Analysis of Vegetation Fractional Coverage Dynamics Based on Physiographic Spatial Models

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Abstract

Since remote sensing was deployed to monitor fluctuation in vegetation at the Earth's surface, Estimation of vegetation fractional coverage (VFC) in connection with drivers played a necessary significance in global energy cycle, ecological systems and climatic model simulation. This study addresses some categories of datasets that were derived from the MODIS NDVI[1] images, DEM and Land Cover Data during of 11 years in Guangdong Province, China. Here, we just focus on major changes of VFC in relation to Physiographic factors such as slope and elevation in 2000, 2005, 2010, besides VFC dynamics of different land-use types in 2000, 2004-2006, 2009, and finally VFC dynamics by city positions in 2000, 2005, 2010. The VFC was directly calculated from NDVI images, and time series analysis of VFC was predicted subsequently. VFC dynamics were handled by Arc GIS along slope, elevation, different land-use types, and consequently VFC dynamics by city positions. These pathways indicated that vegetation fractional coverage projections of the future role of land-use changes in Southeast Asia must not only capture the complex socio-economic and human drivers of land-use change, but also account for the specific physiographic conditions under which the drivers of change operate. This recognition requires moving beyond some of the simplifications that persist in much of the current understanding of the causes of land use and land cover change.

Introduction

In recent decades, we have witnessed that multi-temporal Modis NDVI data to be applied for detection of vegetation coverage changes, and then estimate dynamic from the timing of changes [10]. However, there have been no studies that use the long-term data record at an approximately annual time step to map current vegetation dynamics by explicitly incorporating physiographic factors-derived and recovery trends in predictive models [9]. Several studies have investigated the physiographic boundary plays an important role to allocate forest resources in complex topography [1]. The objectives of this paper are to analyze VFC dynamics along physiographic factors, different land-use maps and geographical location of cities were obtained in vectorial format and their land use dynamics were analyzed during the same period (2000-2010), handled by G.I.S. software.

Methodology

Fig.1exhibits DEM[2] (a) and relief of Guangdong Province located in the south of China. It should be noted that our study area occupies an area of 179,800 km^2 and bounded by 20º13′-25º31′ North latitudes and 109º39′-117º19′ East longitudes, focusing on major mountain ranges and study watersheds (outlined). The Province with north to south highlands surrounded by flat-lying coastal plains and alluvial valleys, and is geographically separated from the north by a few mountain ranges collectively called the Nan Mountains (Nan Ling). The highest peak in the

[1]Normalized Difference Vegetation Index
[2] Digital Elevation Model

province evaluated Shikengkong 1,902 (m) above sea level. This is so that values calculated from geographic information system data unless otherwise noted, Maximum and Minimum Elevation value are considered 0 to 1900 (m). Area computed 179,800 km^2.

