

CHANGE DETECTION OF LAND USE AND LAND COVER
IN COASTAL ZONES OF CHINA (FUJIAN) AND BULGARIA
USING MULTI-TEMPORAL AND MULTI-SCALE
REMOTE SENSING DATA

*Rumiana Vatseva¹, Jinming Sha², Ventzeslav Dimitrov³, Xiaomei Li⁴,
Youfei Chen⁵, Stoyan Nedkov¹*

Key words: Coastal zone, Land use, Land cover, Change Detection, Remote Sensing, GIS.

INTRODUCTION

Land use and land cover change detection is a substantial process in monitoring and managing natural resources and urban development, as well as is central to the interests of the science of global environmental change. Up-to-date land cover information is of crucial importance to scientists, resource managers, and decision makers. Remote sensing is a powerful tool to provide land cover data with high temporal and spatial accuracy.

The study on the coastal land cover and land use is one of the main topics and has gained comprehensive research attention. Coastal zones are areas of substantial importance due to their significant natural and economic resources, as well as to their sensitivity with respect to unfavorable ecological impacts. The investigation of the land cover change in these regions at risk appears to be an essential factor to the integrated coastal zones management. The Bulgarian Black Sea coastal zone as a vulnerable region, which is very sensitive to the diverse natural and anthropogenic impacts on the environment, is an area of special research interest for V a t s e v a

¹ National Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Bulgaria; rvatseva@gmail.com, snedkov@abv.bg

² Centre of Environment and Landscape Management, Fujian Normal University, China; jmsha@fjnu.edu.cn

³ Space and Solar-Terrestrial Research Institute, Bulgarian Academy of Sciences, Bulgaria; vdimitrov@stil.bas.bg

⁴ College of Environmental Science & Engineer, Fujian Normal University, China; lixiaomei@fjnu.edu.cn

⁵ College of Geography, Fujian Normal University, China; yfchen@fjnu.edu.cn

(2005a, 2005b, 2005c, 2006a, and 2006b; V a t s e v a, K o u l o v, 2010). The investigation and mapping of land use change and environmental quality of Fujian province in China represent an important part of the work of S h a and L i (J i a n g, S h a, 2003; S h a, L i, 2004; J i a n g, S h a, 2008; L i et al., 2009; L i, S h a, L i a n, 2010).

The present study aims to analyze land use and land cover change in coastal zones of Bulgaria and Fujian province in China based on satellite imagery. The survey covers about 20 years period during the transition from planned economy to market economy in Bulgaria (1990-2006) and the post-reform era in China (1980-2001). This research was carried out in the frame of the research project “Change Detection of Land Use and Land Cover in Coastal Zones of China (Fujian) and Bulgaria Using Multi-temporal and Multi-scale Remote Sensing Data” during the period 2008- 2011 by bilateral scientific and technical cooperation between Republic of Bulgaria and People’s Republic of China.

STUDY AREAS

Two study areas were selected along the coastal zones in Bulgaria and China. The study area in Bulgaria is the Black Sea coastal zone. It is located in East Bulgaria and is approximately bounded by the coordinates: 41°56'-43°44' N and 27°17'-28°36' E (Fig. 1). The coastline has a length of 378 km and covers the entire eastern bound of Bulgaria stretching from Romania in the north to Turkey in the south. The study area includes all of the 14 coastal municipalities in Bulgaria. This land strip with an area of 5,756 km² is 7 to 40 km wide. The region is characterized by both well preserved natural landscapes and areas with high anthropogenic impact. The northern part features plain and karst relief, while the southern is predominantly lowland with forested hills, lakes, wetlands, and coastal lagoons. The sandy beaches occupy approximately 130 km of the coast. The climate is formed under the influence of the Black Sea. It is moderate-continental in the north and transitional-Mediterranean in the south. The summer is relatively warm and the winter is mild, the average annual precipitation is 440-900 mm. The region is an important center of tourism during the summer season from May to October.

The study area in China is Fujian Province which is situated in the Southeaster part of the country on the coast of the East China Sea (23°31'-28°18' N and 115°50'-120°43' E) in middle and south subtropics (Fig. 2). Its territory includes 121,400 km² of land and 136,300 km² of sea. It covers a land of 480 km from East to West and 530 km from North to South. Its coastline stretches 3,324 km and has many bays and more than 1500 islands. In 2010, the province’s population is 36,930,000, and the Gross National product value is 147.3712 billion Yuan. The province is mostly mountainous, mountains and hilly areas constitute over 80 % of Fujian’s land area. Plains are concentrated in its southeast coastal areas. Fujian has a subtropical humid monsoon climate, with favorable hydro-thermal conditions, the average annual temperature is 15-21 °C, and the average annual precipitation is 1000-2000 mm. The province has been developed for over 3000 years. As the effects of human activities on nature are relatively profound, different types of land use have been formed under the long time agro-economical activities. Fuzhou was selected as test area for environmental quality assessment. Fuzhou city is the capital and largest city of Fujian with an area of 12,177 km² and population of 7,115,370 inhabitants at the 2010 census.

MATERIALS AND METHODS

The remotely sensed data used for Bulgaria include multispectral images from Landsat TM of 1991 and 1992, Landsat ETM+ of 2000 and 2001, IRS-P6, SPOT 4 and SPOT 5 of 2006 and 2007 (Table 1).

Table 1

Satellite images for the Black Sea coastal zone in Bulgaria

Satellite imagery	Year	Number of Scenes
Landsat TM	1991, 1992	2
Landsat ETM+	2000, 2001	2
IRS-P6	2006	3
SPOT 4	2006	2
SPOT 5	2006, 2007	5

Landsat TM of 1980s and 1990s along with Landsat ETM+ of 2000 and 2001 were used as a time series of images for the land use change study of Fujian, China (Table 2).

