Bulgarian Journal of Agricultural Science, 21 (No 4) 2015, 761-766
Agricultural Academy

COMBINED REMOTE SENSING AND GIS TECHNOLOGIES FOR LAND RESOURCES MANAGEMENT IN BULGARIA

N. KOLEV* and L. KOZELOV
Agricultural Academy, BG - 1373 Sofia, Bulgaria

Abstract

KOLEV, N. and L. KOZELOV. Combined remote sensing and GIS technologies for land resources management in Bulgaria. *Bulg. J. Agric. Sci.*, 21: 761–766

Joint remote sensing, synchronous ground based studies, combined with GIS technologies for estimation of the state of urban and agricultural lands provide a valuable source of information for management of urban green territories and agricultural activities on the field. They constitute a part of the data base used for operation of a number of models for evaluation and forecast of the state of urban territories and land (soil and vegetation) resources.

Based on satellite images studies, simple relations between the water and temperature regimes of soil and vegetation covers and their optic or thermal characteristics are sought. These studies have to be combined with GIS technologies for evaluation of spatial distribution of urban green territories and agricultural land management.

Key words: land resources, remote sensing, management, GIS technologies

Introduction

Joint remote sensing and synchronous ground based studies, combined with GIS technologies for estimation of the state of urban and agricultural lands, provide a valuable source of information for management of urban green territories and agricultural activities on the field. They constitute a part of the data base used for operation of a number of models for evaluation and forecast of the state of urban territories (Borisov, 2014, 2015a,b) and soil and vegetation resources (Stoichev et al., 2000; Rousseva, 2002; Dinev et al., 2003). Based on satellite images studies, simple relations between the water and temperature regimes of soil and vegetation covers and their optic (Carlson et al., 1990; Kancheva et al., 1992) or thermal characteristics (Kolev et al., 2006) are sought. Much more complicated is remote sensing evaluation of the state of agricultural areas when they are occupied by various crops at different stages of development and urban areas with mixed class objects, and observation in area frames (Van Diepen et al., 1998; Borisov, 2014, 2015a,b) is needed. These studies have to be combined with GIS technologies for evaluation of spatial distribution of urban green territories and agricultural land areas.

The objective of this work is to determine the status of the urban green and agricultural lands for land survey and the collection of information about the nature, land productivity and management, helping us for development of an understanding of the main processes in agriculture and rural society (Kabakchiev et al., 1985). Collected data and information for agroecology management is now proving so important in helping to find answers to current agricultural, environmental and social problems for management of territories (Stoichev et al., 2000; Rousseva, 2002; Rousseva et al., 2003; Borisov, 2014, 2015a,b).

Materials and Methods

The countries involved in the European Communities (EC) are using remote sensing to help fulfill the requirements and mandate of the EC Agricultural Policy, which is common to all members. The requirements are to register the lands and to dentify and measure the main properties of important crops throughout Europe, and to provide forecast of production before end of vegetation period. Standardized procedures for collecting these data are based on remote sensing technology, developed and defined

E-mail: *nvkolev@mail.bg

through the MARS project (Monitoring Agriculture by Remote Sensing).

The users can obtained many types of remotely sensed data, from low-resolution to high-resolution radar, spectro- and radiometry images and data, and numerous sources of ancillary data. These data are used to classify crop type over a regional scale to conduct regional inventories, assess vegetation condition, estimate potential yield, and finally to predict similar statistics for other areas and compare results. Multisource data from images of spectrometers, IR thermometers, and radars are introduced for increasing classification accuracies. Remote sensing data have to be verified with land surface observations in the test areas from a national network of test poligons (Milenov et al., 2014), distributed in main agroecological regions of Bulgaria, and based on the climate and soil types.

Five land zones are outlined on the territory of Bulgaria. The Northern Bulgaria forest-steppe zone covers the Danube Hilly Plain, the Northern Balkan areas and mountainous highlands up to the altitude of 650-750m, and is characterized with Temperate Continental climate type. The Southern Bulgarian Xerothermic zone covers the territory of Southern Bulgaria up to the altitude of 750-800 m, and is characterized both with Semi-continental climate type and transitional Continental-Mediterranean climate type. The mountain climate zone covers the altitude over 800 m (Kabakchiev et al., 1985).

