COMPARISON OF DIFFERENT RESOLUTION SATELLITE IMAGERIES FOR FOREST CARBON QUANTIFICATION

H. L. Shrestha

Keywords: Forest carbon, satellite imageries, image processing, Crown projection areas (CPA), NDVI

Abstract: *The current trend of the monitoring of the forest involves the measurement of aboveground forest biomass carbon using the multisource forest inventory techniques. The multisource forest inventory techniques involve the multiple data inputs such as GIS, Remote sensing, GPS, field measurement and existing information. The remote sensing data are useful for the quantification of aboveground forest carbon using the spectral and spatial characteristics of the data. The application of remote sensing data for the forest carbon quantification may enhance the efficiency in terms of resource allocation, time spent and interoperability and ultimately support the efficient National Forest Monitoring System as a basis for the REDD (+) implementation in future.*

The study tried to compare the methods and results from the multi-spatial resolution satellite imageries for the quantification of forest biomass carbon i.e. Landsat TM(30m), RapidEye (5/6.5m) and WorldView PAN (0.5m). The medium resolution imageries like Landsat and RapidEye images have scope to process at the plot level where as WorldView PAN has scope to process upto the tree by tree level. Thus the methods of operation involves mainly two stream i.e. NDVI extraction for the plot average for Landsat and RapidEye data and CPA analysis for the individual tree for WorldView data.

The result shows the higher R2 (0.6) relation in CPA method rather than the NDVI relation with the total forest carbon if we see the linear relations. While we see the polynomial relation, we get the R2 value of 0.77 from the NDVI value of RapidEye which support conclude the use of WorldView PAN image and RapidEye image for the quantification of forest carbon.

1 INTRODUCTION

1.1 Background

Forest has greater role in the mitigation of climate change impacts (Stern, 2009) which ultimately contributes more than 18% GHG emission to the atmosphere due to the deforestation and forest degradation. The forest has dual role in carbon flux from the biomass either sink or source of emission of carbon (Shrestha et al., 2012).

Biomass estimation has opportunity to mingle with the remote sensing data provided the capability of spectral and spatial characteristics of the satellite images. The spatial characteristics termed as resolution matters for the resolving capacity of the images to quantify for the precisely upto the pixel sizes. High resolution imageries are useful upto the tree level identification and scope to quantify precise quantification of forest carbon (Bhattarai et al., 2012).

However, the technology has capability to into deeper to the extent of half a meter resolution and products are available at coarser resolution with 250m MODIS data. If we go to the high resolution, there is opportunity to go to the depth of detail quantification, still we may have burden of huge resolution data processing sometime they are more than the output expected.

The spectral characteristics on the other hand support to interpret the earth feature specifically trees and shrubs while quantifying while they are higher spectral characteristics. If the spatial domain is lower than the high spectral characteristics are not convincingly support for the interpretation (Blaschke et al., 2000).

There is the need of comparative study on the capability of different spectral and spatial characteristics of satellite imageries which optimally can be applied for the quantification of forest carbon in Nepal, however the general estimates can be prepared using the FAO statistics (Oli and Shrestha, 2009).

The study area is of the Pine plantation at Mid-hill of Nepal extended at the 7 hectare of areal coverage.

The study carries the comparison of WorldView PAN, RapidEye images and Landsat imageries to get the precise measurement of aboveground forest carbon.

Methodology adopted for the study are different as per the inputs as required by the characteristics of the images. WorldView images were processed using the Spatial and spectral characteristics. Individual trees were delineated using the image segmentation techniques and linked with the biomass estimated from the field measurement. The field measured tree based carbon measurement were later correlated with the CPA estimated using the segmentation techniques more specifically with the approach of local maxima and minima (Blaschke et al., 2000).

RapidEye images and landsat images are more processed to develop the NDVI images from the spectral characteristics of the image as both of the images are having lower resolution respectively of 5m and 30m. The field plots laid in the ground were of 500 sqm during the field crusing having 12.6m radius. Thus, single plot in the ground covers 20 numbers of RapidEye pixels where as the plot hardly covers the single pixel of Landsat pixel.

1.2 Objective

The main objective of this study is to compare the methods and results of different resolution satellite data for the estimation of forest carbon and biomass.

1.3 Study sites

The study site is the plantation of Pinus roxburghii (Chir Pine) of almost 25 years old with the areal coverage of 7 hectares. The study site lies in the 84°42'25.70"E - 84°42'47.52"E longitude and 28° 0'36.62"N - 28° 0'50.86"N Latitude.