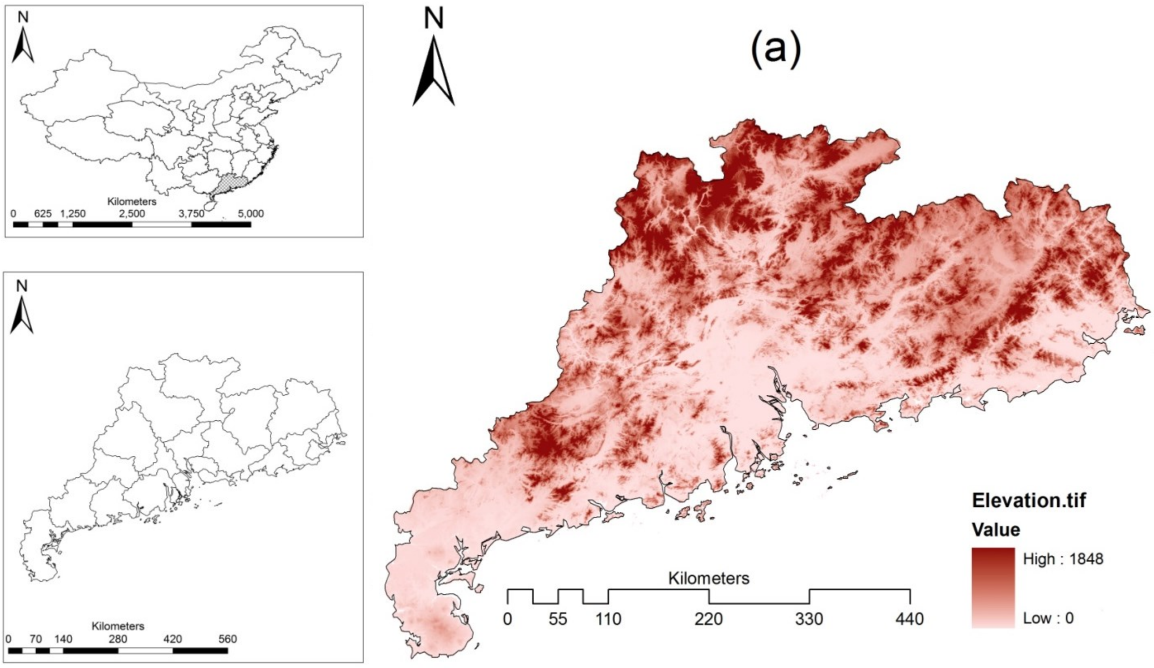

Figure 1: Digital elevation map of Guangdong Province, China.

With the help of Cell Statistic the Mean values of NDVI images were completely obtained for growing season annually and in addition for the whole period. Then using Raster Calculator, we could calculate the values of VFC for our study period additionally. NDVI$_{min}$ is minimum of NDVI value and NDVI$_{max}$ is maximum of NDVI value. The formula of VFC is as follows;

$$VFC = \frac{NDVI - NDVImin}{NDVImax - NDVImin} \quad (1)$$

Among many forest structure variables, vegetation fractional cover, defined as the fractional area (projected vertically) of vegetation canopy occupying a given land area [5], is a key parameter for modeling the exchanges of carbon on the land surface and for monitoring urban environment and urban growth [4].

As already mentioned, physiographic boundaries as Elevation, Aspect and Slope are used to determine the key driving factors of the VFC changes. Thus, we used land use data and geographical location of cities as supplementary data in this research.

Results and Discussions

VFC Dynamics along Terrain Gradient (Slope) and Elevation

The polygon theme of changes was then overlaid with the following GIS layers one at a time, to assess the spatial relationships between VFC changes and the respective factors are as follow; (1) Elevation zones (m) that is divided to four categories as <200 (m), 200-450 (m), 450-700 (m) and >700 (m), (2) Aspects, (3) Slope (°) that converted to <9 (°), 9-17 (°), 17-25 (°) and >25 (°) respectively. A brief description of the GIS layers used and VFC dynamics along terrain gradient in 2000, 2005 and 2010 is presented in Table 1.

The results showed that VFC along the Slope <9 (°) was evaluated 0.681, 0.666, 0.684 in 2000, 2005 and 2010 respectively, so that with -1.5% from 2000 to 2005, VFC values had decreasing trend, and with 1.8% increase from 2005 to 2010 has experienced a rising trend.

The mentioned process applies along the Slope 9-17 (°) and Slope 17-25 (°) in 2000, 2005 and 2010, but VCF along the Slope >25 (°) with values 0.817, 0.812 and 0.805 has been on the decline (Table 12). In fact VFC was faced with declining with -0.5% from 2000 to 2005 and with -0.7% from 2005 to 2010. The results of VFC dynamics along the Elevation dictated that at different Elevation and various altitudes; change in VFC dynamics is visible. This observation during the period of 5 years is highlighted completely. According to Table 1, VFC along the Elevation <200 (m) with 0.4% from 2000 to 2005 and with 0.5% from 2005 to 2010; has been rising in all periods, but on the other side this process along the Elevation 450-700 (m) with -2.6% from 2000 to 2005 and with -0.9% from 2005 to 2010 was faced with decline. Others values are modified as follows;

Table 1: VFC dynamics along terrain gradient (slope) and elevation

Year	Slope(°)				Elevation (m)			
	< 9	9-17	17-25	>25	<200	200-450	450-700	>700
2000	0.681	0.709	0.771	0.817	0.717	0.834	0.851	0.834
2005	0.666	0.703	0.767	0.812	0.721	0.820	0.825	0.796
2010	0.684	0.717	0.772	0.805	0.726	0.830	0.816	0.781

***Criteria for gradient classification: < average, average+1SD~ average+2SD,>above average+2SD.**
Average slope= 9°, SD of slope= 8°, Average elevation=200 m, SD of elevation= 250m