Table 2

Satellite images for Fujian province in China

Satellite imagery	Year	Number of Scenes
Landsat TM	1986, 1989	16
Landsat TM	1990, 1996	16
Landsat ETM+	2000, 2001	16

A wide variety of ancillary data was used for both study areas, such as digital topographic and thematic maps, orthophotos, statistics, and in-situ data from multi-year field observations.

The concept of image classification of remote sensing was applied using two methods for land use and land cover change detection:

- Visual interpretation of multispectral satellite imagery
- Automatic image classification.

Land cover and land use changes in the Black Sea coastal zone in Bulgaria were identified by application of the visual interpretation (Büttner et al., 2004; Feranec et al., 2007) of Landsat images applying the methodology and nomenclature of the CORINE Land Cover (CLC) project (Heymann et al., 1994; Perdigao, Annoni, 1997; Bossard et al., 2000; Feranec et al., 2006; EEA, 2007; Büttner, Kosztra, 2007; Steenmans, Büttner, 2007). The CLC changes were registered when the following geometric criteria were met: minimum changed area of 5 ha and minimum polygon width of 100 m. Land use and land cover change reflects only real landscape dynamic processes. Several GIS procedures were applied for integration of the single CLC1990-2000 and CLC2000-2006 change segments,

checking the physical and logical integrity, creation of CLC2000 and CLC2006 vector database by overlay procedures, application of cleaning procedures for providing topologically correct seamless geo-database, final checking and composition of land cover and land use change maps. The identification of land cover and land use change also includes field checking, correction and verification of the results.

The automatic classification (unsupervised and supervised) of remote sensing data is more suitable for land use mapping in a large area. The unsupervised image classification method using ISODATA classification technique, or “clustering”, was performed for Fujian province. Initially, Landsat satellite images were pre-processed and then classified using ENVI and ArcGIS. Land use mapping was achieved through interpretation of Landsat TM and Landsat ETM+ satellite images of 1980s, 1990s and 2001. Post-classification, a decision support system based on expert-knowledge was used to update the classification products according to existing land use database using ArcGIS 9.3. For this study, seven classes were used: farmland, orchard, forest, pasture, construction, transport and water.

Maximum likelihood supervised classification was applied for Fuzhou. The images were classified using signatures from training sites that include all seven land cover types. The signatures were collected by digitizing polygons on the up-to-date, high-resolution orthophoto, and then projecting them onto the Landsat images to collect the training samples. Knowledge of the area and information collected during field work were important inputs, which were used by the software to classify the pixels into similar groups based on sample signatures specified.

Following the classification of imagery from the individual years, a multi-date post-classification comparison change detection algorithm was used to determine land use change in Fujian province in two intervals, 1980-1990 and 1990-2001. This is the most common approach to change detection and has successfully been used to monitor land use change in Fujian province. The post-classification approach provides “from-to” change information and the kind of landscape transformations that have occurred were calculated and mapped. As a result two land use change maps were derived.

An ecological threshold was identified for assessment of environmental changes of Fujian province. The ecological threshold is a point or zone between alternate ecosystems. In the threshold, ecological process parameters, function and composition change greatly, while they are relatively stable out of the threshold (Li, Sha, Meng, 2010). Normalized Difference Vegetation Index (NDVI) is usually regarded as an important indicator of environment (Li et al., 2009; Li, Sha, Lin, 2010). Based on the spectral response differences of the land cover types several indices or ratios were calculated for the period 1990-2001: NDVI, RVI, Greenness, Wetness, Wet grade, Ground temperature, Annual average temperature, Soil brightness (NDSI), Brightness (BI), DEM, Slope, Rain erosion, Soil erosion, Vegetation, Relation between NDVI and vegetation, and Forest grade.

For environmental assessment of Fuzhou the remote sensing (RS) background value was calculated. The RS background value of environment is a composed image calculated by a series of images on image, such as water, heat and vegetation. The background value reflects environment through different aspects, quality, ecological asset and capacity of environment (Jiang, Sha, 2008). The RS background value images were got with fitting equations.

RESULTS AND DISCUSSION

Satellite imagery constitute the base data source for generation of land cover and land use data for both study areas in Bulgaria and China for about 20 years period: 1990–2006 for Black Sea coastal zone and 1980–2001 for Fujian province.

The survey of the Bulgarian Black Sea coastal zone reveals that in 2006 more than 51 % of the area was occupied by arable land, about 40 % of the area was covered by forest and semi-natural areas, 5.9 % was occupied by artificial surfaces, about 0.5 % were wetlands and more than 1.5 % were water bodies (Table 3). The land cover/land use map (Fig. 3) shows the structure and spatial distribution of land cover and land use in coastal zone in Bulgaria for 2006.

Table 3

Land cover and land use in the Black Sea coastal zone in Bulgaria for 1990–2006

CLC class	1990		2000		2006	
	Area (km ²)	%	Area (km ²)	%	Area (km ²)	%
Artificial surfaces	331.28	5.75	333.52	5.79	341.19	5.93
Arable land	3004.18	52.19	2992.13	51.99	2985.29	51.89
Forest and semi-natural areas	2296.06	39.88	2305.52	40.05	2304.7	40.06
Wetlands	32.05	0.56	30.57	0.53	30.57	0.53
Water bodies	93.04	1.62	94.61	1.64	90.95	1.58
TOTAL:	5756.35	100.00	5756.35	100.00	5756.35	100.00

Land use data for Fujian province in China in 2001 (Table 4, Fig. 4) show the dominance of forest (61.53 %) and farmland (33.3 %), as well as distribution of construction (2.21 %) and orchard (2.16 %).