Land degradation processes, mostly soil erosion and acidification, really cover more than ¾ of the country territory and vary on intensively cultivated lands and on lands being in a natural state (Rousseva, 2002).

The organisation of the use of remote sensing and GIS technologies requires the landed property satellite or ortho-photo images with the purpose of development and implementation of Detailed Development Plans (DDPs) in urban territories. The change of images of lands and the society unprepared to conduct urban development predictions fairly and in the Community wide interest, including building up. The choice is an application of regulator regimme for citizen when the Community is the owner of technical and social infrastructure (Borisov, 2014).

The methodology based on satellite images of land and canopy surface combined by agronomy observations on the fields includes the creation of test areas, based on the agroecological conditions of the country (Borisov, 2015a,b; Dilkova et al., 1998; Van Diepen et al., 1998).

Phenologiccal observations of the state of agricultural crops are also carried out, including evaluation of the general status of crops and their phenophases, evaluation of leaf area index, coefficients of projective leaf cover, turgor state, colour range, determining the quality of mineral feeding etc.

The agronomy observations include preparation of vegetation calendars of the main economy important crops and based on these calendars - monitoring of status of crops in the main their phenological phases in the pilot fields of the test areas and as a result – management of cultivation of crops, irrigation of lands and harvesting.

The national network of test areas (Kolev et al., 2006; Milenov et al., 2014), is organised and based on the agro ecological conditions of the country and laboratories of agricultural research institute and universities with the possibility for rapid soil and agrochemical analyses. There are pilot fields in these test areas in which land surface agronomy observations and agrophysical measurements can be carried out.

The choice of these pilot fields is based on the block structure of the agricultural lands with good agricultural practice and with sizes 50 - 100 - 200 ha, occupied by one type of crop.

The European Earth Observation Programme COPERNICUS provides useful data including urban and agricultural range of issues. The processing and dissemination of the information, which corresponds to user needs, is carried out within the "COPERNICUS service component". Land component is observed through COPERNICUS, including soil and crop monitoring on the agricultural lands and forecasting of crop yields, helping to make our lives better and safer.

The COPERNICUS service component depends on Earth observation data, collected from space (satellites), air (airborne instruments, balloons to record stratosphere data, etc.), water (floats, shipboard instruments, etc.) or land (measuring stations, seismographs, etc.). These facilities are called the COPERNICUS infrastructure component; non-space based installations in the COPERNICUS infrastructure component are generally referred to as "in situ component".

Remote sensing for agricultural purposes has intensive development in Bulgaria during the last twenty years. The researches in this area are supported by the governmental authorities of the country and by the Bulgarian Information Office of Programme COPERNICUS. Scientists and specialists from the institutes of the Bulgarian Academy of Sciences and the Agricultural Academy of Bulgaria participate in these investigations and have accumulated rich experience in this collaborative work in the last years.

The data of remote sensing can be used in the agricultural management only when they are combined with data from synchronous or quasi synchronous land surface "soil-plant-athmosphere" system agronomy observations, and agrophysical and microclimatic measurements and with GIS technologies.

The management of productivity of land resources requires quantitative evaluation of the state of main energy budget elements of the “soil-plant-athmosphere” system on the field for the successful evaluation of soil fertility, soil pollution protection and crop productivity. Many of the processes are essential to soil and to nutrient substances movement and plant growth, such as exchange of heat, moisture and movement of contaminants depend significantly on the soil properties and canopy folliage.

There are studies for estimation of water content values of soil and crop canopy based on radiothermal and temperature maps of the agricultural areas by airplane radiometry and thermometry. The results obtained show as well that schedulled radiometry of the areas during the whole agricultural period should be provided for crop growing management. Only then can be manifested the qualitative variations in radiothermal maps effected by the water content of soil and vegetation cover during the different stages of crop development.

Results and Discussion

Soil and terrain database, land degradation status and soil vulnerability assessment are the results of the work in the last decade of years, based on a common European methodology and GIS technology.

