SATELLITE IMAGERY FOR ASSESSING GROWTH IN AREA OF ARECANUT PLANTATIONS IN DAKSHINA KANNADA, KARNATAKA

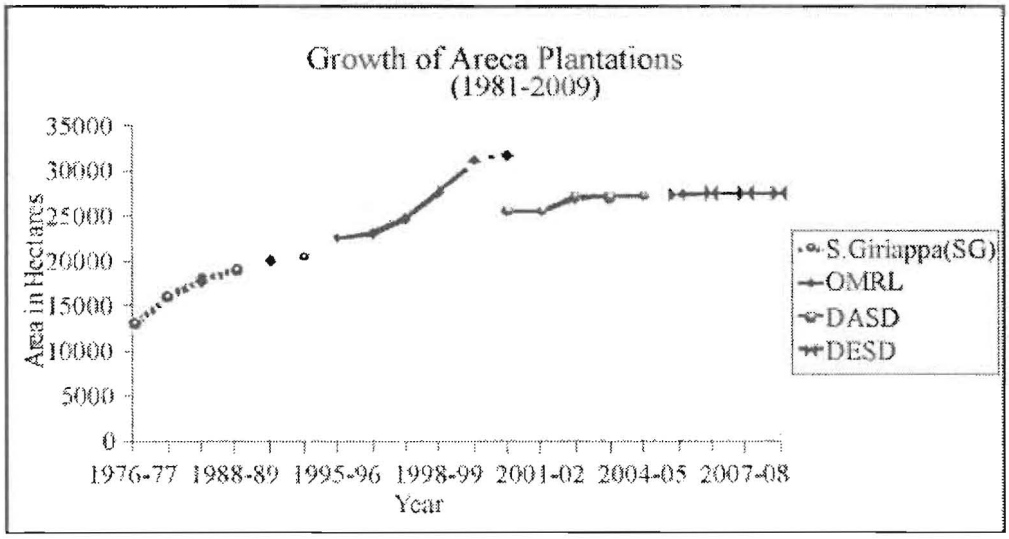
S.Chethan and Amba Shetty

Introduction

Arecanut (*Areca Catechu* L.), the seed of Arecanut palm grown in tropical regions of the world holds a significant value in Indian context. Primarily used as a masticatory, Arecanut finds a place in socio-religious functions, has several pharmacological uses and along with its by-products like husk and leaf sheath is used in manufacture of disposable plates, paper boards, decorative items etc. (Annamalai, Azeez, & Nayar, 2004). Therefore, as a commodity it has good commercial value prompting farmers to migrate to Arecanut cultivation abandoning other low net worth crops. Consequently in 2006-07, India led the league with a production of over 550000 tonnes and Karnataka accounted for the highest, 39% of the produce (DASD, 2008). Maximal share of Karnataka's produce comes from Dakshina Kannada since several years (DES, 2007, 2009, 2010a, 2010b). Over seven million farmer families are directly dependent on Arecanut farming and more than 60 million people indirectly depend on Arecanut for their livelihood by way of labour in Arecanut gardens (ARDF, 2011).

Area under Arecanut plantations has been ever increasing as is evident from the past studies(Giriappa, 1994; OMRL, 2002; DASD, 2008; DES, 2007, 2009, 2010a, 2010b) (Figure 1).With an unprecedented growth in Arecanut

Figure 1: Growth of Areca Plantations (1981-2009)