Table 4

Land use in Fujian, China for 1980–2001

Type	1980s		1990s		2001	
	Area (km ²)	%	Area (km ²)	%	Area (km ²)	%
Farmland	36116.00	29.65	41900.95	34.4	40561.97	33.30
Orchard	236.88	0.19	2472.64	2.03	2626.13	2.16
Forest	83087.74	68.21	73594.64	60.42	74952.03	61.53
Construction	1301.7	1.07	2411.74	1.98	2687.81	2.21
Transport	5.09	0.004	12.18	0.01	9.99	0.01
Water	1002.16	0.82	962.26	0.79	957.93	0.79
Pasture	55.53	0.05	450.68	0.37	9.24	0.01

The assessment of land use/cover change (LUCC) in the 14 Bulgarian Black Sea coast municipalities shows that the LUCC total area was 6682.9 ha in 1990–2000 and 3754.7 ha for the period 2000–2006 (Table 5).

Table 5

Land use/cover change in the Bulgarian Black Sea coastal zone for 1990–2006

Land use/cover change type	1990-2000 (ha)	1990-2000 (%)	2000-2006 (ha)	2000-2006 (%)
Enlargement of urban fabric	28.9	0.43	63.7	1.70
Enlargement of construction sites	-	-	417.9	11.13
Enlargement of sport & leisure areas	-	-	289.0	7.70
Enlargement of industrial and transport units	-	-	96.5	2.57
Enlargement of mineral extraction sites	55.9	0.84	18.8	0.50
Intensification of agriculture	1025.1	15.34	228.3	6.08
Extensification of agriculture	2275.8	34.05	377.4	10.05
Afforestation	2005.5	30.01	599.5	15.97
Deforestation	1291.7	19.33	1663.5	44.30
TOTAL:	6682.9	100.00	3754.7	100.00

The results indicate that the urban area expanded substantially along the Black Sea coast during the period 1990-2006, mostly to the detriment of arable land and woodland. Between 1990 and 2000, the changes consist mostly in abandonment of agricultural land, afforestation, and deforestation. Geographically, they are situated almost exclusively in the interior of the coastal municipalities and are evenly distributed (Fig. 5). Urban changes were not observed up to two kilometers from the coastline.

During the second period, 2000-2006, the LUCC results are due mainly to urbanization “hotspots” in seven municipalities: Nesebar, Sozopol, Primorsko, Tsarevo, Kavarna, Balchik, and Pomorie (Table 6). Most of urban changes are situated

Table 6

Urban change 2000–2006 in the two-kilometer wide strip along the Black sea in Bulgaria

Municipality	Enlargement of urban fabric (ha)	Enlargement of construction sites (ha)	Enlargement of sport & leisure areas (ha)	Enlargement of transport units (ha)	TOTAL (ha):
Kavarna	-	18.7	-	-	18.7
Balchik	-	214.0	-	-	214.0
Nesebar	-	164.8	121.8	-	286.6
Pomorie	5.1	-	-	-	5.1
Sozopol	-	-	119.6	-	119.6
Primorsko	21.4	-	-	27.7*	49.1
Tsarevo	17.1	-	47.5	-	64.6
TOTAL (ha):	43.6	397.5	288.9	27.7	757.7

* Small airport for charters at a distance of 4 km.

in the southern part of the Bulgarian coastal zone (Fig. 5). Urban changes in the two-kilometer band along the coast cover 757.7 ha, however, 88.6 % (671.6 ha) of them are located in the one-kilometer land strip. The areas of the towns of Nesebar (with the Sunny Beach Resort and the village of Ravda), Sozopol, Primorsko and Tsarevo (with the villages of Lozenets and Sinemorets) experience the greatest urbanization pressure. This is in close connection with tourism development and includes construction of hotels, second homes, sport and leisure facilities areas, including golf courses, and a small airport for charter planes (V a t s e v a, K o u - l o v, 2010).

The study of land use change in Fujian province in China indicates two different trends in economic policy for the period 1980–2001. Generated maps (Fig. 6) illustrate that land use change during the first period 1980–1990 covers much larger areas than in the second period 1990–2001. This is closely connected with the state economic policy and the period of rapid economic growth in China (with an annual growth of over 9 %) after 1978. Agricultural policy was changed and the structure of the economy contributes to this type of land use and land cover change. The agricultural policy was shifted from the planned economy and collective land management system to market-oriented economy. The introduction of individual contract system for land management in 1983 encouraged a large increase in farmland and orchard mostly to the detriment of woodland. Fujian's economy is characterized by rapid industrialization since 1990, which cause a gradual reduction of agriculture share in the Gross National product value and gradually increase of industry share. As a result land use change was associated with the abandonment of arable land and pastures, and their transformation into forest.

The study illustrates an increasing trend of urban areas with a decreasing trend of arable land, grassland and wetland. Land use changes from one category to others have been clearly represented by the NDVI composite images, which were found suitable for delineating the development of land use change in Fujian.

The map of eco-environment quality change in Fujian province for 1990-2001 was generated as a result of analysis of calculated indices and ratios based on satellite images (Fig. 7). Eco-environment is referred to the biological environment for human beings. It is analyzed separately from abiotic environmental elements such as water, air, soil, etc. It is usually expressed with biological characteristics such as vegetation species, coverage, density, etc. In fact, eco-environment reflects the state of plant ecosystems, because biological properties are the direct results of the interaction between plant and its environmental factors such as humidity, soil nutrients and temperature, etc. Figure 7 shows that the most changed areas in Fujian province for 1990-2001 are located along the coast. The Wuyi mountain and Nanping city were not changed, while Minhou county, Fuding city and Zhangzhou city were changed for the worse, as well as Luoyuan county and Shounin county were changed for the better.

The remote sensing (RS) background value was proposed as an indicator for quality assessment of eco-environment based on satellite imagery (J i a n g, S h a, 2008). Moreover, a series of RS background value grades were defined (Table 7).

