Evaluation of Canopy Cover of Street Trees in Urban Forests Using by Satellite Data

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Abstract: Information on structure of city forest such as species composition and canopy cover density is a prerequisite for planning, design and management of vegetation in cities in local and regional scale. For this purpose in present study, different inventory methods Including 100% inventory by using 20meters transects and aerial images (1:8000 scale) and spot satellite image were compared for evaluating canopy cover surface of street trees with 1 kilometer length is Sep2009 , to develop an optimum and suitable method to evaluate canopy cover of these trees. In 100% inventory considered as the basis for comparing with various methods, canopy surface of these trees was calculated in each 15m transect. Results of paired –T test indicated that results of 100% inventory and aerial photos ($p = 0.52$, $t = 0.809$, $df = 23$) and satellite image ($p = 0.48$, $t = 0.847$, $df = 23$) don't differ significantly. Regression results indicated that using aerial images ($R^2 = 0.92$) and spot images ($R^2 = 0.89$) is relevant to evaluate street trees canopy cover.
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Key words: canopy cover, street trees, inventory, aerial photograph, spot images.

1. Introduction

City forests are considered among important elements and components of civil ecosystems. Since trees are considered as most important index of civil landscape (Gary and Geff,2005) , it's necessary as first step for landscape sustainable development to recognize and record information about civil trees , so that based on collected data analysis , planning needed to maintain and develop landscape being performed. (konijnendijk etal., 2005 , white, 2002).Information on structure and function of civil forests is necessary to increase advantages and decrease costs of management related to civil forests (wood , et al., 1999). Information helping better management of civil forests are including canopy cover surface , tree and shrub coverage percent , percentage of coverage afforested in the city, percent of land various covers , tree and bush species available in the city and required data in single – tree surface including species , mean diameter at breast height , cutting. Surface, tree height, canopy height, canopy width, fresh and dried foliage rate . While it seems that most civil foresters are managing a valuable capital but they aren't aware of their wealth and the number of trees in what area they are managing and they don't know there what species of trees in what extent in the city. In some cases will cause negligence in optimum management of these resources (ward & Johnson, 2007). To take inventory of street trees modern complex methods such as 100% inventory, using aerial photos. Satellite images, computerized techniques or simpler methods like. Evaluation from inside the car and other different sampling can be used. However, using inventory techniques in different conditions is dependent on the goal of inventory method, and the method used must be evaluated in respect of accuracy and spent cost. Several studies have been performed on inventory method from urban forests. Indian Inventory Institute used two stage methods to define coverage of tree outside of the forest.

By using obtained results suggested random classification method for inventory method from trees outside of the forest. studied various techniques to define optimum method to evaluate canopy cover of street trees by using GIS technique (Geographic Information system) and results indicated that 100% inventory method or sampling in GIS medium may be suitable with low time and cost spent to evaluate street trees(wood et al., 1999).

Currently , with development of remote sensing data with high local resolution power most problems of urban planning and management have been solved. Many studies have been performed by using aerial photos and satellite data such as spot in evaluating canopy coverage of urban forests (Coillie et al , 2007 , zhang et al., 2007 , Jensen & Hardin , 2005 , Goetz et al. , 2003 , Freeman & Buck , 2003).

In present study, function of aerial photos and spot images was studied to provide street trees canopy cover map and its results were compared to 100%

inventory method in respect of accuracy and spent cost. This study aims to compare accuracy and costs of evaluating street trees canopy cover on aerial photos and spot satellite images to 100% inventory method and developing a suitable inventory method to evaluate street trees canopy surface. So that it could be possible to develop an optimum and suitable technique for evaluating street trees canopy cover and management of these valuable resources.