[1] in a study entitled vegetation cover change and physiography in mountain watershed were reported that there is an increase in forested area (forest plus shrublands) by 7.6% during 1976–2000. Forest dynamism (changes including improvement, deterioration, gain, and loss) was highest in low-elevation, south-facing and less-steep slopes that were closer to roads. They were also concluded that the highest net improvement and gain to forested area also took place in those locations proportionately and finally forest degradation occurred at twice the rate of improvement in high elevation areas (2300 m).
[7] in the field of land use and land cover change after agricultural abandonment in Mediterranean mountain area (Catalan Pre-Pyrenees) described that the influence of physiographic factors in land cover change processes in the terraced areas of the catchment is also considered. The results demonstrated that within the terraced areas, north-facing and more elevated steeper slopes are more intensely afforested. However, an accurate analysis of the role played by these factors in land cover change cannot be carried out because the pattern of land abandonment is not independent of these physiographic characteristics. Furthermore, field observations at the terrace scale are evidence of the relevant influence of local topography in afforestation dynamics. Thus it can be overall concluded that physiographic factors as Elevation, Aspect and Slope affect on the forest cover change. These results were consistent with our results. Overlay of VFC changes and slope gradient, aspect and elevation maps, made it possible to calculate classifying terraced areas according to the 3 physiographic factors mentioned above.

VFC Dynamics of Different Land-Use Types

The VFC dynamic of different land-use polygon themes in 2000, 2004-2006 and 2009 were overlaid in Arc View GIS and polygons of forest (Closed (>40%) broadleaved and needle-leaved forest), grass (Mosaic grassland (50-70%), crop (irrigated cropland), built-up (city, town region and village residential area), bare land and other use were mapped. The results showed that forest and crop have respectively fallen with values 83%, 83%, 82.6% and 70.4%, 68.9%, 55.8% during the years of 2000, 2004-2006 and 2009 (Table 2). In fact forest was decreased with -0.4% from 2004-2006 to 2009 and crop was faced with decline with -1.5% from 2000 to 2004-2006 and with -13.1% from 2004-2006 to 2009. In the beginning, Grass was developed with 2.2% from 2000 to 2004-2006, but this process of grass improvement with -20.9 from 2004-2006 to 2009 was transformed.

On the other side built-up process with 44.3%, 55.8% and 56.1% have been increasing. The process of built-up has been expended with 11.5% from 2000 to 2004-2006, and with 0.3% from 2004-2006 to 2009. Other results in the below table are as follows;

Table 2: VFC dynamics of different land-use types

Year	Forest	Grass	Crop	Built-up	Bare land
2000	0.830	0.751	0.704	0.443	0.427
2004-2006	0.830	0.773	0.689	0.558	0.369
2009	0.826	0.564	0.558	0.561	0.364

***Data source: LUCC 2000, Global land cover map 2004-2006, Global land cover map 2009.**
Crop=irrigated cropland, Forest= Closed (>40%) broadleaved and needle-leaved forest, Grass=Mosaic grassland (50-70%) / forest or shrubland (20-50%)
*** The decrease of VFC of grass and crop from 2005 to 2009 may be linked to climate change in 2009.**

The map of VFC dynamics of woodland, shrub, pasture, city region and other land-use types was calculated in 2000. The spatial coverage of these land cover classes is shown in Figure 2. The results showed that VFC dynamics of forest area such as woodland, rest woodland dominated a large part of total area in 2000, and the areas under shrub, pasture, bare ground, dry field and other use were scattered across the study area (Fig. 2). Also it is visible that open wood covered small percent discretely in the north and northeast. Dry and paddy field more formed southwest, central and northeast parts. City or town region occupied central parts with small percentage. Other different land use type depends to VFC dynamic be seen symbolic (Fig. 2).