Figure 1. Study location

2 MATERIALS AND METHODS

2.1 Materials

Satellite imageries from the different spatial resolution and spectral characteristics (see Table 1) for the study.

Image	Spatial resolution	Bands
Landsat	30m	7 (MSS)
RapidEye	5m (6.5m)	4 (MSS)
WorldView	0.6m	1 (PAN)

Table 3 Satellite images used for the study

2.2 Methods

The overall method of the data analysis comprises image analysis, field measurement and relate between image indices and carbon information.

2.2.1 *Image analysis: Object based image analysis and NDVI image indices*

High resolution satellite image of WorldView image of 0.5m resolution was processed using OBIA techniques (Mallinis et al., 2008) for getting the tree delineation and crown projected area (CPA) of individual trees.

RapidEye image of 5m resolution and Landsat image of 30m resolution were processed to get the NDVI value for the entire area of study.

2.2.2 *Field measurement and carbon quantification: Tree based and area based*

The field measurement was carried by using the 12.56m radius plots to maintain 500m area for circular sample plot (Brown et al., 1989). The trees more than 10 cm DBH were measured with individual tree identification in printed satellite image map. The heights of individual trees were also measured using Vertex.

The biomass carbon was quantified using species specific allometric equation for Chirpine for individual tree first and then those were calculated for the plot average and density of biomass carbon in the forest (Chave et al., 2005; Ogawa et al., 2005).

2.2.3 *Allometric relation: Tree based correlation with CPA and area based correlation with NDVI values*

The individual tree biomass carbon and the CPA were regressed to find the best fit equation in case of WorldView data.

The plotwise average tree biomass carbon and the NDVI values extracted using the circular plot of 12.56 were regressed to find the best fit equation in the case of RapidEye and Landsat images.

2.2.4 *Apply best fit regression relation to the entire study area for the estimation of carbon stock in the stand.*

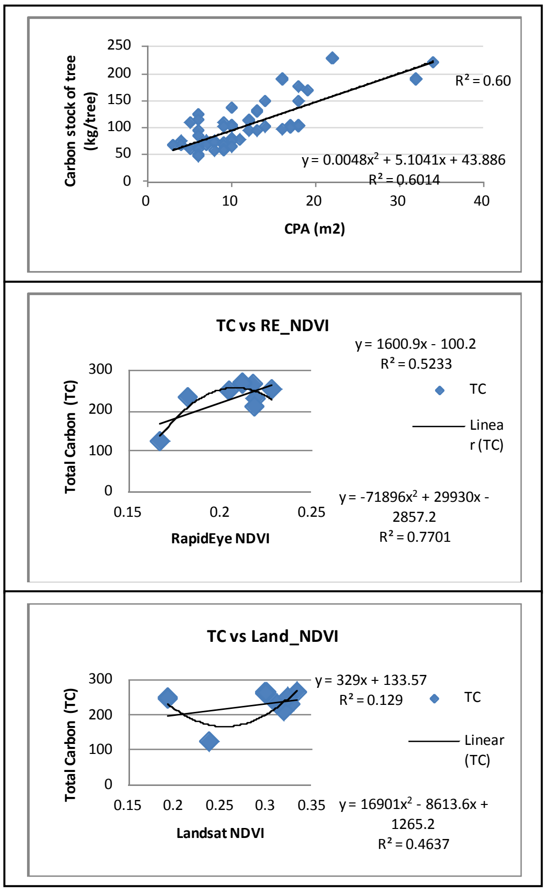
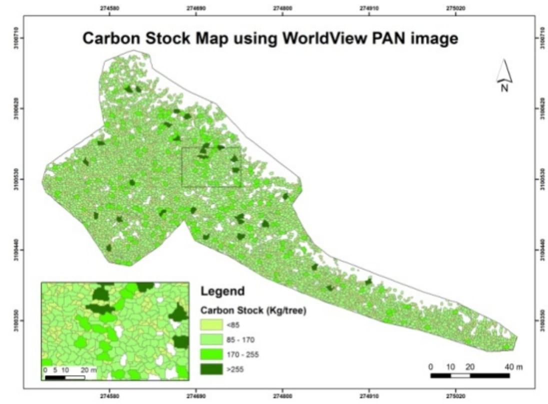
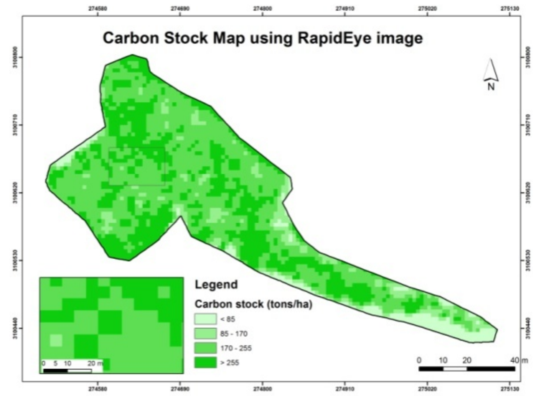