Various environmental components, such as vegetation, soil, topography, etc. were analyzed (J i a n g, S h a, 2003; S h a, L i, 2004) to assess the quality of eco-environment of Fuzhou city. As a result, the RS background value images of Fuzhou for

Table 7

Remote Sensing (RS) background value grades and its relative attributes

Grade	RS background value	Eco-type	Topography and altitude	Vegetation coverage and vegetation type	Water and heat features
1	500-451	Shady and hydrophilic vegetation featuring high coverage broad leaved forest and mixed forest with coniferous and deciduous species	Mountains with medium altitude (1000-1200 m)	Evergreen deciduous trees, with the vegetation coverage reaching 90%	Relative humidity: 70-80%, shady and cool
2	450-401	Shady vegetation featuring medium coverage broad leaved forest and mixed forest with coniferous and deciduous species	Mountains with low altitude (500-1100 m)	Subtropical coniferous and deciduous trees, and evergreen deciduous species, with the vegetation coverage of 90-80%	Relative humidity: 60-70%, shady and cool
3	400-351	Vegetation featuring low coverage xerophytic coniferous forest	Mountains with low altitude	Coniferous forest	Relative humidity: 40% shady
4	350-301	Rainy vegetation featuring shrubbery	Mountains of different types	Evergreen broad leaved forest and shrubbery	Relative humidity: 50-60%, warm
5	300-251	Shady vegetation featuring grassland	High mountains (with altitude above 1200 m)	Meadow, mountain grassland	Relative humidity: 30%, cool
6	250-201	Vegetation featuring economic forest	Coastal hill land, plain, and river valley	Mango, bamboo, tea, love tree, and orchard	Relative humidity: 30%, warm
7	200-151	Vegetation featuring wetland	Farmland on plain	Various crops	Relative humidity: 50%, dry and hot
8	150-101	Thermophilic and dry vegetation featuring arid and open land	Peninsula and beach	Dry crop, and mixture of shrub and grass	Relative humidity: 20%, dry and hot
9	100-51	Vegetation featuring artificial buildings	Plain	Human settlement and site of construction	Relative humidity: 20%, dry and hot

1989, 2000 and 2001 were composed (Fig. 8). The RS background value calculation gives good results when it is used for small areas and for short period (up to 2 years). The results obtained are targeted for regional management and planning.

CONCLUSIONS

This study reveals the land use and land cover change in coastal zones of Bulgaria Fujian province in China for about 20 years period during the transition from planned economy to market economy in Bulgaria (1990-2006) and the post-reform era in China (1980-2001). The “hotspots” land use and land cover changes in seven municipalities in the Black Sea coastal zone in Bulgaria are identified. The analysis shows a decrease of the area of forest and agricultural lands in favor of urban areas mainly for tourism and recreation-related infrastructure. The results for land use change in Fujian province in China clearly indicate two different trends in economic policy related to the market-oriented land management since 1983 and rapid industrialization since 1990. The findings of change detection analysis reveal the continuous spatial increment of urban areas and decreasing trend of arable land, grassland and wetland.

The assessment of eco-environment quality change based on satellite image analysis shows that the most changed areas in Fujian province for 1990-2001 are located along the coast. The remote sensing (RS) background value is proposed as an indicator for quality assessment of eco-environment on the example of Fuzhou.

The present study reveals that the coastal zones in Bulgaria and China, Fujian province, became most vulnerable in this time of rapid industrial development, urban modernization and tourism development for the past few decades. The baseline information generated on land use and land cover pattern of these areas would be of immense help in formulation of policies required for regional management and planning.

Acknowledgements

The project “Change Detection of Land Use and Land Cover in Coastal Zones of China (Fujian) and Bulgaria Using Multi-temporal and Multi-scale Remote Sensing Data” was funded by the National Science Fund per contract № DO 02-10/2008 of the Institute of Geography, Bulgarian Academy of Sciences and Ministry of Education, Youth and Science, Bulgaria, as well as by the Fujian Provincial Science and Technology Department: the key international cooperation project No. 2009I006, Fujian, China.

REFERENCES

- Bossard, M., J. Feranec, J. Othel. 2000. CORINE Land Cover Technical Guide – Addendum 2000 (European Environmental Agency). <http://terrestrial.eionet.europa.eu/CLC2000>
- Büttner, G., B. Kosztra. 2007. CLC2006 Technical Guidelines, p. 45.
- Büttner, G., J. Feranec, G. Jaffrain, L. Mari, G. Maucha, T. Soukup. 2004. The CORINE Land Cover 2000 Project. EARSel eProceedings 3(3), 331-346.