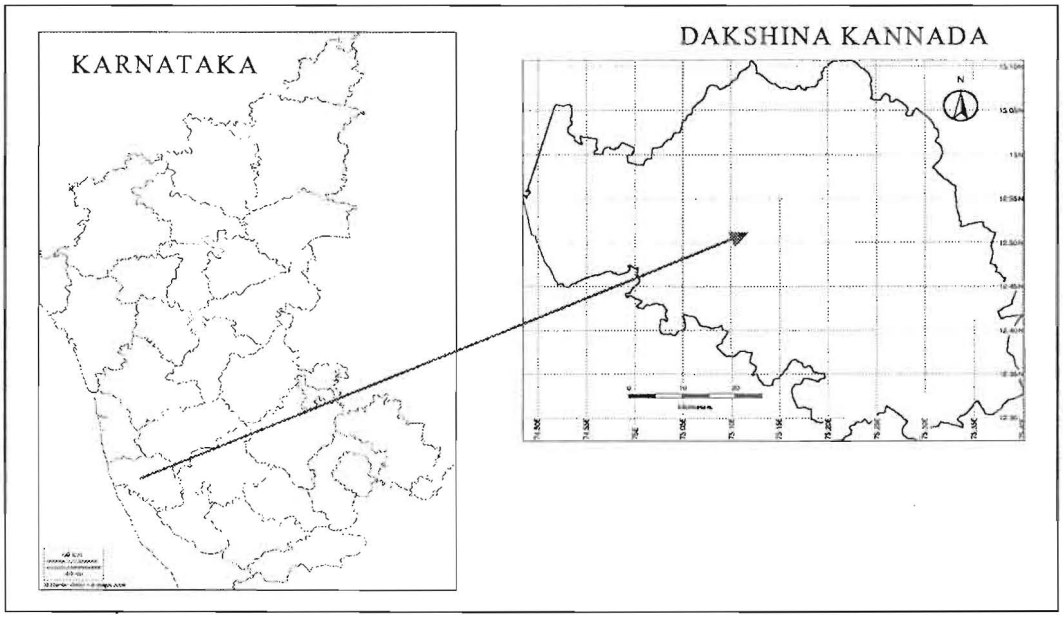
* Dept. of Applied Mechanics & Hydraulics, National Institute of Technology Karnataka, Srinivasnagar, Surathkal - 575 025, Mangalore.

plantations especially after 1990s growers started facing issues in terms of fluctuating yields, unstable prices, fast spreading diseases like yellow leaf disease, fruit rot etc.

Study area and satellite images

The study area is Dakshina Kannada district of Karnataka State in India. Dakshina Kannada (DK) is a coastal district covering an area of 4866 sq. km. The district lies between 12°27' and 13°10' North latitudes and 74°46' and 75°40' East longitudes. The district is divided into five taluks - Mangalore, Bantwal, Belthangady, Puttur and Sullia. The main crops of Dakshina Kannada are arecanut, paddy, coconut, pepper and cocoa. Figure 2 shows the location map.

Figure 2: Location Map of Study Area



This study makes use of three years' Landsat 7 ETM+ data -

1. 1999 - Acquisition Date: 18 December 1999
2. 2003 - Acquistion Date: 27 January 2003
3. 2010 - Acquistion Dates: 30 January 2010, 03 March 2010 and 06 May 2010. Three scenes had to be used to fill in the scan line gaps in the image.

(SLC-Off: May 31, 2003 marked the failure of Scan Line Corrector (SLC) which compensates for the forward motion of the satellite. Still Landsat ETM+ is capable of acquiring useful scenes especially for the central portion of scenes (NASA, 2008), but an estimated 22% of the area is lost at the edges.)

The current study area is covered by two Landsat scenes - Path: 145, Row: 051 and Path: 146, Row: 051. As it was known a priori that area covered by 146,051 had negligible or no arecanut plantations for the purpose of this study only the scene 145,051 was considered.

Methodology

Reference data

Reference data often referred to as ground truth does not include only data collected from field surveys but can only approximate the truth of actual ground conditions (Lillesand, Kiefer, &

Chipman, 2007). For this study the ground truth was collected using high resolution satellite imagery from DigitalGlobe, GeoEye and Europa Technologies. For the entire study area of Dakshina Kannada Google earth has images from these three providers resulting in a free source of high resolution satellite data. Resolution varies from 60 cm - 2.5 m depending on the region. Arecanut plantations all over the region were prominently identifiable through these images. Figure-3 shows an Arecanut plantation near Kaniyoor in Puttur taluk identified in Google earth. Furthermore, Arecanut being sun dried in the front yard could be distinctly seen (marked in red) in the images. This helped in confirming the plantations were indeed Arecanut.

One more helpful feature was geolocation-

Figure 3: Arecanut Plantation as seen in Google Earth

oriented photo sharing website Panoramio, which is again a service from Google. The photos uploaded on the site are accessible as a layer on Google earth. This feature pointed some photographs which showed Arecanut plantations at remote places. In addition to all these sources of information, a priori knowledge about the location of Arecanut plantations in the district helped a lot in marking training sites. Distinct colours for Arecanut plantations in Landsat False Colour Composite were also identified which again made training site selection faster.