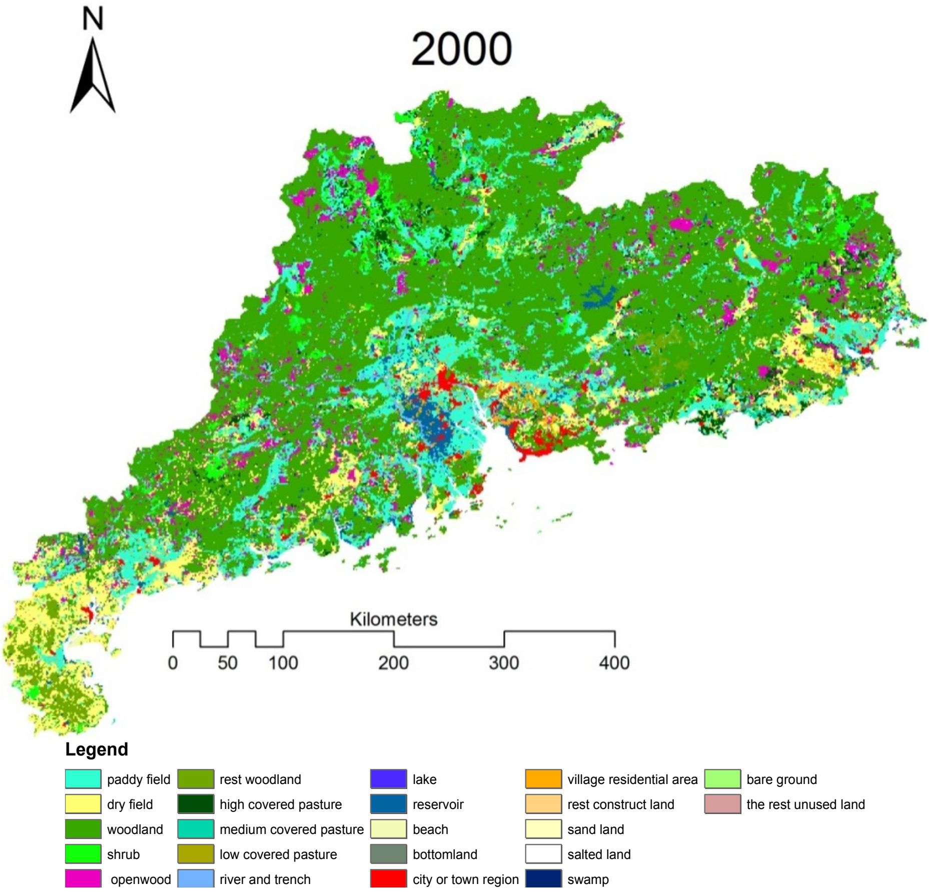

Figure 2: Map of VFC dynamics of different land-use types in 2000

In 2004-2006, the closed to open vegetation (>15%) broadleaved evergreen or semi-deciduous forest (<5m), mosaic forest or shrub-land (50-70%)/grassland (20-50%) and closed to open (>15%) grassland area were represented more than half of Guangdong Province (Fig. 3), so that this category was the most abundant VFC changes of land cover category. The closed to open vegetation (>15%) broadleaved evergreen or semi-deciduous forest (<5m) occupied an extensive area in the west, northwest and north parts of Guangdong Province. On the other hands, closed vegetation as closed (>40%) broadleaved deciduous/needle leaved ever green forest (>5m) scattered in the southern parts, and rain-fed croplands, closed to open (>15%) grassland or woody vegetation on regularly flooded have been scattered patches in the middle and east parts with covering steep slopes in the north zone.

Dense forest was restricted to the southwestern part and alluvial area close to sea of the study area, representing a small percentage of the total area. Less dense canopies were also observed, gradually turning into sparsely vegetated areas toward the central parts, it was while artificial surface, associated areas and urban (>50%) has been progressed. Some scattered VFC changes of other land-use patches also existed (Fig. 3). In all, the percentage of open forest and grassland is more, neither dense of closed vegetation is much lower in 2004-2006 compared to 2000.