- Feraneč, J., G. Büttner, G. Jaffrain. 2006. CORINE Land Cover Technical Guide – Addendum 2006.
- Feraneč, J., G. Hazeu, S. Christensen, G. Jaffrain, M. Bossard. 2007. CORINE land cover changes detection in Europe (case studies of the Netherlands and Slovakia). – *Land Use Policy*, 24, 234-247.
- Heymann, Y., Ch. Steenmans, G. Croisille, M. Bossard. 1994. CORINE Land Cover. Technical Guide. Office for Official Publications of the European Communities, Luxembourg, 136 p.
- Jiang, Z. L., J. M. Sha. 2003. Analysis of Fuzhou's Vegetation Eco-environment by Remote Sensing. – *Journal of Subtropical Resources and Environment*, Issue 03, DOI: cnki:ISSN:1009-248X.0.2003-03-001, http://en.cnki.com.cn/Article_en/CJFDTOTAL-FJDL200303001.htm
- Jiang, Z. L., J. M. Sha. 2008. Research into RS Background Value of Vegetation Eco-environment with Fuzhou Taken as an Example. – *Journal of Fujian Normal University (Natural Science Edition)*, Issue 4, Page 80-85, ISSN: 1000-5277.
- Li, X. M., J. M. Sha, X. M. Meng. 2010. Identification the spatial threshold of ecological indicator NDVI by application of optimal dividing algorithm for ordinal. Sixth International Conference on Natural Computation (ICNC), Vol. 8, pp. 4435-4439, ISBN: 978-1-4244-5958-2, DOI: 10.1109/ICNC.2010.5583497.
- Li, X. M., J. M. Sha, J. L. Lian. 2009. Identification of the Characteristic Scale for NDVI in the Subtropical Region of China by Use of Wavelet Analysis. – Fifth International Conference on Natural Computation (ICNC), Vol. 6, pp. 382-386, ISBN: 978-0-7695-3736-8.
- Li, X. M., J. M. Sha, J. L. Lian. 2010. Regional characteristic scale of NDVI based on wavelet analysis. – *Acta Ecologica Sinica*. 30(11): 2864-2873.
- Perdigão, V., A. Annoni. 1997. Technical and Methodological Guide for Updating CORINE Land Cover Data Base (Joint Research Centre, European Environmental Agency, Luxembourg) 124 p.
- Sha, J. M., X. M. Li. 2004. Research on Image Processing and Classification of Mountain Soils in Southeast China. *Terinformatika – 2004*, NyME GEO, Szekesfehervar, p. 1-10, <http://www.geo.info.hu/rendezvenyek/10eves/4/10%20jinming%20remote.pdf>
- Steenmans, Ch., G. Büttner. 2007. Mapping Land Cover of Europe for 2006 under GMES. – In: Proceedings of the 2nd Workshop of the EARSeL SIG on Land Use and Land Cover, 202-207.
- Vatseva, R. 2005a. Landscape changes in the Bulgarian Black Sea coastal zone in 1990-2000 identified from Landsat satellite images. – In: Proceedings of the Annual Conference of the Remote Sensing and Photogrammetry Society with the 2005 NERC Earth Observation Conference “Measuring, Mapping and Managing a Hazardous World”, Portsmouth, UK, CD-ROM.
- Vatseva, R. 2005b. Methodological aspects of thematic geographic map development using satellite images. – *Problems of Geography*, 1-2, 64-72 (in Bulgarian).
- Vatseva, R. 2005c. Methodological aspects of land cover changes mapping in the Bulgarian Black Sea coastal zone for the period 1975-2000 using Landsat satellite images. – In: Proceedings of the International Scientific Conference 2005 “Ecology and environment protection”, Blagoevgrad, Vol. 2, pp. 185-191.
- Vatseva, R. 2006a. Land Cover Mapping at Scale 1:50 000 in the Southern Bulgarian Black Sea Coastal Zone Using Remote Sensing and GIS. – In: Proceedings of the First International Conference on Cartography and GIS, Borovets, Bulgaria, CD-ROM.
- Vatseva, R. 2006b. Land Cover Changes Mapping in the Municipalities of the Burgas Region Coastal Zone for the Period 1990-2000 Applying Remote Sensing Data. – In: Proceedings of the International Conference on Geodesy and Cartography GEOS 2006, Prague, Czech, CD.

- V a t s e v a, R., B. K o u l o v. 2010. Land Use/Cover Changes and Sustainability of Tourism Development in the Bulgarian Black Sea Coastal Zone. – In: Car, A., Griesebner, D., Strobl, J., (Eds.): Geospatial Crossroads @ GI_Forum '10. Proceedings of the Geoinformatics Forum Salzburg. Wichmann Verlag, Germany, pp. 215-218, ISBN 978-3-87907-496-9.
- x x x E E A. 2007. CLC2006 technical guidelines. EEA Technical report, Copenhagen, p. 70.

ОТКРИВАНЕ НА ПРОМЕНИ В ЗЕМЕПОЛЗВАНЕТО И ЗЕМНОТО
ПОКРИТИЕ В КРАЙБРЕЖНИТЕ ЗОНИ НА КИТАЙ (ФУДЖИЯН)
И БЪЛГАРИЯ С ИЗПОЛЗВАНЕ НА РАЗНОВРЕМЕННИ
И РАЗНОМАЩАБНИ ДАННИ ОТ ДИСТАНЦИОННИ ИЗСЛЕДВАНИЯ

Р. Вацева, Дж. Са, В. Димитров, Ш. Ли, Ю. Чен, Ст. Недков

(Резюме)

Откриването на промени в земното покритие и земеползването е важна част от мониторинга и управлението на природните ресурси и урбанизацията, а също е в центъра на научните изследвания на глобалните промени в околната среда. **Особено внимание се обръща на крайбрежните зони поради съсредоточените в тях значителни природни и икономически ресурси и чувствителността им към неблагоприятните екологични въздействия.** Изследването на промените в земното покритие и земеползването в тези подложени на риск територии се превръща в основен фактор за интегрираното управление на крайбрежните зони. За провеждането на ефективни дейности от съществено значение е обективната и актуалната информация за състоянието на земното покритие и земеползването, получена по данни от дистанционни изследвания.

Основна цел на настоящото изследване е да се направи сравнителен анализ на промените в земеползването и земното покритие в крайбрежните зони на България и Китай (провинция Фуджиян) по данни от сателитни изображения. Изследването включва приблизително 20-годишния период на преход от плано-во стопанство към пазарна икономика в България (1990–2006) и на бързо икономическо развитие след реформите в Китай (1980–2001). Районът на изследване в България обхваща Черноморската крайбрежна зона, разположена между 41°56'–43°44' N и 27°17'–28°36' E, с 5756 km² площ, 7–40 km ширина и 378 km дължина на бреговата линия. Характеризира се както със силно антропогенизирани територии, така и с добре запазени природни ландшафти. В Китай районът на изследване е провинция Фуджиян, която се намира на югоизточното крайбрежие на страната, между 23°31'–28°18' N и 115°50'–120°43' E, със 121 400 km² площ на сухоземната част (от изток на запад 480 km, от север на юг 530 km), и 136 300 km² на акваторията, с 3324 km дължина на бреговата линия, повече от 1500 острова, население – 36,9 млн., и столица гр. Фуджоу (площ 12 177 km² и население 7,1 млн.).

