growth rate of 5.47%. Male comprises about 49.23% and female 50.77%.

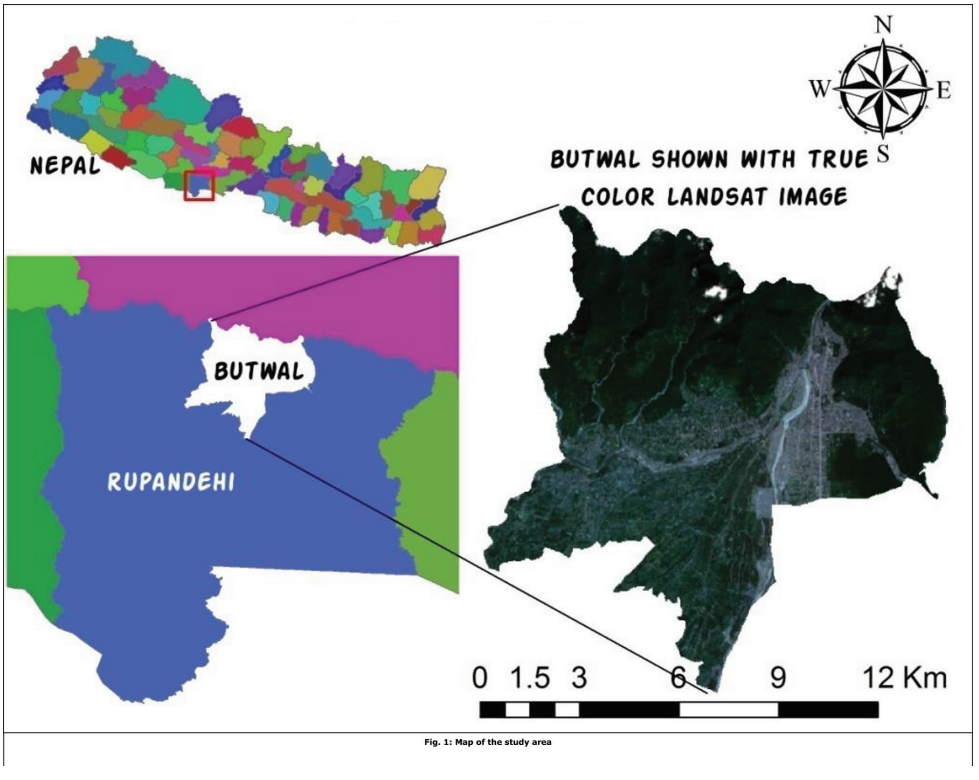

Fig. 1: Map of the study area

Data collection

The primary data like GPS points, condition, distribution and descriptions of green spaces were collected directly from the field using GPS receiver, field observation

and key informants interview. The secondary data comprises of geographical and demographic data along with remotes sensing imageries. Geographical and demographic data of the study area were collected from the published annual report 2015 of Butwal sub metropolitan city. The Landsat dataset is one of the most valuable datasets for understanding the global land cover status and is freely provided by the United States Geological Survey (USGS) over the internet (Woodcock et al. 2008). Thus, for the purpose of this study, Landsat 8 Operational Land Imager (OLI) imageries covering the study area (path/row = 142/41), were downloaded from the USGS website on 26th October, 2015. The OLI data were of fair quality and the multispectral data were good. The detail of satellite data is given in Table 1.

Table 1: Details of the satellite data used for study

Satellite Imagery	Bands	Wavelength (µm)	Resolution (m)
Landsat 8 Operational Land imager (OLI) and Thermal Infrared Sensor (TIRS)	Band 2 - Blue	0.452 - 0.512	30
	Band 3 - Green	0.533 - 0.590	30
	Band 4 - Red	0.636 - 0.673	30
	Band 5 - Near Infrared (NIR)	0.851 - 0.879	30
	Band 8 - Panchromatic	2.107 - 2.294	30

Data analysis

Visible bands (b3, b4 and b5) of Landsat 8 (OLI) imageries were layer stacked and area of interest (AOI) was extracted and a *min-max* radiometric correction was applied to get better visual result using ERDAS Imagine 2014. The imageries were then classified using object based image classification approach in eCognition Developer 64. The rule set of the image classification is presented in Fig. 2 Then the classification output was analyzed and compared with other ancillary data.