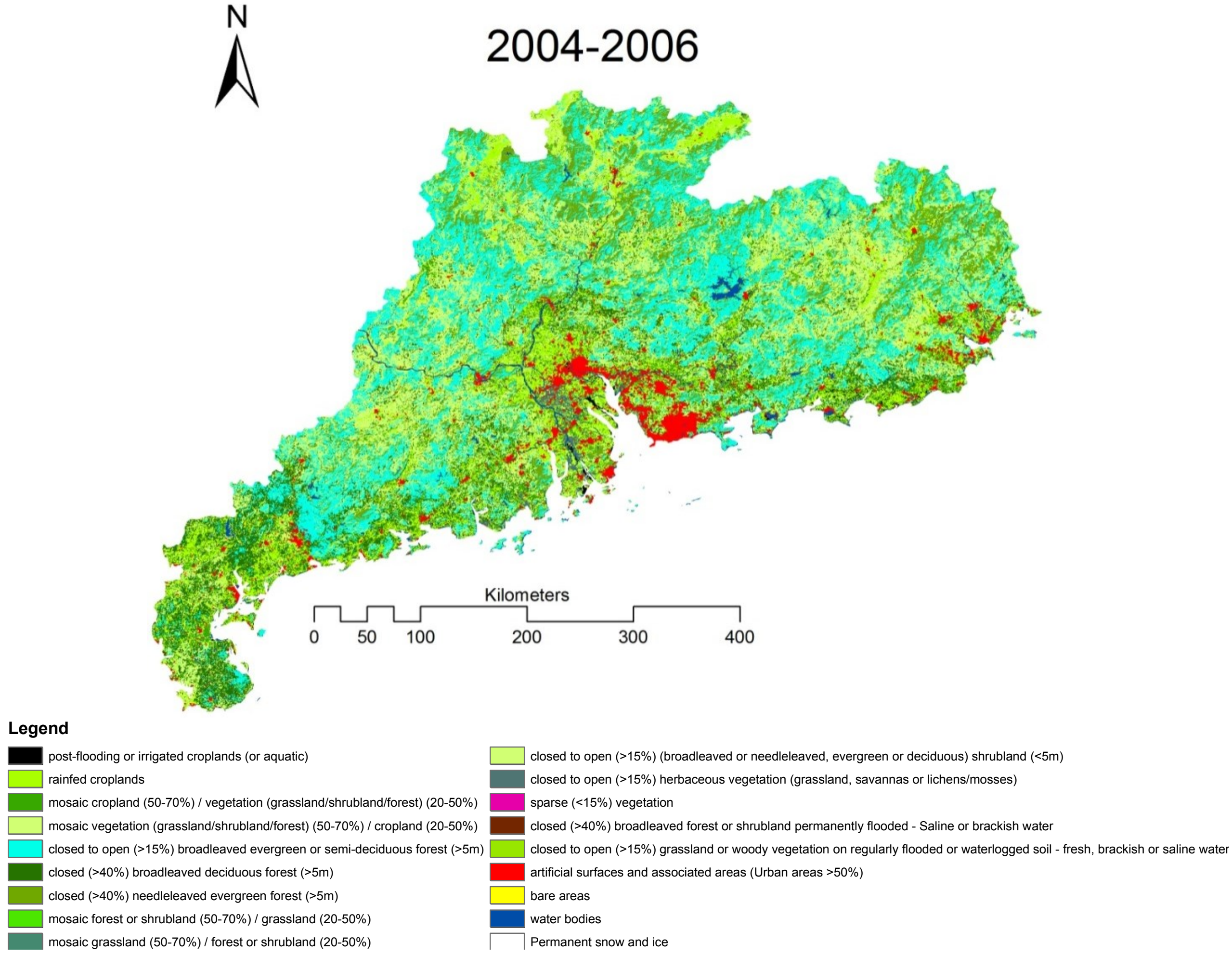

Figure 3: Map of VFC dynamics of different land-use types in 2004-2006

The accuracy assessment of the Table 2 results showed that VFC dynamics under built-up area (city, town region and village residential area) were increased from 55.8% in 2004-2006 to 56.1% with 0.3% growth in 2009 where the grass (mosaic grassland (50-70%) was decreased from 77.3% to 56.4% with -20.9% decline and forest lands (closed (>40%) broadleaved and needle-leaved forest) from 83% to 82.6% with -0.4% reduction and crop (irrigated cropland) was experienced declining trend from 68.9% to 55.8 with -13.1% in the same periods. According to Fig. 4, it can be seen that a large part of study area was under closed to open (>15%) broadleaved evergreen or semi-deciduous forest (>5m). On the other side rain-fed croplands and close to open (>15%) grassland or woody vegetation on regularly flooded was significantly scattered. Artificial surface expanding and associated area (urban area >50%) was occupying in central and coastal areas; however this process compared with 2000 and 2004-2006 has been rising significantly.

