Domain Land Use/Cover Data Model Enabling Multiple Use for Turkey

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SUMMARY

Land use/ land cover (LULC) information, one aspect of GI, has huge important in natural resource management, environmental management, risk management, and the applications like this. By this way, land cover data presenting the physical coverage of the earth surface and land use data presenting its socio-economic purpose should be produced and used with common approaches. In Turkey, LULC data has been used in different standards and there is no a common definition and classification system accepted in public institutions. In this study, the public institutions working with LULC data were determined and data needs for their environmental projects and GIS applications were analyzed. Depending on this Field Work, LULC classification system was defined from local to national level hierarchically, based on CORINE (Coordination of information on the environment) classification system. That was done as to scale groups and data usage levels including 5 levels. Feature catalogues and application schemas were prepared to use LULC data effectively. To test this model, LULC feature class with high resolution (Level 5) was produced by using QuickBird satellite image and cases of Trabzon Municipality. To use this data on various domains, that was generalized to other use levels with low resolution (Level 4 to 1) by generalization techniques. As a case study, LULC data were used on various thematic applications at different levels, such as planning, urban atlas, and like this. By this way, Turkey LULC data model was designed and tested to promote the multiple use of LULC data to support environment, public health, and the sustainable development of urban areas, and like this.

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1. INTRODUCTION

Determining land cover/use types with their spatial and temporal distribution is necessary for a wide range of studies. Knowledge of the present distribution and area of such agricultural, recreational, and urban lands, as well as information on their changing proportions, is needed by legislators, planners, and state and local governmental officials to determine better land use policy, to project transportation and utility demand, to identify future development pressure points and areas, and to implement effective plans for regional development. In many cases, the terms land cover and land use are regarded as mutual, exchangeable expressions, although there are differences between them. Land cover refers to the physical material covering the surface of the Earth including vegetation, water, soil, and physical features those created by human activities such as buildings, asphalt, etc. On the other hand, land-use refers to the way how land is used by humans and their habitat [Ramachandra and Kumar 2004]. By this way, land use is characterized by the arrangement and activities people undertake in a certain land cover type to produce or change it [Gregoria and Jansen, 2000, Anderson, etc., 1976]. This can establish a direct link between land use and land cover and can be described with LULC acronym.

Most land cover classification systems are also hierarchically structured because such a classification offers more consistency owing to its ability to accommodate different levels of information. These systems generally start with high classes and divide them into more detailed sub-classes to help us use land cover data efficiently [Car 1997; Glasgow 1995]. However, there is no a standard classification system that has been accepted internationally [Duhamel, 1995]. Many systems have been developed for a certain purpose, at a certain scale, and using a certain data type. As a result, countries define their own national land-cover classification systems. However, land-cover data coming from different countries should also be used in coordination. As an example, Coordination of information on the environment (CORINE) project was executed in 13 European countries in 1991 by European Commission (EC). The purpose of the CORINE programme was to combine and coordinate all the attempts which have been made over the years at international, community, national and regional levels to obtain more information on the environment and to monitor how it changes. Following the pilot project in Portugal, the methodology and the CORINE land-cover nomenclature, which consists of three levels, was defined. The first level, which includes five items, indicates the major categories of land cover on Earth. The second level, consisting of 15 items, is for use on scales of 1:500 000 and 1: 1 000000 and the third level, having 44 items, is to use in the projects on a scale of 1: 100 000 [EEA, 1997, 2008].. Similar to CORINE project, HarmonISA project [Hall 2006] was also initiated in 2003 for the automatic integration of LULC data in the three regions of Friuli Venezia-Giulia (Italy), Slovenia and Carinthia (Austria).

In this study, The use of LULC data was examined in public institutions of Turkey. According to the field work, the needs and expectations of public institutions were determined to produce and use LULC data. LULC data was modeled and classified hierarchically as sub-classes of CORINE database. The model enables hierarchical classification of LULC based on scale of the map and data usage levels. This model aims at meeting user needs on all application levels of Turkey. To use spatial data on various domains, that was generalized to low resolution feature classes (Level 4 to 1) by generalization techniques as case study.