В изследването са използвани изображения от различни сателити и сензори с резолюция 30 m: Landsat TM, Landsat ETM+, IRS-P6, SPOT 4 и SPOT 5. Събрани са допълнителни данни, които включват тематични и топографски карти и статистически данни. Използвани са два основни метода за откриване на промени в земното покритие и земеползването по данни от сателитни изображения: 1) Визуална интерпретация на сателитни изображения; 2) Автоматизирано откриване на промени с използване на алгоритми със и без обучение на класификатора.

Резултатите за промените в земното покритие и земеползването в Черноморската крайбрежна зона в България идентифицират седем общини като „горещи точки“: Несебър, Созопол, Приморско, Царево, Каварна, Балчик и Поморие. Анализът показва намаляване на площта на горите и земеделските земи и увеличаване на урбанизираните райони, свързани главно с развитието на туризма. Резултатите за промените в земеползването в провинция Фуджиян, Китай, ясно показват две различни тенденции в икономическото развитие във връзка с пазарно-ориентираното управление на земите след 1983 г. и бързата индустриализация след 1990 г. Анализът разкрива постоянно високи темпове на увеличаване на площта на урбанизираните райони и тенденция за намаляване на обработваемите земи, пасищата и влажните зони.

Оценката на измененията в качеството на околната среда въз основа на анализа на сателитните изображения показва, че най-силно променените райони в провинция Фуджиян за периода 1990–2001 г. са по протежение на крайбрежието. Предлага се индикатор за фоновата стойност на екосредата като показател за оценка на качеството на околната среда по данни от дистанционни изследвания на примера на гр. Фуджоу.

Проучването разкрива, че крайбрежните зони на България и Китай – провинция Фуджиян, през последните няколко десетилетия са станали най-уязвимите райони във връзка с развитието на туризма, модернизацията на урбанизираната среда и бързото развитие на индустриализацията. Получената информация и генерираните цифрови данни за крайбрежните зони на България и Китай могат да бъдат използвани за целите на регионалното развитие, планиране и управление.

Това изследване е осъществено при изпълнението на научноизследователски проект на тема: „Откриване на промени в земеползването и земното покритие в крайбрежните зони на Китай (Фуджиян) и България с използване на разновременни и разномасштабни данни от дистанционни изследвания“ в периода 2008–2011 г., финансиран от Фонд „Научни изследвания“ към Министерство на образованието, младежта и науката, България (договор ДО 02-10/2008) и от Департамент „Наука и технологии“ на провинция Фуджиян, Китай (ключов международен проект за сътрудничество 2009I006) в рамките на двустранното научно-техническо сътрудничество между Република България и Народна Република Китай.