Table 4 Comparison of R2 relating WorldView, RapidEye and Landsat data with total forest carbon

3 RESULTS AND DISCUSSION

The result shows the wall to wall map using the best fit regression equation using CPA in case of WorldView and NDVI in case of RapidEye image.





The relation of between total carbon is regressed with the parameter used and found that CPA method has higher R2 value (0.6) while we are looking linear relation. If we see the Polynomial relation there, NDVI of RapidEye is giving the best result with the R2 value of 0.77.

4 CONCLUSION

In conclusion, the result derived from the study gives the freedom to conclude that the RapidEye image and WorldView images can give the better estimates of forest biomass carbon as compare to the Landsat images.

References:

Bhattarai, T.P., Skutsch, M., Midmore D.J. and Rana, E.K., 2012. *The Carbon sequestration potential oc community based forest management in Nepal, International Journal of climate Change: Impacts and Responses, Vol 3(2)*, pp 233-253

Blaschke, T; Lang, S; Lorup, E; Strobl, J; Zeil, P., 2000. *Object-oriented image processing in an integrated GIS/remote sensing environment and perspectives for environmental applications* . In: Cremers A, Greve K (Hrsg.): Umweltinformation für Planung, Politik und Öffentlichkeit /Environmental Information for Planning, Politics and the Public. Metropolis Verlag, Marburg, Vol 2: 555-570.

Brown, S.; Gollespie, A.J.R. and Lugo, A.E., 1989. *Biomass Estimation methods for tropical forests with applications to Forest inventory data, Forest Science, Vol. 35 (4)*, pp. 881-902

Chave, J.; C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers , D. Eamus , H. Fo¨ lster , F. Fromard, N. Higuchi , T. Kira , J.-P. Lescure , B. W. Nelson, H. Ogawa , H. Puig , B. Riera and T. Yamakura, 2005. *Tree allometry and improved estimation of carbon stocks and balance in tropical forests*, *Ecosystem Ecology, Oceologia* 145, pp 87-99

DFRS, 1999. *Forest Resources of Nepal (1987–1998)*, Publication No. 74, Kathmandu: Department of Forest Resources and Survey.

Mallinis, G; Koutsias, N; Tsakiri-Strati, M; Karteris, M, 2008. *Object-based classification using Quickbird imagery for delineating forest vegetation polygons in a Mediterranean test site*, ISPRS Journal of Photogrammetry & Remote Sensing, 63, 237–250.

Oli B. N. and Shrestha K., 2009. *Carbon status of forests of Nepal: An overview*, Journal of Forest and Livelihood 8 (1), pp 62-66.

Shrestha, H. L., Bajracharya, R. M. and Sitaula, B.K., 2012. *Forest and soil carbon stocks, pools and dynamics and potential climate change mitigation in Nepal*, Journal of Environmental Science and Engineering B1, Vol1(6), pp 800-811

Stern, N. (2006), *Stern Review Report on the Economics of Climate Change (pre-publication edition)*. HM Treasury

Acknowledgements: Author acknowledges the contribution from Department of Plant Resources, Government of Nepal and ICIMOD, Nepal for the financial and working support. I am also thankful to Forest Resource Assessment (FRA) Nepal under Department of Forest Research and Survey (DFRS) for sharing satellite data (RapidEye).

Author's Information

Name:	Him Lal Shrestha
Academic Qualification:	PhD in Environment Science
Organization:	Ministry of Population and Environment
Current Designation:	Ecosystem Restoration Specialist
Work Experience:	12 years
Published Papers/Articles:	20
e-mail:	hlshrestha@gmail.com