Software

As pointed out earlier this work used only free and open source software. They were: Geographic Resources Analysis Support System (GRASS) GIS (GRASS Development Team, 2011) and Quantum GIS (QGIS) (Quantum GIS Development Team, 2011)

Image Classification

Six ETM+ bands namely band 1, band 2, band 3, band 4, band 5 and band 7 were classified using the maximum likelihood classifier. Five different land use/land cover classes (Arecanut, water, built-up/open land, vegetation and others) were assessed but main emphasis was on Arecanut plantations. Refinement of training sites was an integral part of work inorder to improve the classification accuracy. Producer's and user's accuracies were computed.

Amidst this, the scene obtained for 2010 was a SLC-Off scene, which necessitated in filling the gaps in each band. For the purpose, one primary scene and two fill scenes (for gap-filling), all SLC-Off were used. Landsat 7 scene of 30 January 2010 served as primary scene while fill scenes used were of 03 March 2010 and 06 May 2010. March's data was used as first fill scene while May's was used as second fill scene. The first fill scene was used to populate any data void pixels in the primary scene which corresponded to "good" data in the fill image.

The second scene continued to fill void pixels resulting in a gap-filled product.

Accuracy assessment

Thematic maps resulting from image classification always contain errors. This calls for determination of error sources, minimize them and inform the user about the percentage of trust he can place on the thematic information (Jensen, 2005). One standard practice of establishing classification accuracy is the generation of an error matrix. An error matrix compares the pixels in a classified map with the information in the reference data supplied. Same error matrix method was used here to check the classification accuracy in this work.

Results

Table 1: Areal Growth of Arecanut Plantations

Year	Area in ha.	% cover	Accuracy Producer's	Accuracy user's
1999	27449	6	95	70
2003	29345	7	92	80
2010	47639	11	93	81

The classified images of 1999, 2003 and 2010 are presented in Figures 4, 5 and 6.

Table 1 indicates the area estimates obtained from image classification. The results are compared with the estimates published by two different sources namely, ORG-MARG Research Pvt. Ltd.(OMRL, 2002) study for Campco which was undertaken to understand the demand supply position and marketing force effecting the Arecanut pricing in India and routine compilation by The Directorate of Arecanut and Spices Development (DASD, 2008).