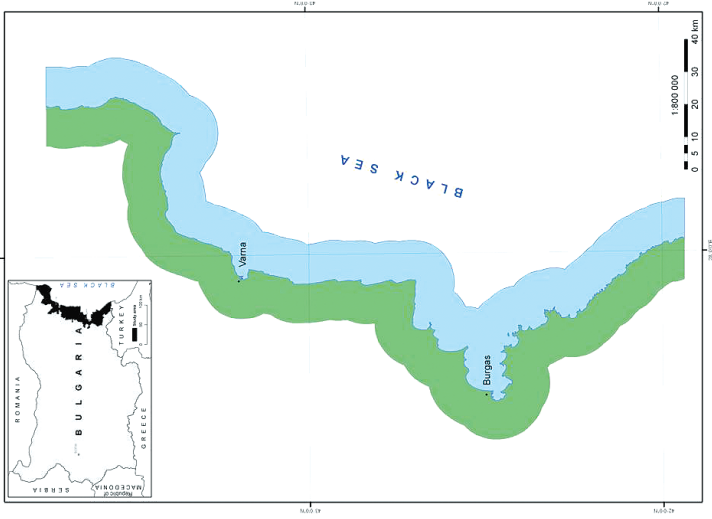


Fig. 1. Study area of the Black Sea coastal zone in Bulgaria

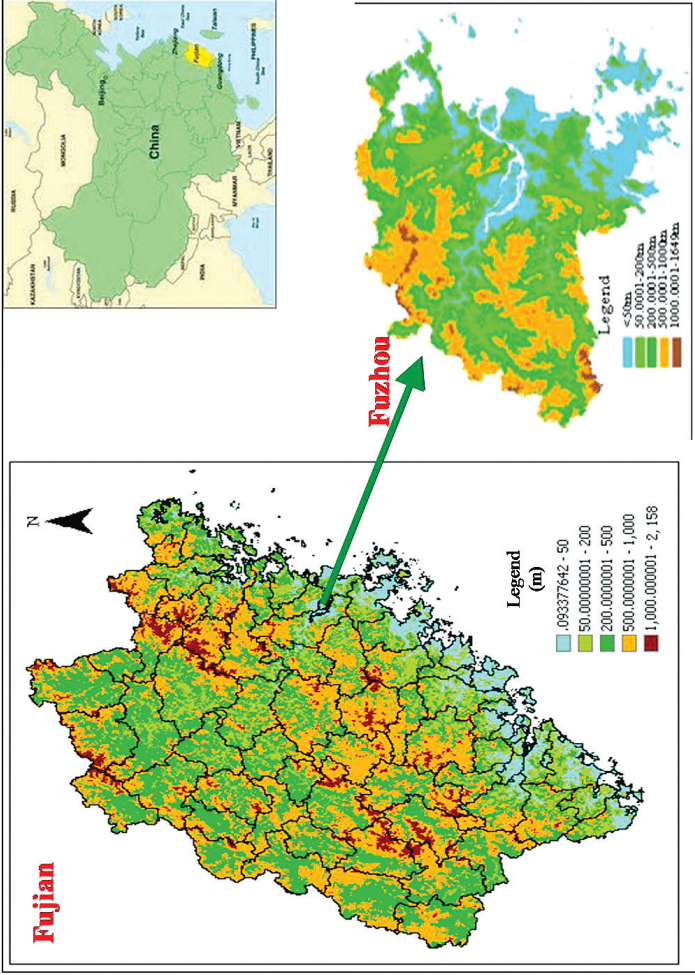


Fig. 2. Study area of Fujian Province in China

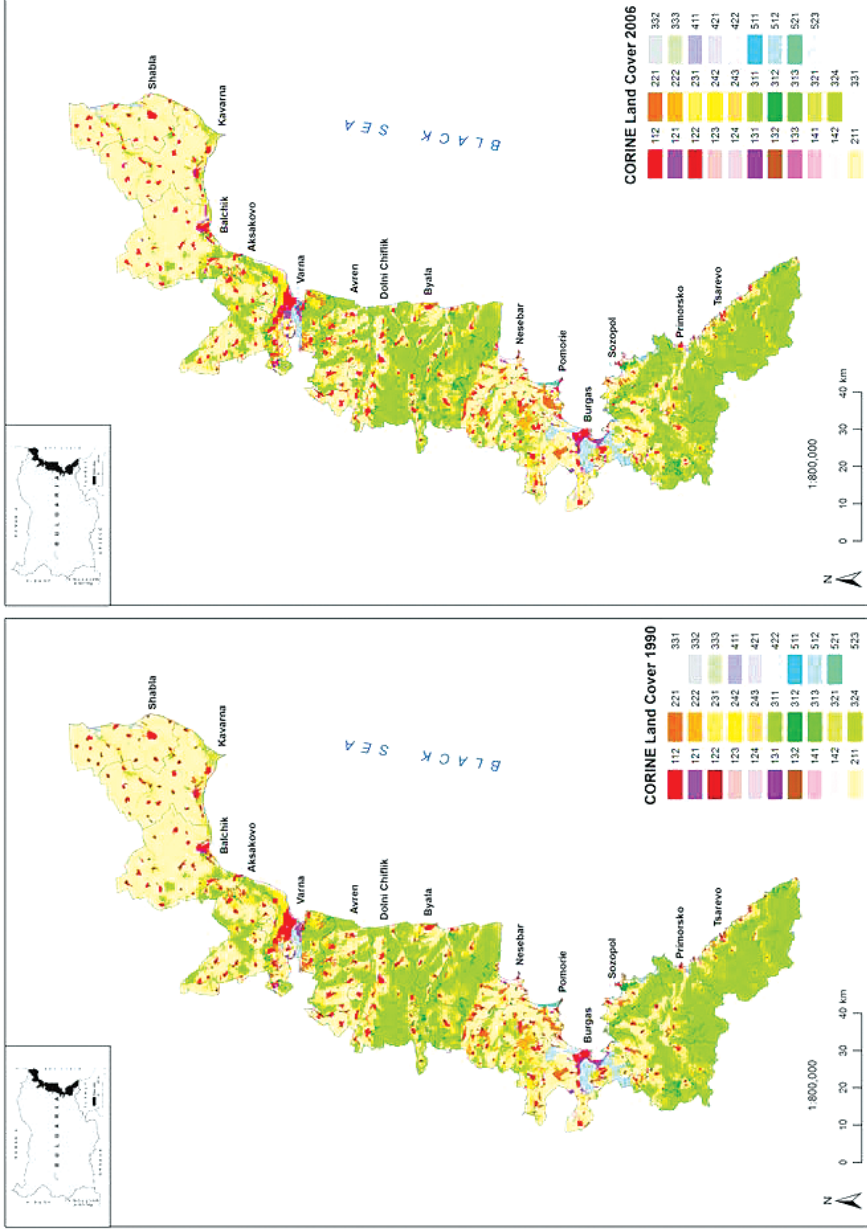


Fig. 3. Land cover and land use in the Bulgarian Black Sea coastal zone for 1990 and 2006 (*Legend: 1xx – artificial surfaces; 2xx – arable land; 3xx – forest and semi-natural areas; 4xx – wetlands; 5xx – water bodies*)

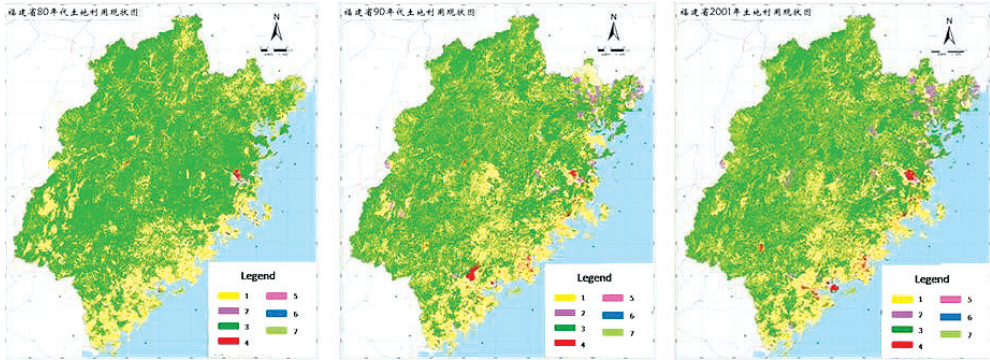


Fig.4. Land use in Fujian, China for 1980-2001 (*Legend: 1 – farmland; 2 – orchard; 3 – woodland; 4 – construction; 5 – transport; 6 – water; 7 – grassland*)