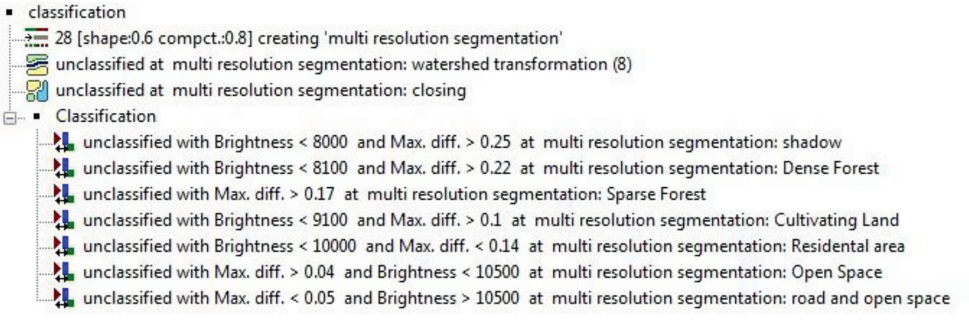

Fig. 2: Rule set for image classificatioon

While classifying medium resolution (15 m pan sharpen) image, green features from urban areas vanished resembling non-vegetated areas, and some paved and constructed surfaces of peri-urban areas dissolved to vegetation covered areas. This error is called classification error (Gresmehl, Napton 1982 in Campbell, Wynne 2011) and is considered to be mutually compensating as it is likely that underestimation of forest in one part of the image can compensate for the overestimation of forest in the other part of the image.

Results and Discussion

Green space coverage

The total green space available in Butwal Sub-Metropolitan City was calculated by summing up forested area and agricultural land. Prior to this, other minor land cover classes were merged to the nearest neighborhood features in the land cover classification map. The final land cover map is presented in Fig. 3 and final land cover statistics is presented in Table 2.

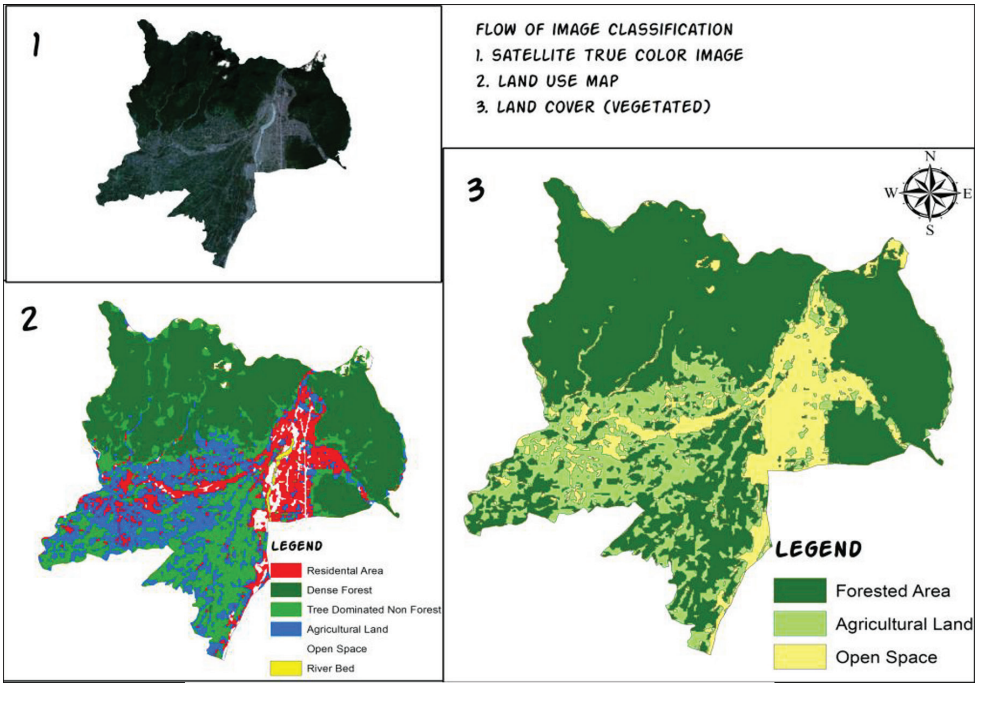

Fig. 3: Object based image classification

Table 2: Land cover statistics of Butwal Sub-Metropolitan City

S.N.	Land Cover Type	Area (km^2)	Percentage cover
1	Forest area	65.60	65.15
2	Agricultural land	20.77	20.62
3	Other	14.32	14.22
	Total	100.69	100