There is an example of chosen test areas in pilot region “Plovdiv”, including territories with intensive agriculture and mountain territories, shown in Figure 1.

The test poligon ‘PLOVDIV’, shown in Figure 1, covers a territory of about 50 000 -75 000 ha and includes plain fields with intensive agriculture and fields of mauntain territories. There are three districts (Chirpan, Bratya Daskalovi and Belozem) in which are organized field works validation of satellite images and datasets, including new Sentinel family datasets.

Pilot area Chirpan district: The soil cover of the plain fields is mainly chernozem smolnitza with 0.60 – 0.80 m humus horizon and with high soil fertility. Geographycal parameters include locality East-Nord of Plovdiv, Chirpan dis-

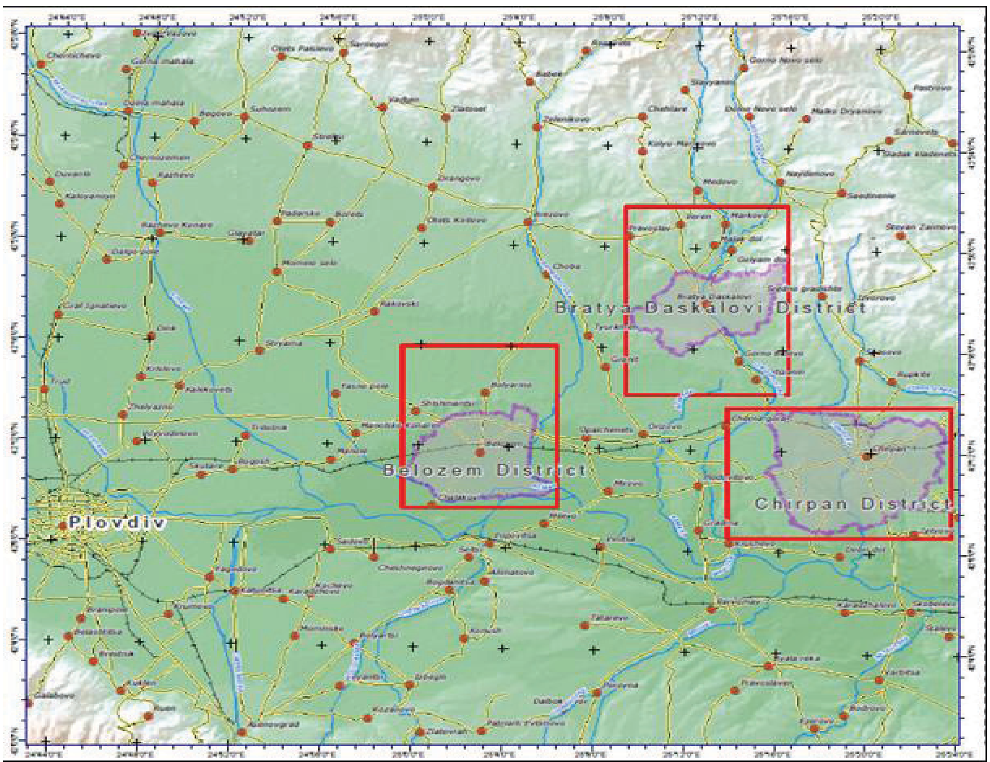

Fig. 1. Pilot areas in test region “Plovdiv” of the National network of test regions in Bulgaria for land surface observations of soil and plant resources (Milenov et al., 2014)

trict with relief – flat, category of soil "Leached Smolnitza", altitude 165 - 245 m, average annual temperature – 12.9°C, annual total presipitation - 576 mm, mean land evaluating rating - 69 and natural vegetation – grasslands.

Pilot area Belozem district: The soil cover of the plain fields is mainly "Solonetz-Solonchak". Geographycal parameters include territories East of Plovdiv, with relief – flat, altitude - 120 - 160 m, average annual temperature – 12.0°C, annual total presipitation: 561 mm, mean land evaluatind rating - 09 and natural vegetation: grassy (medows). The area of lands, affected by salinization processes are distributed in this district.