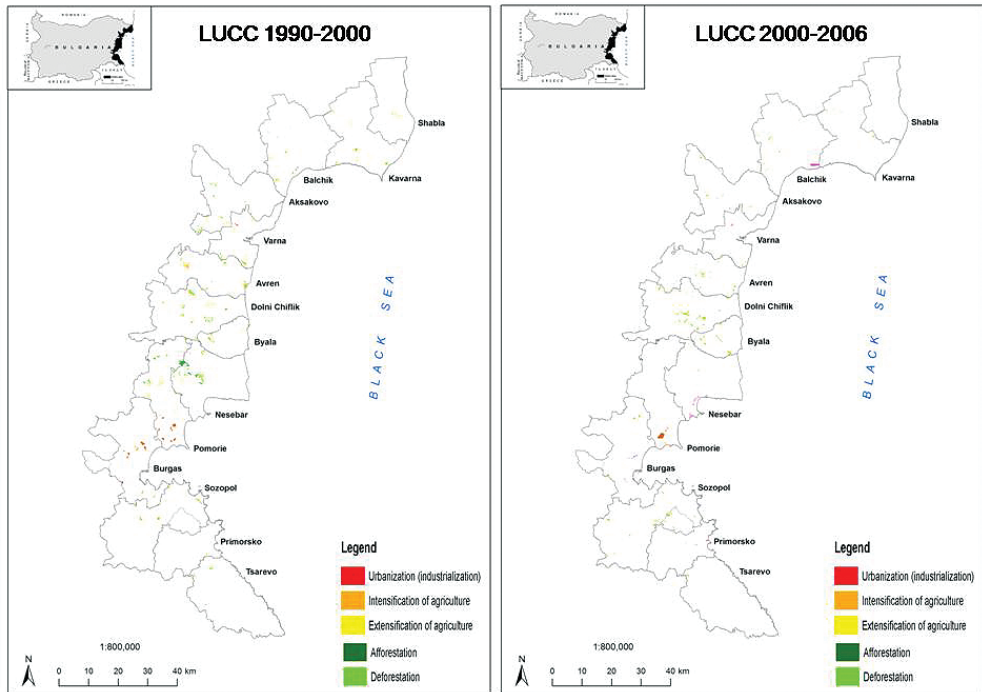


Fig. 5. Land use/cover change (LUCC) in the Bulgarian Black Sea coastal zone for 1990–2000 and 2000–2006

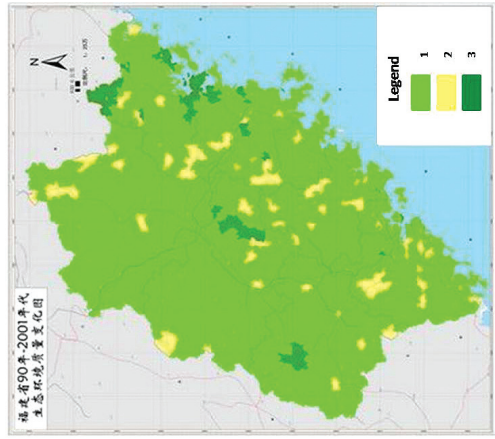
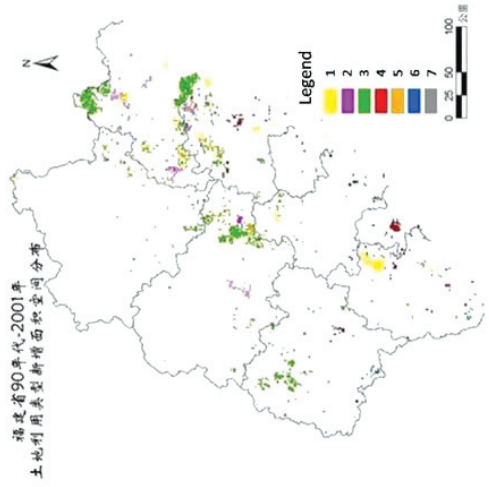
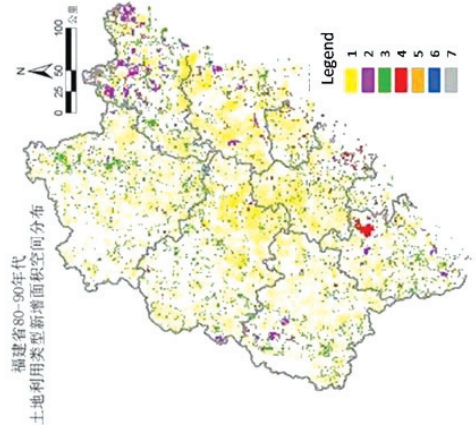


Fig. 6. Land use change in Fujian, China for 1980–1990 and 1990–2001 (*Legend*: 1 – increasing farmland; 2 – increasing orchard; 3 – increasing woodland; 4 – increasing construction land; 5 – increasing transport land; 6 – increasing water area; 7 – increasing grassland)

Fig. 7. Change of eco-environment quality in Fujian, China for 1990–2001 (*Legend*: 1 – no change; 2 – change for the worse; 3 – change for the better)

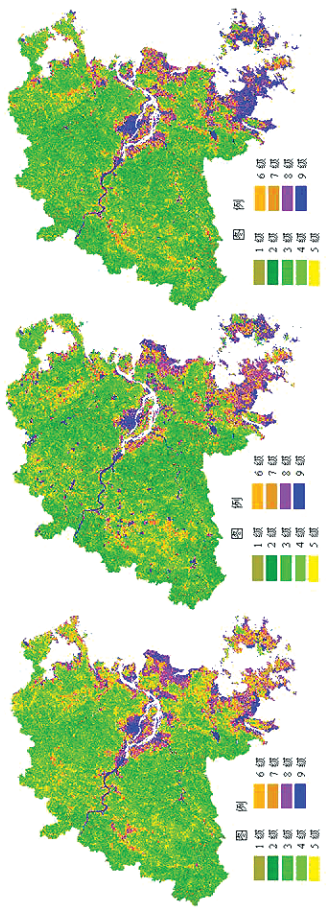


Fig. 8. Grading the quality of eco-environment in Fuzhou, China for 1989, 2000 and 2001 (*Legend*: 1–9 grades in Table 6)