2. LAND USE/COVER DATA NEEDS OF PUBLIC INSTITUTIONS IN TURKEY

Turkey has already achieved some success in standardization of land cover data at some degree. However, there are still different approaches while describing land cover types. When GIS projects implemented by Ministry of Forestry and Ministry of Agriculture are inspected, it can be seen easily that there is no standard in the description and definition of land covers; therefore, there is also no common hierarchic system used to determine classes and subclasses. As a result, projects executed by them have not reached to desired level as needed. Additionally, since these institutions have worked independently and without coordination, there are also many overlaps in the projects, which results in duplication of efforts to do the same thing. It also has been found that data collected for a specific purpose were of little or no value for a similar purpose. [LRCD, 2004]. According to Reconstruction and Development Act (No. 3194), land use in urban areas must be planned and implemented by considering given standard legends on the act [Offic.Gaz., 1985]. Ministry of Agriculture classifies agricultural land into four categories as arable land, land for specific products, orchard and groves, and marginal agricultural land (not suitable for agriculture) according to Soil Protection and Land Use Act (No. 5403). [Offic.Gaz., 2005].. Additionally, there is also no standard while describing land use information of land parcels. Directorates of Land Registry and Cadastre records the land use type of each land parcel during cadastre; however, this effort is far beyond setting standardization since defining the land use type of each land parcel is left to the initiative of the employees.

According to ministrial reports [LRCD, 2006] and the Field Work executed to the public institutions of Turkey that produce and use spatial data, the public institutions using LULC data were determined and grouped hierarchically. Provincial System is the main administrative unit of Turkey. Main approach is that if a spatial database is modeled for a particular province, it should also be applicable from local to national level for all other provinces. 12 of Public Institutions, highlighted as yellow rectangles in Figure 1, have been analyzed to examine Land Cover/Use data needs in their environmental projects and GIS applications. Their administration levels, main functions as producer (P) or user (U), and responsibilities are listed in Table 1. Trabzon, one of the 81 provinces of Turkey, was chosen as a pilot province, so that proposed classification system will be a model for all other provinces. Land Cover/Use data needs were determined with Data /Function Matrix that was produced as a result of Fieldwork executed to public institutions of Trabzon on Table 1. User requirements are described in use case analysis. As a result of these analyses, land use classes for urban area, arable land, forest, wetlands, water bodies are determined and listed based on the map legends of various institutions. As a result, 163 land use classes were determined and categorized in local level.

Table 1. Public Institutions' Use Level, Function, and Work Discipline about Land Cover/Use Data

Public Institutions/ Organizations	Use Level	LCUD	Work Discipline
Provincial Public Administration	3	P/U	Responsible from construction of infrastructure and control of illegal urbanization in areas out of reconstruction and development plans made by municipalities. Produces LULC data for environmental management plans and site selection analysis of public facilities.
(Municipalities/County/Belde	3/4	P/U	Responsible from all urbanization activities including construction and maintain of infrastructure, making and implementing urban plans, and generating land use data, etc.
Regional Directorate of Provincial Bank	2	P	Provides financial support for the engineering projects conducted by local authorities. Supports mapping projects which also produce LULC data
Provincial Dir. of Public works and settlement	3	U	Uses LULC data to produce costal area management and disaster management plans.
Dir. Of Cadastre	3/4	P	Determines land use attribute of land parcels when determining their area and ownership.
Regional Dir. of State ports and airports Const	2	U	Uses LULC data while making infrastructure and construction plans of airways and waterways and terminals such as airports and seaports.
Regional Dir. Of Transportation	2	U	Uses LULC data while making infrastructure and construction plans of roads.
Regional Dir. Of Forestry and Management	2/3	P	Produces cadastre maps and lands use data and maps for forest. Produces forest management plans. Determines forest, park, recreational and conservation areas.
Regional Dir. Of State Hydraulic Works	2	P	Responsible from protection and control of flood and soil erosion.
Regional Dir. of Mineral Research and Exploration	2	U	Uses LULC data while producing mining district maps and determining mineral locations
Provincial Dir. of Agriculture	3	P/U	Produces soil and land cover maps to determine the best locations for agriculture. Generates land use data of arable lands.
P: Provider, U: User			

3. UVDM:AR- Turkey National Spatial Data Exchange Model for Land Surface

The name of LULC data model, produced in this study, is "Turkey National Spatial Data Exchange Model for Land Surface" with UVDM:AR acronym. The model enables hierarchical classification of land cover/use classes based on scale of the map and data usage levels. This classification system is based on CORINE Land Cover (CLC) classification, which is utilized in European countries. The CLC nomenclature is a physical and physiognomic land cover nomenclature comprising three levels. The nomenclature is strongly related to the process of image interpretation, scale, and the smallest spatial unit. The spatial unit corresponds both to an area of homogeneous land cover and to an aggregation of small

homogeneous areas that represent a land cover class such as water, forest, etc. The spatial unit represents a significant surface in relation to the work scale and can be distinguishable from other surrounding units. All spatial units are polygons. This structure guarantees the topology coherence because the overlapping of two polygons is impossible. As a spatial unit, the smallest area that can be represented as a land cover class in the map is 25 hectare. [EEA, 2000, 2008].