Pilot area Bratya Daskalovi district: The soil cover of the plain fields is mainly "Chernozem Smolnitza" with 0.80 m humus horizon and with high soil fertility. The territory includes also moumtain areas with fores soils. Geographycal parameters include locality North-East of Plovdiv", with altitude - 200 - 800 m, average annual temperature – 12.0°C, annual total presipitation: 565 mm, mean land evaluating rating - 68 and natural vegetation: forest – Ouk vegetation and grasslands. The soil cover of the mountain territories includes mainly medow soils and typical Cinnamonic forest soils with low soil fertility.

Figure 2 shows an example of comparison between the real status of the park "Bedechka" in Stara Zagora (an ortho-photo image) and the prediction of Detailed Development Plans without the use of the advantages of the regulation.

These processes of land management by remote sensing have to deal with two major aspects of the land: physical resources (soil, topography, climate etc.) and socio-economic resources (soil characteristics and land qualities, farm size and size of blocks, management level, technologies and their mechanisation, availability of manpower, other human activities). There are used many types of remotely sensed data, from low resolution to high-resolution satellite images and data (radar, radiometry and thermometry data) and numerous sources of ancillary data.

It is necessary to combine sensor and measurement devices and systems nework with communication to the GIS

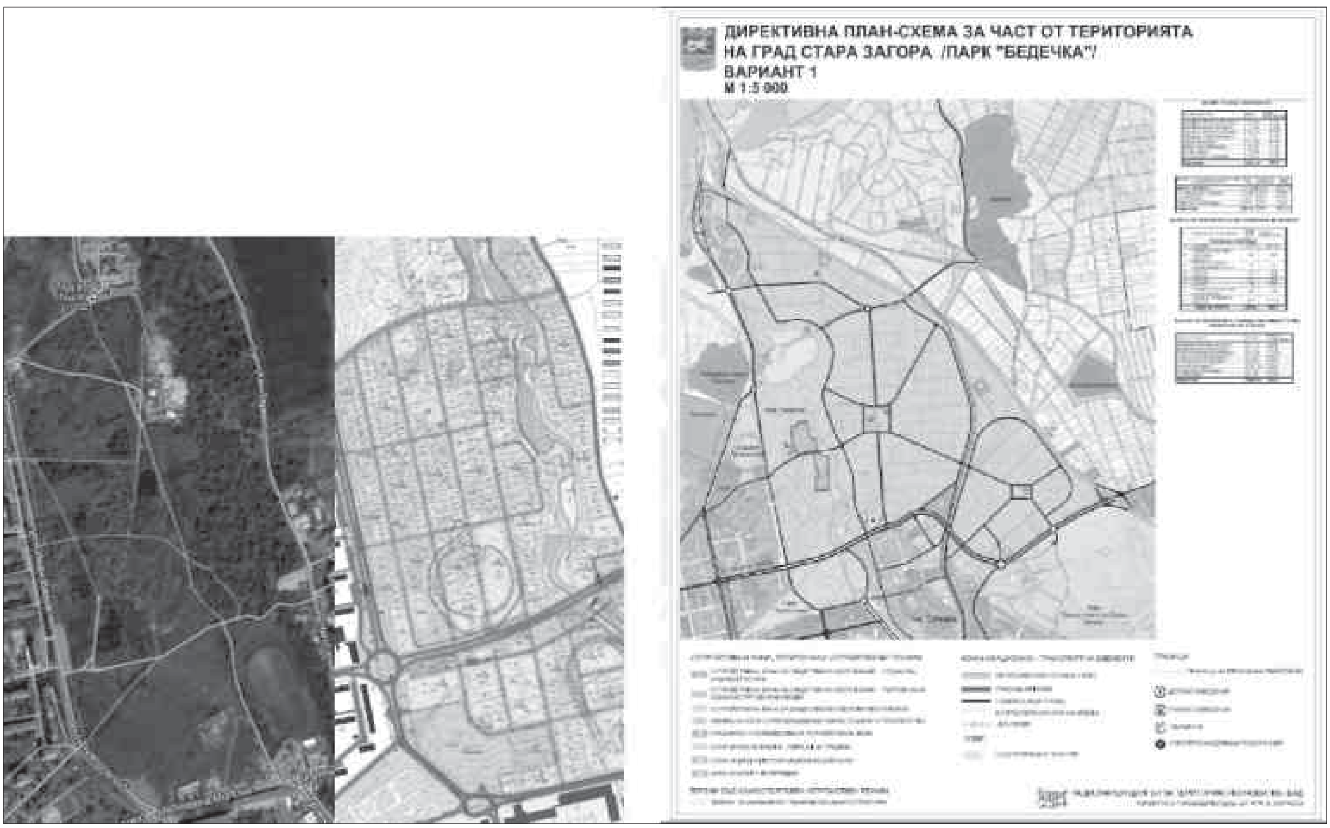

Fig. 2. A comparison between the actual status of the rark "Bedechka" ortho-photo) and the prediction of DDP, without the use of a regulation (Borisov, 2014)