Figure 4: Classified Image - 1999

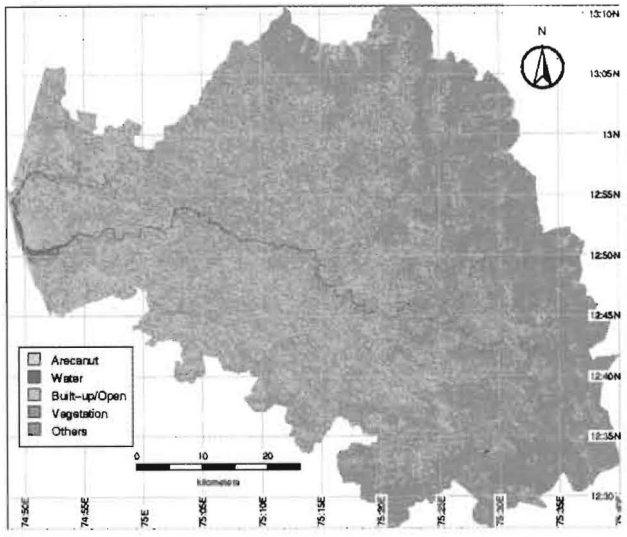


Figure 5: Classified Image - 2003

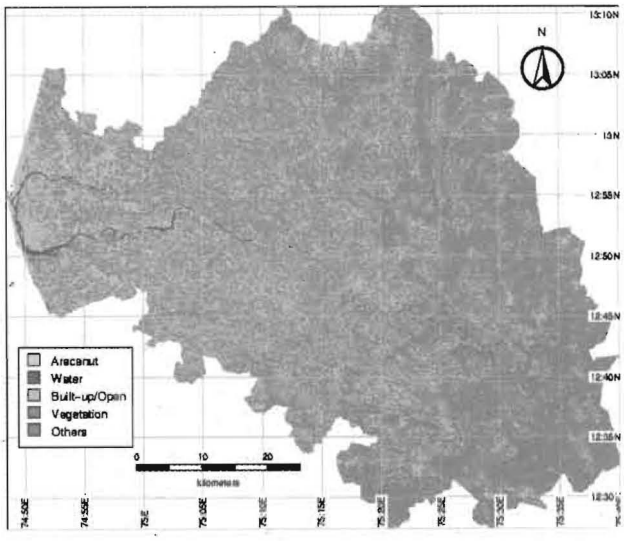


Figure 6: Classified Image - 2010

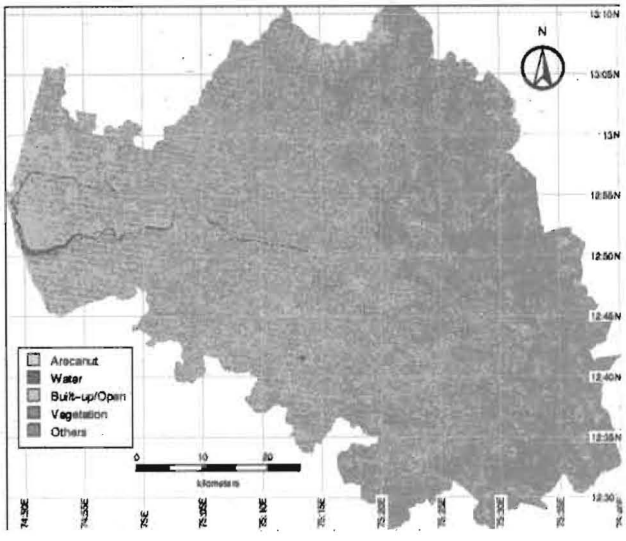


Table 2: Comparison of Results with Literature

Year	OMRL, 2002	DASD, 2008	Chethan, 2011
1999	31127 ha	NA	26801-28313 ha.
2003	NA	27092 ha	27825-33959 ha.

Conclusion

The fact that area under Arecanut plantations is increasing is proved by this study. Out of the total land area in Dakshina Kannada, area under Arecanut has grown from 6% in 1999 to 11% in 2010. The results are in accordance with the growth pattern recorded earlier. While conventional techniques take months to years just to compile crop statistics, digital image processing of satellite data can yield reliable information in a fraction of that time. Furthermore, outputs of conventional techniques often get outdated at the time of result publication. Also obtaining historical information of this quantum from field studies is rather impossible. Assessing vegetation health, area, yield forecasting will all be possible with remotely sensed data. Thematic maps can effectively disseminate this information to a larger audience. Free data coupled with free and open source software can provide cost effective, reliable and trustworthy information which can be a source of inspiration for agencies looking for free/low cost solutions. The open source nature of software makes them easily customizable too. The results can be used to prove the reliance of farmers of the Dakshina Kannada region on Arecanut which can be presented before decision makers for demanding support prices at times of market instability.

References

Alhammadi, M. S., & Glenn, E. P. (2008). Detecting date palm trees health and vegetation greenness change on the eastern coast of the United Arab Emirates using SAVI. *International Journal of Remote Sensing*, 29(6), 1745-1765. doi: 10.1080/01431160701395195.

Annamalai, S. J. K., Azeez, S., & Nayar, N. M. (2004). Alternative Use of Arecanut and Utilisation of By-products. In D. Balasimha & V. Rajagopal (Eds.), *Arecanut* (pp. 254-258). Kasargod: V. Rajagopal.

Arecanut Research and Development Foundation(ARDF) (2011). ARDF - About Arecanut. Retrieved May 20, 2011, from http://www.arecanut.org/arecanut.html.

Arvidson, T., Gasch, J., & Goward, S. N. (2000). Global vegetation-Assessing Landsat 7/ETM+ coverage of tropical rainforest and global agricultural and forest extents. *Geoscience and Remote Sensing Symposium, 2000. Proceedings*. IGARSS 2000. IEEE 2000 International (Vol. 1, p. 393-395). IEEE.