2. Material and Methods

The Study area is located in district of Rasht with 49º 36´27" - 49º 36´ 39" E Longitudes and 37º15´ 47" - 37º 15´ 44" N altitude including street trees of both sides of street .It has been studied in Sep 2009.
Trees of this region are planted with 3 ± 1.1 average spaces from each other. These trees are in more unsuitable conditions due to construction and light shortage and most of them are dried or drying. Canopies are in unusual conditions due to their closeness to each other and they become ellipsoid most trees canopy have been inclined toward the street.
Different inventory method techniques used to evaluate canopy area and their methods are including:

Inventory method:
In studies performing to compare various inventory method techniques, firstly studied community is inventory method by 100% inventory and those techniques will be evaluated through comparing obtained results of various sampling methods and their actual rates (100% inventory method). In present study also 100% inventory method technical has been used as a basis to compare various methods to evaluate canopy cover area.
Firstly after square turn, street length divided to 20 m bands. Total number of bands taken in both sides of the street was 25 transects that according to length of transects; it has been measured 500 m totally.
In this method large and small length of tree canopies were measured by tape – measure. Equation 1 was used to evaluate canopy area. To obtain total area of transect canopy, canopy area of transect canopy, canopy of trees located in each transect was summed. Finally, mean, standard deviation and total area of canopy were calculated.

$A = (D_1/2) \times (D_2/2) \times 3.1415$ (1)

A = tree canopy area (m^2)

$D_1 =$ Small diameter of tree canopy (m)

$D_2 =$ Large diameter of tree canopy (m)

Aerial photographs:
Aerial photographs taken in last aerial photograph method from Rasht in 2009 with 1:8000 scale by Army forces geographical information organization were used to obtain canopy cover in each transect . Firstly these aerial photographs were geometric corrected using 1 : 2000 maps in software ERDAS IMAGINE 8.4 with 0.4 RMse.
Then limit of studied region was mapped on them and implemented on studied limit by using ArcGIS 9.2 software. Amount of canopy surface was defined in each transect by using ArcGis9.2 through digitalization of tree's canopy cover surface. Mean and standard deviation of total area in aerial photographs were calculated after measurement of total surface of transects and its transformation to 11.5, SPSS medium (Table 1).

Spot image
In this technical, raw photographs of spot satellite purchased by municipality geographic information center were used. Spot detail takes photographs (multi spectrum) with 4 bands (green, red , near infrared and mid infrared) with 10 meters resolution power and panchromatic with 2.5 meter resolution power (Dial et al., 2003) . Spot photograph has been under geometric correction through image by image technique with aerial photograph in ERDAS IMAGEINE software medium with 0.2 RMSe. (Goetz et al., 2003). ArcGIS software was used to define transects and tree canopy surface size in photographs. Then by digitalization of tree's canopy cover surface, canopy cover rate in each transect was calculated in GIS medium (Breisgau , 2003 and Dwyer & Miller , 1999).
Obtained measurements were transformed to 11.5 SPSS medium. Then mean and standard deviation of total area of transects were evaluated. And also paired t – test and regression relations were calculated. It is worth mentioning that when implementing each method, time and cost of each utilized method were recorded.

3 Results:
Results including total area , mean , standard deviation , standard error , standard error percentage and total cost spent in each method are given in table 1.
Data normality was studied using kolmogrov – Smironov test so that data was normal. Paired t – test were used to compare obtained areas from land 100% inventory method, aerial photos and satellite images. Results of paired t-test between 100% inventory method and aerial photos (p = 0.52 , t = 0.809 , df = 23) and satellite image (p = 0.48 , t = 0.847 , df = 23) indicated that obtained data don't differ significantly

from 100% inventory method so that figures represent this fact (Figure 1and 2) . Results of regression analysis indicated that aerial photos and Spot images respectively with 92% and 89 clearing coefficient indicate that it is possible to evaluate canopy cover surface of street trees with high accuracy using dada utilized in present study (Table 2).

Table 1. results obtained through various methods.

Inventory methods	100% inventory method	Aerial photograph	Spot image	Aerial images difference to land reality	satellite image different to land reality
Total area	4145.34	4093.45	3870.16	52.9	275.17
Average area of transect	140.78	142.65	137.1	2.1	3.6
Standard deviation (m^2)	15.3	12.36	11.40	2.94	3.9

Table 2. prediction model , regression coefficient , significance late.