UVDM:AR includes LULC nomenclature comprising 5 levels as seen on Figure 2. The first, second, and third level classification of UVDM:AR are based on the CLC with coded attribute values hierarchically, as explained below;

- UVDM:AR Level-1 consists of 5 main classes described with integers between 1 and 5 to represent land covers at 1:500.000 or smaller scales. For example, "*Artificial surfaces*" is described by "1".
- UVDM:AR Level-2 contains 15 classes to be used at map scales between 1:100.000 and 1:500.000. These categories are described with two digit integers such that the digit to the left represents upper level (Level-1), whereas the digit to the right describes the land cover type at the second level. For example, "12" represent "*Industrial, Commercial, and Transport units*", which is a sub-class of artificial surfaces represented with "1" at level-1.
- UVDM:AR Level-3 consists of 44 classes to be used at applications using maps at a scale of 1:100.000 and larger. In this level, the categories are described with three digit numbers as the children of categories at level-2. For example, "*Industrial or commercial units*" is represented with "121", which means that this land cover is sub-class of the unit represented with "12". In fact, these classes are not only categories of different land covers, but also categories of different land use. Therefore, a deductive analysis is required to determine level-3 and sub-level classes.

UVDM:AR classes at level-4 and level-5 was defined and grouped hierarchically as the sub-categories of level-3 as explained below. Especially, 163 land use classes in level-5 were determined through negotiations with the representatives of various institutions using land-use data, as explained below;

- UVDM:AR Level-4 contains 103 categories to be used at applications using maps at a scale of 1:25.000 and larger. These categories are described with four digit integers such that the digit to the left represents upper level (Level-3), whereas the digit to the right describes the land use type at the second level. For example, "1211" represent "*Industry Areas*", which is a sub-class of the unit represented with "121" at level-3.
- UVDM:AR Level-5 consists of 163 categories to be used at applications using maps at a scale of 1:5.000 and larger. In this level, the categories are described with three digit numbers as the children of categories at level-2. For example, "*Organized Industry Areas*" is represented with "12111", which means that this land cover is sub-class of the unit represented with "1211" at level-4.

Table 2. Example UVDM:AR LULC Nomenclature

1. Level > 1:1.000.000	2. Level > 1:500.000	3. Level > 100.000	4. Level > 1:25.000	5. Level > 1:5.000
1 Artificial surfaces	11 Urban Fabric	111 Continuous urban fabric	1111 High Density Urban	11111 High Density Urban
			1112 Mid-Density Urban	11121 Mid-Density Urban
			…	… …
		112 Discontinuous urban fabric	… …	… …
		… …	… …	… …
	12 Industrial, commercial, and transport	121 Industrial or commercial units	1211 Industry Areas	12111 Organized Industry
				12112 Free Industry Zone
				12113 Industy Areas
				… …
		122 Road and rail networks	… …	… …
	… …	…	… …	… …
2 Agricultural areas	21 Arable land	211 Non irrigated arable land	2111 Cereal, Grain, etc.	21111 Cereal, Grain, etc.
			2112 Fallow Areas	21121 Fallow Areas
			2113 Edible plants	21131 Edible plants
			… …	… …
		…	…	…
	…	…	…	…
3 Forest and semi natural areas				
4 Wetlands				
5 Waterbodies				
5 classes	15 classes	44 classes	103 classes	163 classes