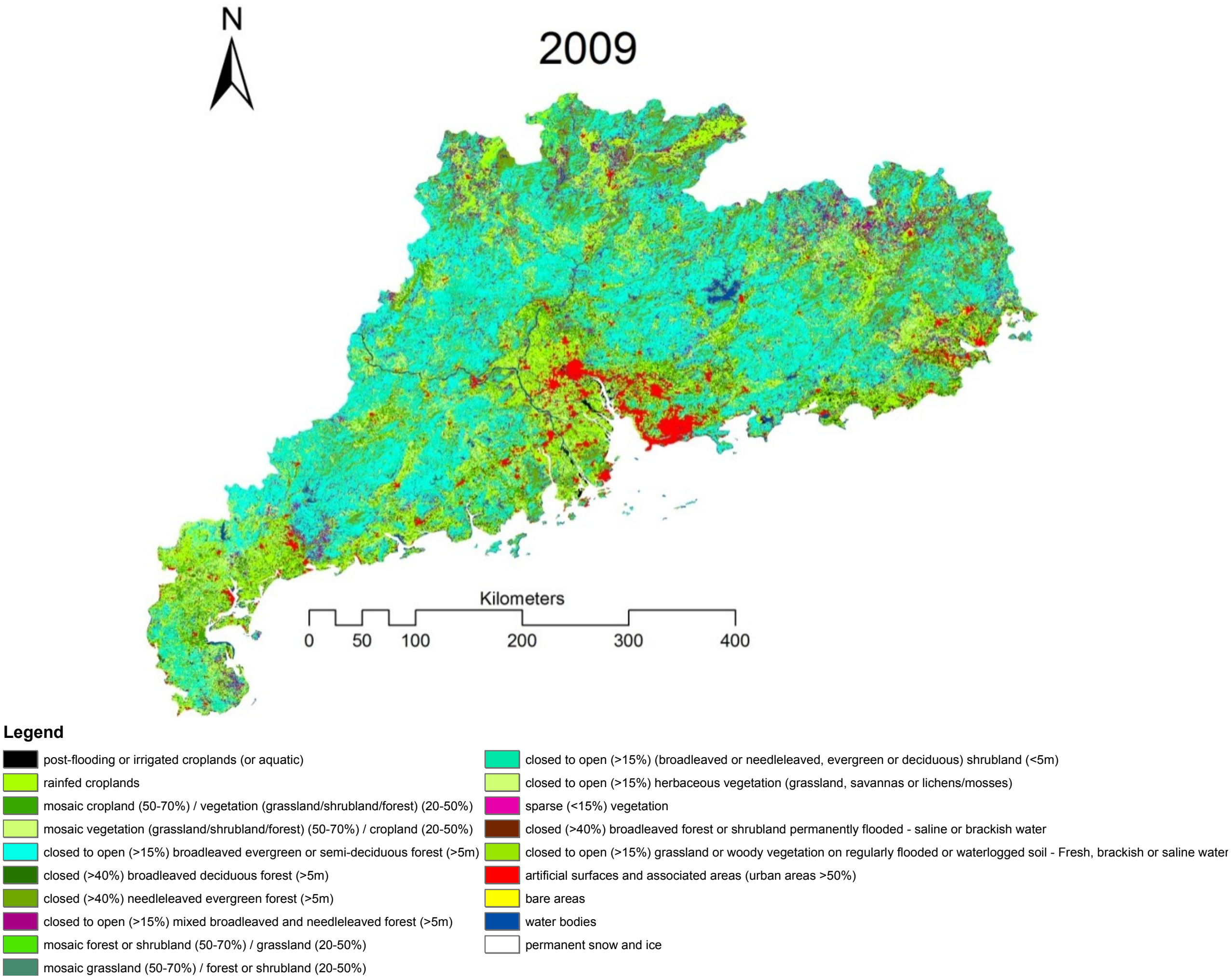

Figure 4: Map of VFC dynamics of different land-use types in 2009

[6] in analysis of the trends and driving factors in land use changes from 1956 to 2000 in Marina Baixa, SE Spain clarified that the analysis of changes in land cover and land use over time as sources of information and geographical diagnosis at a regional scale is primary to improving knowledge of land cover and land use modeling. They showed that the main driving forces of landscape change are economic and social (tourism development and agricultural intensification) but urban planning is also a key element to take into account in the land use model. They were profited combined Cellular Automata, Markov Chain and Multi-Criteria land cover prediction procedure.

[8] in a research titled monitoring land use/cover change using remote sensing and GIS techniques reported that the data of the study area categorized into five different classes namely vegetation, agriculture, barren, built-up and water body. They indicated that during the last two decades, vegetation and built-up land have been increased by 3.51% (9.39 km^2) and 3.55% (9.48 km^2) while agriculture, barren land and water body have decreased by 1.52% (4.06 km^2), 5.46% (14.59 km^2) and 0.08% (0.22 km^2), respectively.

[11] in other matters as land-use change simulation and assessment of driving factors in the loess hilly region; a case study in Pengyang County explained that the associated kappa values decreased from 0.83 in 1993-2000 to 0.27 and 0.23 in 2001-2005. They also concluded that forest and grassland were the land-use types with highest commission errors, which implies that conversion of both the land-use types mentioned above is the main determinant of change of kappa values. Their study indicated that the land-use change was driven by the synthetic multiply factors including natural and social-economic factors (e.g., slope, aspect, elevation, distance to road, soil types, and population dense) in 1993-2000 until “Grain for Green Project” was implemented and has become the dominant factor in 2001-2005.