Of the total area of Butwal Sub-Metropolitan City, 65.60 km^2 is found to be covered by forest. Moving on, 20.77 km^2 of the land area is found to be under cultivation and the field verification confirmed this to large extent. Thus, the total green space available in Butwal Sub-Metropolitan City is found to be 86.37 km^2 i.e., 85.77% of the total area.

Components of urban green spaces

The green spaces found in Butwal Sub-Metropolitan City are mainly composed of community forests, agriculture land, classified land, community parks, green belts and others.

Community Forests: The larger patches of community forests are found in the northern *Chure* hills. Most of the *Chure* forests are high forests. Other smaller community forests, mostly plantations, are found in the southern peri-urban plains. There are 16 community forests registered in District Forest Office (DFO). They have a land cover of 4333.96 hectares (43.34 km^2) i.e., 42.62% of the total municipal area.

Agricultural Land: Cereals and vegetables are main agricultural products produced in this farmland. Of the total municipal area, 20.77 km^2 (20.62%) is found to be under agricultural use.

Classified Land: The areas that are open, partially or fully vegetated and allotted for public use rather than for private use are categorized as classified land. The classified land found in Butwal includes army camp, college area, local market area, bus park, exhibition spot and play ground. These classified lands are found to cover 167.69 hectares (1.68 km^2) of the total municipal area.

Community Parks: Altogether 14 community parks are found in Butwal Sub-Metropolitan City. Of which, 3 are recreational parks, 6 are memorial parks, 1 is religious cum recreational park, and 4 others including Road Islands.

Greenways/Greenbelts (Road side plantation and traffic strip): Greenways are also called linear parks, because they are narrow vegetated corridors. They can have multiple uses and functions, such as improving environment quality, providing recreation, and serving as alternative transportation route (bicycles and foot path). Butwal has Greenways/Greenbelts: about 5 km along the Siddhartha highway, 1.5 km along the Mahendra highway and numerous other shorter ones along main and subsidiary roads. These Greenways/Greenbelts include both planted and natural occurring vegetated corridors.

Others: Other green spaces include *Chautaris,* street verges, streams, roof top plantations, vertical greenery, etc. There are more than fifty *Chautaris* in Butwal Sub-Metropolitan City.

Green space availability/Green space per person

The population of former Butwal Municipality was 118,462 and the area was 69.28 km^2. In the process of restructuring of Nepal, 2 VDCs were added to Butwal Municipality and it was upgraded to Butwal Sub-Metropolitan City. Hence, at present, Butwal Sub-Metropolitan City has a total population of 138,742 and a total area of 100.69 km^2 with the population density of 1,364.38 people per km^2.

The total green space available in Butwal Sub-Metropolitan city is 86.37 km^2. Therefore, for the population of 138,742, green space available per person is 622.52 m^2 in Butwal Sub-Metropolitan City. The per capita green space of 622.52 m^2 is considerably higher than the international standards: 20 m^2 park area per capita (Wang 2009). FAO and WHO recommended 9 m^2 green open space per city dweller (Kuchelmeister 1998), and1.62 ha (four acres) open space per 1000 population (Abercrombie 1945). In case of Nepal, Hetauda municipality, one of the cities claimed to be green, have 23% of its land covered by forest area with per capita forest area of 121 m^2 (Shrestha 2013). One of the greenest cities in the world is Curitiba in Brazil, with per capita green space of 52 m^2, followed by Rotterdam, New York City and Madrid. A Siemens Green City Index report calls New York

and Singapore the role models of spatial planning, as both cities have been able to combine extensive green spaces with high population density. At the lower end, Tokyo has just 3 m^2 and Buenos Aires 1.9 m^2 of green space per person (Karayannis 2014). However, the spatial units of these studies held worldwide are metropolitan city holding multimillion populations. In the context of Butwal, the population pressure is still very low and informal green spaces are wide in range than the managed parks and recreational areas. This must be the reason that Butwal has such a high per capita green space. However, in future, when population increases and all the agricultural land and tree dominated areas within municipal area will be converted to the settlements, the per capita green space is likely to go down.