maps, for the application of fertilizers and other agricultural activities based on soil analyses and agrometeorological data collection and visualization. There has to be included decision support software for soil nutrient balancing and plant protection based cultivation models.

Airplane remote sensing radiometry and infrared thermometry have been organised by us, over the Belozem and Chirpan districts for discovering simple relations between the properties of soil and vegetation cover and their optic or thermal characteristics. There are obtained soilmoisture and thermal maps of a cotton field near Chirpan district, as examples of the images of remote sensing technology, shown in Figure 3.

The soil moisture map shows that there are places in the field with high soil moisture and in these places the temperature of cotton canopy is low, shown in the thermal map.

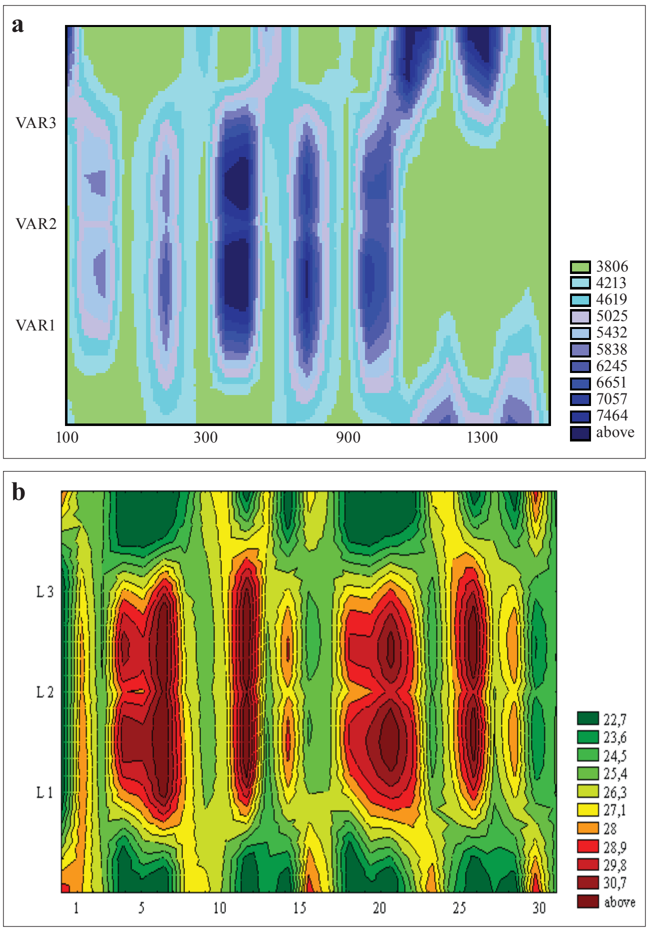

Fig. 3. Soil moisture (a) and thermal (b) maps of a cotton field near Chirpan, obtained by an airplane laboratory flight on 07 July 2004 at 12:00

These data are used to estimate the land quality, to classify crop type and its status at the same time over a regional scale and to conduct regional inventories, assess vegetation condition, estimate potential yield, and finally to predict similar statistics for other areas and compare results. Multisource data were introduced for increasing classification accuracies and for providing information about vegetation structure, which proves valuable when attempting to differentiate between crop types.

As part of the Integrated Administration and Control System (IACS), remote sensing data supports the development and management of databases, which include cadastral information, declared land use, and land parcel sizes measurement. This information is taken into account when applications for land parcel subsidies are cosidered.