Bauer, M., Cipra, J., Anuta, P., & Etheridge, J. (1979). Identification and area estimation of agricultural crops by computer classification of Landsat MSS data. *Remote Sensing of Environment*, 92, 77-92.

Chae, H. S., Kim, S. J., & Ryu, J. A. (1997). A classification of multitemporal Landsat TM data using principal component analysis and artificial neural network. *Geoscience and Remote Sensing, 1997. IGARSS'97. Remote Sensing-A Scientific Vision for Sustainable Development., 1997 IEEE International* (Vol. 1, p. 517-520). IEEE.

Dadhwal, V., Singh, R., Dutta, S., & Parihar, J. (2002). Remote sensing based crop inventory: A review of Indian experience. *Tropical Ecology*, 43(1), 107-122. Varanasi, India [etc.] International Society for Tropical Ecology, 1961-.

Directorate of Arecanut and Spices Development(DASD) Calicut (2008). *Area and Production Statistics of Arecanut and Spices*. (P. Premaja & P. K. Malathy, Eds.)(p. 74).

Directorate of Economics and Statistics (DES) (2007). *Fully Revised Estimates of Principal Crops in Karnataka for the Year 2005-2006. Crops* (p. 174). Bangalore.

Directorate of Economics and Statistics (DES) (2009). *Fully Revised Estimates of Principal Crops in Karnataka for the Year 2006-2007. Director* (p. 176). Bangalore.

Directorate of Economics and Statistics (DES) (2010a). *Fully Revised Estimates of Principal Crops in Karnataka for the Year 2007 - 2008. Crops* (p. 169). Bangalore.

Directorate of Economics and Statistics (DES) (2010b). *Final Estimates of Area, Production and Yield of Important agricultural crops in Karnataka 2008-09. Production* (p. 73). Bangalore.

Giriappa, S. (1994). *Arecanut Production and Marketing in India* (p. 150). New Delhi: M.D. Publications Pvt. Ltd.

GRASS Development Team. (2011). Geographic Resources Analysis Support System (GRASS) Software. Open Source Geospatial Foundation.

Hegde, V. R., Jayaraj, K. R., Karale, R. L., & Subba Rao, P. (1994). Area estimation of arecanut plantations in Sirsi Taluk using IRS data. *Journal of the Indian Society of Remote Sensing,* 22(3), 149-153. doi: 10.1007/BF03024776.

Jensen, J. R. (2005). *Introductory Digital Image Processing: A Remote Sensing Perspective* (3rd ed.). Upper Saddle River, NJ 07458: Pearson Prentice Hall.

Lillesand, T. M., Kiefer, R. W., & Chipman, J. W. (2007). *Remote Sensing and Image Interpretation* (Fifth.). New Delhi: Wiley India (P.) Ltd.

MacDonald, R., Hall, F. G., & Erb, R. (1975). The use of LANDSAT data in a large area crop inventory experiment (LACIE). *Symposium on Machine Processing of Remotely Sensed Data.* West Lafayette, Indiana: The Institute of Electrical and Electronics Engineers, Inc.

National Aeronautics and Space Administration(NASA) (2008). *Landsat 7 science data users handbook. Landsat Project Science Office* (Vol. 2008, p. 186). Landsat Project Science Office.

Org-Marg Research Pvt. Ltd.(OMRL) (2002). *Market Survey on Arecanut* (p. 147). Mumbai.

Palaniswami, C., Upadhyay, A., & Maheswarappa, H. (2006). Spectral mixture analysis for subpixel classification of coconut. *Current Science*, 91(12), 1706-1711. Current Science.

Ruecker, G., Shi, Z., Mueller, M., Conrad, C., Ibragimov, N., Lamers, J. P. A., et al. (2007). Cotton yield estimation in Uzbekistan integrating MODIS, Landsat ETM+ and field data. *ISPRS Archives XXXVI-8/W48 Workshop proceedings: Remote sensing support to crop yield forecast and area estimates* (pp. 123-129).

Quantum GIS Development Team (2011). Quantum GIS Geographic Information System. Open Source Geospatial Foundation Project.

Vaidyanathan, A. (2011). *Report of the Expert Committee for Improving Agricultural Statistics.*

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