Conclusion and Recommendation

From this study, it can be concluded that the total green space available in Butwal Sub-Metropolitan City is 86.37 km^2 i.e., around 86% of total municipal area and per capita green space is around 623 m^2, i.e., much higher than most of the international standards and that of the greenest cities in the world. Therefore, it can be concluded that Butwal has sufficient green spaces to provide adequate open spaces and maintain carbon dioxide oxygen balance for its dwellers.

In absence of previous studies and records, comparative analysis could not be undertaken. Nevertheless, this study has established a baseline and it is anticipated that these results will help policy makers and relevant stakeholders realize the importance of managing urban green spaces for the betterment of the urban dwellers. Above that, this study is just a step towards green urban planning therefore before drawing any conclusion or before any further planning several other studies is needed to be undertaken.

a. The services provided by the green space were not taken into the account in this study. A further study assessing the service provided by green space is necessary.
b. The extent, reachability and spatial distribution of the managed parks were not taken into the consideration in this study. Therefore, further studies are required to assess the usability/accessibility of green spaces.
c. The study is based on 30 m (15 m panchromatic) Landsat imageries. The imageries of higher resolution can be used for more detailed and accurate measure of the distribution of green spaces.

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Literature Cited

Abercrombie P. (1945): *Greater London Plan 1944*, HMSO, London, 25/-. An advance limited edition.

Barnett G., Doherty M., Beaty M. (2016): *Urban Greenspace: Connecting People and Nature*. Available at https://www.griffith.edu.au: https://www.griffith.edu.au/__data/.../environmental-city-13-barnett.pdf

Campbell J. B., Wynne R. H. (2011) *Introduction to Remote Sensing* (Fifth Edition ed.). New York: The Gulford Press.

Cleve C., Kelly M., Kearns F.R., Moritz M. (2008): *Classification of the wildland-urban interfae: Acomparison pf pixel and object-based classificiations using high-resolution aerial photography*. Computers, Environment and Urban Systems. Available at: doi:10.1016/j.compenvurbsys.2007.10.001

Devkota K. (2012): *Dynamics of Urbanization in Nepal: The Role and Response of Local Government.* Kathmandu: Alliance for Social Dialogue, Policy Research Fellowship Program 2012.

Firpo P. R. (2016): *Urban Green Space*. Available at GIS Research: http://www.geos.ed.ac.uk/~mscgis/07-08/s0787547/

Gold S. M. (1980): *Recreation Planning and Design.* New York: McGraw-Hill.

Karayannis G. (2014): *Dissecting ISO 37120: Why shady planning is good for smart cities*. Available at Smart City Counsil: http://smartcitiescouncil.com/article/dissecting-iso-37120-why-shady-planning-good-smart-cities

Kuchelmeister D. G. (1998): Urban Forestry in the Asia-Pacific Region: Status and Prospects. *Asia-Pacific Forestry Sector Outlook Study Working Paper Series*.

Laliberte A. S., Rango A., Herrick J. E., Fredrickson E. L., Burkett L. (2007): *An object-based image analysis approach for determining fractional cover of senescent and green vegetation with digital plot photography*. Journal of Arid Environments 69(1): 1-14.

Wang X. J. (2009): *Analysis of problems in urban green space system planning in*

China. Journal of Forestry Research 20(1): 79-82.

Wolch J. R., Byrne J., Newell J. P. (2014): Urban green space, public health, and environmental justice:The challenge of making cities 'just green enough'. *Landscape and Urban Planning* , 234-244.

Woodcock C. E., Allen A. A., Anderson M., Belward A. S., Bindschadler R., Cohen W. B., Gao F., Goward S. N., Helder D., Helmer E., Nemani R., Oreapoulos L., Schott J., Thenkabail P. S., Vermote E. F., Vogelmann J., Wulder M. A., Wynne R. (2008): *Free access to Landsat imagery. Science 2008*, 320, doi:10.1126/science.320.5879.1011a.