According to past researches, we can conclude that the during the study period (i.e., 2000–2010), barren land was decreased due to conversion in agriculture, vegetation and built-up land. The major category of forest and crop were decline due to urbanization and climatic factors. The area under classification of the grass land has been a growing trend and the area under category of the built-up land has increased due to mainly expansion of the Guangzhou town area during the last decade. The our findings indicated that the present approach of driving forces of land cover changes in Asia needs rethinking to accommodate physiographical, climatic factors and socioeconomic variations across the county, province and country. The present research illustrated that the findings from the Modis NDVI data and digital elevation map using Arc View technique are important technologies for temporal analysis and quantification of spatial phenomena related to vegetation coverage change which is otherwise not possible to attempt through conventional mapping techniques. However vegetation fractional coverage change detection enable to made possible by these technologies in less time, at low cost and with perfect accuracy.

VFC Dynamics by City Positions

The VFC dynamic based on the physiographic factors in 2000, 2005, 2010 was included; (I) slope and (II) elevation, and based on different land use classification in 2000, 2004-2006, 2009 were as follows: (I) forest, (II) grass, (III) crop, (IV) built-up and (V) bare land.

Results of VFC dynamics by cities position in the three periods of 2000, 2005 and 2010 showed that VFC decreased with -4% from 2000 to 2005, and increased with 3.8% from 2005 to 2010 in Dongguan in the south region of Guangdong Province. In the north, Shaoguan was experienced VFC dynamics with 1.1% from 2000 to 2005, and with -1.6% from 2005 to 2010. In the west, Maoming was faced with VFC decline with -0.1% from 2000 to 2005, but on the other hand, VFC could improve with 3.4 from 2005 to 2010. Finally, in the east region of Guangdong Province, Shanwei had VFC decline with -0.2 from 2000 to 2005, however from 2005 to 2010 VFC was developed with 3.2% decisively (Table 3).

The least amounts of VFC dynamics were related to Dongguan in the south and Shanwei in the east region of Guangdong Province, owing to be near to artificial surfaces, associated and urban areas <50%. On the other side, the high amounts of VFC dynamic were depended on Shaoguan in the north and Maoming in the west (Table 3), because Shaoguan and Maoming were covered by close to open (>15%) broad leaved evergreen or semi-deciduous forest (>5m), and closed (>40%) broad leaved deciduous/needle leaved evergreen forest (>5m).

Table 3: VFC dynamics by city positions

Year	South (Dongguan)	North (Shaoguan)	West (Maoming)	East (Shanwei)
2000	0.578	0.816	0.757	0.699
2005	0.538	0.827	0.756	0.697
2010	0.576	0.811	0.790	0.729

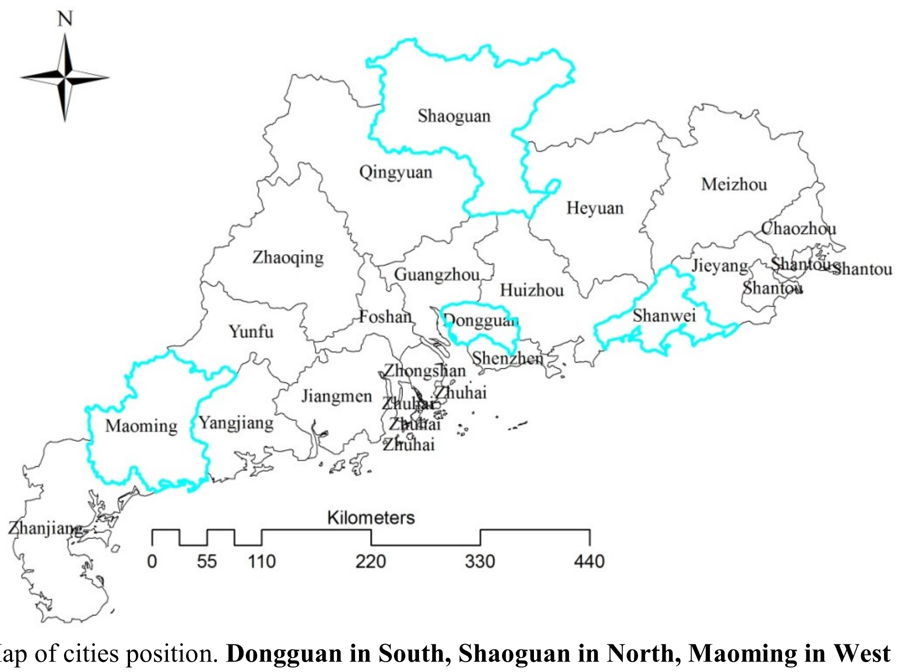

Figure 5: Map of cities position. **Dongguan in South, Shaoguan in North, Maoming in West and Shanwei in East**