The benefit of the application of remote sensing and GIS technologies will be: easy and well organised land management for all purposes; documentation for export and import; up to date inventory and map system and fast reaction to market opportunities and strategic development results for all kinds of GIS related management needs.

Conclusions

Analysis of the driving forces of land resources management in Bulgaria shows that the system is fundamental for developing the national policy and strategy for sustainable land use and land degradation protection.

Having the data and information collected by observations and measurements, agronomists can monitor the dynamics of the processes in the field and their influence on crop growth, plant diseases, insect activity, crop water stress, etc.

The obtained soil and crop water content and temperature maps of the agricultural areas reveal a qualitative difference between dry and wet conditions of crop growing and could be used for management practice of crop-growth in agriculture.

References

Borisov, B., 2014. The urban planning as a specific methodological instrument of the public planning. Bulgarian Academy of Sciences, *Engineering Sciences*, **LI** (4): 33-46.

Borisov, B., 2015a. Urban Planning Blagoevgrad, *Avangard Prima*, Sofia, 148 pp.

Borisov, B., 2015b. Urban Planning Stara Zagora, *Avangard Prima*, Sofia, 164 pp.

Carlson, T., E. Perry and T. Schmugge, 1990. Remote Estimation of Soil Moisture Availability and Fractional Vegetation Cover for Agricultural Fields. *Agricultural and Forest Meteorology*, **52** (1-2): 45-69.

Dilkova, R., G. Kerchev and M. Kercheva, 1998. Evaluating and grouping of soils according to their susceptibility to anthropogenic degradation. Proceedings of the Conference of the ISCO Advances in Geoecology, 31, pp. 125-133.

Dinev, N., N. Kolev, S. Rousseva and V. Kutev, 2003. Analisys of Soil Resources in Bulgaria for Soil Monitoring. *Rep. of the MEW*, Sofia, pp. 156.

Kabakchiev, I., B. Georgiev and P. Bojinova, 1985. Map of the Land Evaluation for Crop Production. N. Poushkarov, *ISSA*, Sofia.

Kancheva, R., A. Krumov and V. Boycheva, 1992. Crop agro-ecological diagnostics by remote sensing technique. In: Proc. of the Central Symposium of the Interational Space Year Conference, Munich, Germany, 30 March – 4 April 1992 (ESA SP-341, July 1992).

Kolev, N., G. Stoimenov, Y. Kirkova, K. Penev and M. Nenov, 2006. Methodology and results of spatial evaluation of heat and water balance of the system "soil-plant-surface air layer". In: Proceedings of III-International Conference Information Technologies, Systems and Equipment in Agrobusiness Industry, pp. 234-241.

Milenov, P., N. Kolev and Zl. Dimitrov, 2014. Remote Sensing and GIS Technologies for Precise Agriculture in Bulgaria. Scientific Conference with International Participation - Bulgarian Agriculture – Horizon 2020, Stara Zagora, pp. 1-12.

Rousseva, S., 2002. Information Bases for Developing a Geographic Database for Soil Erosion Risk Assessments. Monograph, *N. Poushkarov Institute of Soil Science*:, Sofia, pp. 198.

Rousseva, S., M. Banov and N. Kolev, 2003. Some aspects of the present status of land degradation in Bulgaria. In: R. Johnes and L. Montanarella (Eds.) The JRC Enlargement Action, Workshop 10-B, Land Degradation, EC-JRC, pp. 149-164.

Stoichev, D., R. Dilkova and M. Kercheva, 2000. Soil degradation in Bulgaria. In: R. Lahmar, M. Dosso, A. Ruellan and L. Montanarella (Eds.) Soils in Central and Eastern European Countries in the New Independent States (Present Situation and Future Perspectives), JRC, EC, pp. 46-53.

Van Diepen, C. A., T. Van der Wal and H. Boogard, 1998. Deterministic Crop Growth Modelling. Fundamentals and Applications for Regional Crop State Monitoring and Yield Forecasting. Proceedings of MERA Project 1994 – 1996 Results Conference, Space Application Ist – Ispra, pp. 201-227.