4. CASE STUDY

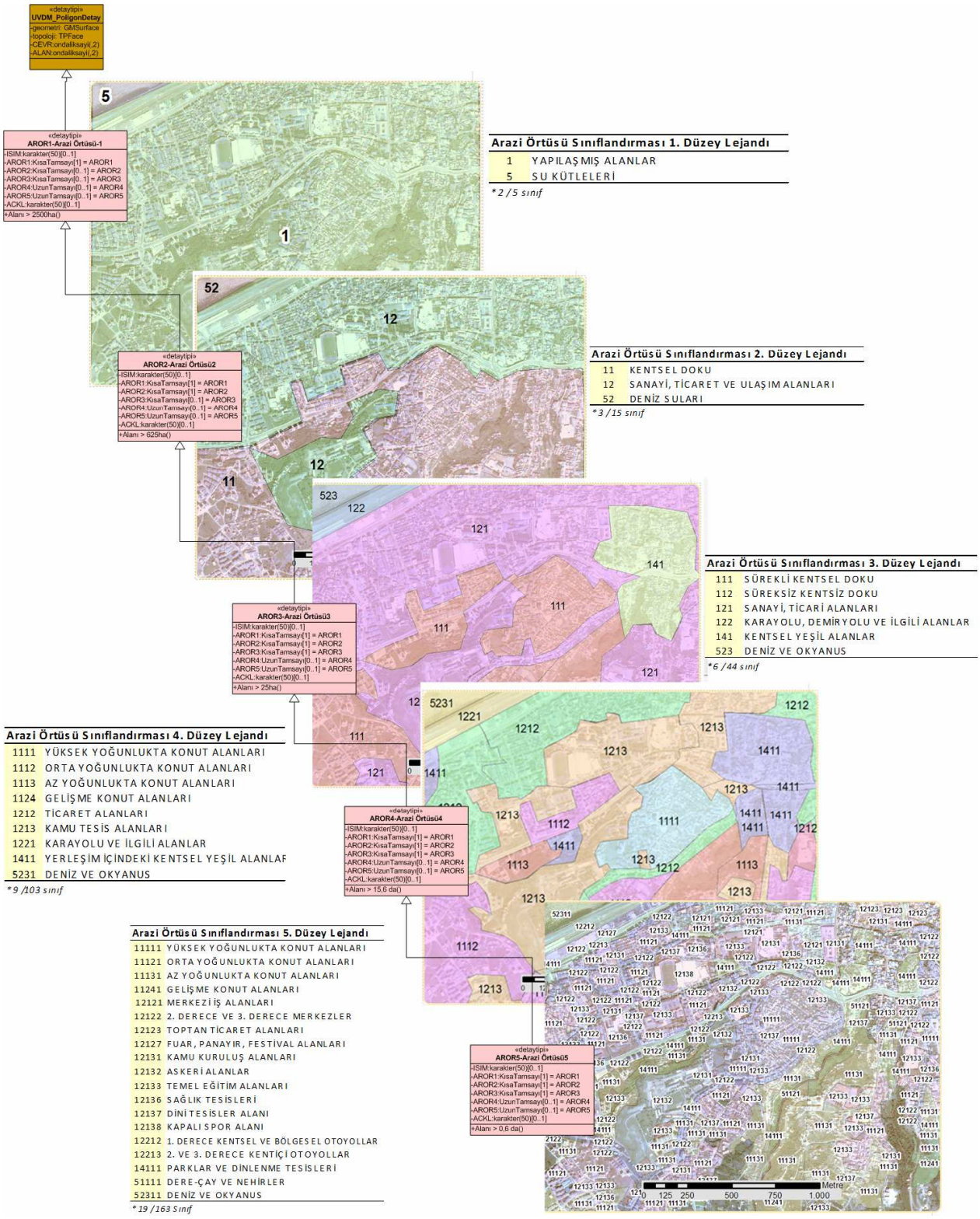
Hierarchical structure of UVDM:AR data classification enable LULC data to be produced at local level and to be used at different levels by generalization. Spatial rules such as attribute coding and the smallest area are used for LULC data generalization. For example, organized industrial zone at level-5 (>1:5000) is annotated with land class code 12111. The smallest area of this class in real world is 625m^2 in a map to the scale of 1:5000. Hence, if a class in level-5 is generalized using CORINE methodology, land cover class and its annotation at level-1 can be obtained as in the following example and Figure 1;

Land class organized industrial zone at level-5, annotated as 12111 at scale >1:5000, is generalized as industrial zone for level-4 and annotated as 1211 at the scale >1:25000 with a minimum area of 15.6 da

- Land class industrial zone at level-4, annotated as 1211 at scale >1:25000, is generalized as trade and industrial zone for level-3 and annotated as 121 at the scale >1:100000 with a minimum area of 25 ha
- Land class trade and industrial zone at level-3, annotated as 121 at scale >1:100000, is generalized as trade, transportation and industrial zone for level-2 and annotated as 12 at the scale >1:500000
- Land class trade, transportation and industrial zone at level-2, annotated as 12 at scale >1:500000, is generalized as urban area for level-1 and annotated as 1 at the scale >1:1000000

As seen on Figure 1, land use data was produced at level 5 with the using of QuickBird satellite image and land use plan of Trabzon city. Then, it was generalized to other level with ArcGIS Toolbox Generalization functions and manul editing techniques.