Area of the Shaoguan was calculated 18038 km^2, Dongguan 2330 km^2, Maoming 11221 km^2 and Shanwei was 4805 km^2 Fig (5). As previously mentioned, there has been a renewed focus on the study of dynamic of urban systems in the last few years in the Guangdong using DMSP/OLS data, as urbanization remains a major development challenge exerting awesome pressure on environmental sustainability. Also we showed that the vegetation factional coverage had least amount on the south (Dongguan) and western regions (Shanwei), where mentioned parts had highest urbanization and industrialization activities. However, according to studies conducted, urban areas currently account for about 30% of the Guangdong's surface; the ecological footprint associated with urban expansion has important environmental consequences. Urbanization often occurs on agricultural land and forests that is generally accompanied by an increase in energy use, and air, water and noise pollution. The increase in impervious surface associated with urban land conversion also leads to a decrease in infiltration and an increase in surface runoff, sedimentation, and eutrophication of wetlands. Uncontrolled urban expansion also leads to the fragmentation of landscapes, destruction of wildlife habitat, and reduction in biodiversity. These impacts make an understanding of the factors driving urban expansion essential to global environmental change research.

[2] in a study entitled linking physical, economic and institutional constraints of land use change and forest conservation in the hills of Nepal reported that during the 24-year period from 1976 to 2000 agricultural land use increased by 35% at a cost of loss of forestland. Agricultural expansion was most conspicuous at higher elevations (1150–2000-m) and at roughly 36%, 18% and 6% of forestland was converted into agricultural activities from higher, middle and lower elevations respectively in the period from 1990 to 2000. Finds were showed that while overall land change patterns in the region are largely explained by elevation and the socioeconomic conditions of people living adjacent to the forestland, more specifically, in sub-regional areas, trajectories reflect the signatures of institutions governing access to land. Therefore we can conclude that socioeconomic conditions of people living, population change, climatic factor such as rainfall and temperature with physiographic factor including the topography of the area, altitude, drainage conditions, degree of erosion, slope and elevation of the land and etc, enable to affective on the land-use/land cover changes. Thus our findings are consistent with scientific results. In another study, [3] in land use change and population growth in the Morobe Province of Papua New Guinea between 1975 and 2000 related that the relation between human population growth and land use change is much debated. Their results showed that between 1975 and 2000, agricultural land use increased by 58% and population grew by 99%. On the other side most new agricultural land was taken from primary forest and the forest area decreased from 9.8 ha person^{-1} in 1975 to 4.4 ha person^{-1} in 2000. They reported that total population change and total land use change were strongly correlated. Most of the agricultural land use change occurred on Inceptisols in areas with high rainfall (42500mmyear^{-1}) on moderate to very steep slopes (10-56%). Agricultural land use changes in logged-over areas were in the vicinity of populated places, and in close proximity to road access.

Conclusion

The study of VFC dynamics of different land-use types and city position were integrated remote sensing and spatially explicit data to develop statistical model of urbanization and vegetation coverage. Relationships between forest coverage change and the driving factors were quantified in residential and commercial-industrial parts in Guangdong Province. The results indicated that accessibility, neighborhood interactions and spatial policy are important spatial determinants of VFC land use change. On the other side, there are the evidences of frontier residential development on forests and farmlands that could affect rural livelihoods at the urban fringe in south Asia. As well as there are problem are related to institutional factors such as the skewed distribution of private land, the high costs of undeveloped land, and weak land use planning regulations that housing policies reforms are required. In addition, there is also the need to enforce planning regulations to curtail adverse environmental impacts of urban expansion. We could observe differences in the magnitude and direction of significant variables of VFC models of land-use types and city position in Guangdong Province. Though VFC change models should therefore separate residential and commercial land uses to clearly identify the driving factors. Although, the broad patterns of major land-use/cover changes are known with some confidence, and the literature is rich in contending explanations for them. The area of driving forces requires the most attention. To advance, we need much more precise and spatially congruent data. The quality of the physical data, if still inadequate, is far better than that on the human variables, a disparity that will only be widened by the proposed space platform projects.

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