Technique	X Model	R^2	Significance rate
Aerial photo	Y=1.065x-12.02	0.92	0.001
Satellite images	Y=0.788x+19.78	0.89	0.002

y = canopy cover area in 100% inventory method
x = canopy cover area in aerial photos and satellite images.

Results of costing indicated that method of evaluating canopy cover area of street trees from satellite images spends lowest cost rate so that cost spent for 100% inventory method is respectively 6.5 and 34 times higher than costs spent to evaluate canopy cover surface in aerial photos and spot satellite images. While costs spent to evaluate street trees canopy cover in aerial photos is approximately 5 times higher than costs of spot images.
Function in evaluating street trees canopy cover. Thus these two technique were studied in respect of spent cost and time to find suitable method in respect of spent cost.

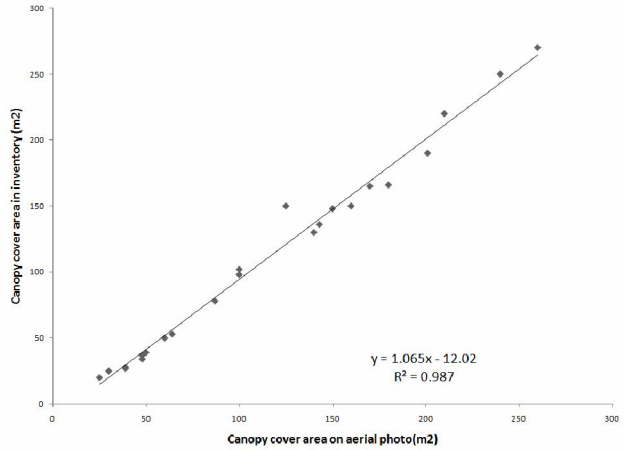

Figure.1 Relationship between canopies covers area estimate in aerial photos and 100% inventory .

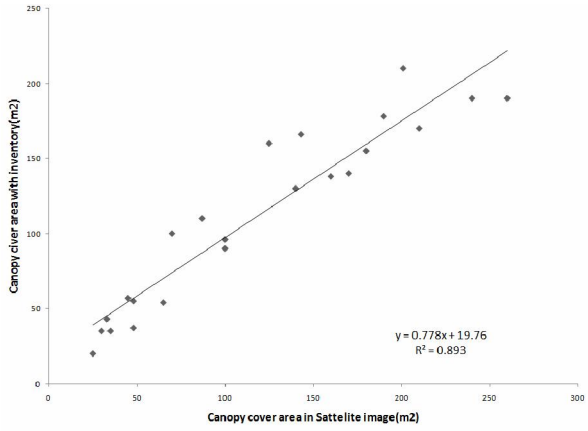

Figure.2 Relationship between canopies covers area estimate in satellite image and 100% inventory

4. Discussions

According to performed calculations , street trees canopy cover evaluate method by using Spot images spent lowest cost rate and had acceptable accuracy. Thus inventory taking from street trees may be used in wide range of big cities. According to this fact, method with lowest spent cost and highest accuracy is optimum technique. Therefore, consistent to results, evaluate of street trees canopy cover evaluation from aerial photos and Ikonos satellite images has highest accuracy (Akbari et al.,2003)
Aerial photos with lower spent cost and time obtain better results compared to 100% inventory technique and can be suitable.
And they may be suitable alternative for territorial inventory technique to calculate canopy cover (Goodwiny , 1996). But it must be noticed that powerful processing systems are required to interpret

aerial photos in wide level in big cities, and corrections required before interpretations in wide level are time – consuming and expensive. Nowadays, according to rapid changes of land uses in urban areas, updated information on street trees canopy cover is needed to be aware on its changes in short – term. Aerial photos with consuming great cost and labor are provided in 10 years periods in Iran. Then according to the fact that satellite images are taken in short – term periods and show changes of land surface , they may be used as suitable tool to supervise changes in street trees canopy surface. While using satellite images with high resolution power such as IKONOS and Quick bird provide us the possibility to utilize them in management of urban forests with lower time and cost consumption compared to aerial photos taken in longer period.

Based on results of present study it could be recommended that it is rational to use aerial images to evaluate tree's canopy cover in small surfaces with high accuracy.

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