Figure 1. Generalization schema of LULC data among different levels



LULC data includes institutional, commercial, residential areas, and like these at local level. These can be used as base data for applications at different levels. As seen on Figure 2, industrial, institutional, and commercial features of LULC data was extracted and used on Trabzon Web Urban Atlas application as base layer. In addition to this, supervised classification technique on Landsat image was used to produce land cover map of East Blacksea region of Turkey. This land cover feature classes are based on Level-3 classification uf UVDM:AR. By this way, various applications and information products can be produced with the using of UVDM:AR model.

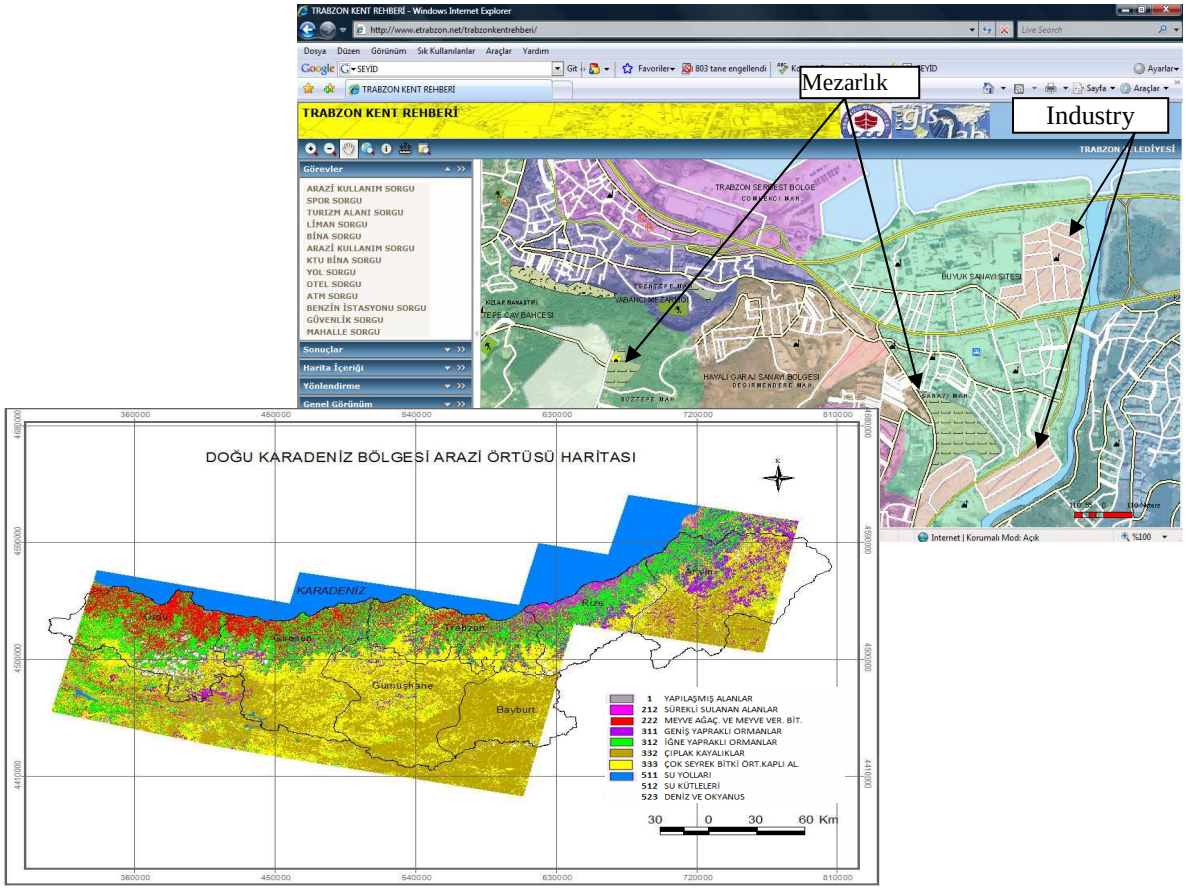


Figure 2. Trabzon Urban Atlas and Land Cover Map of East-BlackSea Region

5. . CONCLUSIONS

A common LULC classification or data model is needed to produce GIS, Remote Sensing, and mapping applications on various disciplines. In this study, LULC classes were defined. Catalogues and application schemas were produced to support harmonized use. The applicability of this model was tested with case studies. As a result of this, LULC data that can be managed from local to national level enables local governments, provincial public administration, general directorates, and ministries to use the data in especially environmental applications. This approach can be the main principle for LULC aspect of spatial data management towards National SDI.

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BIOGRAPHICAL NOTES

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