

FARMING AND OTHER LAND USES IN LISBON METROPOLIS, PORTUGAL

ISABEL MARIA MADALENO

Tropical Institute
Portugal

Abstract

Land is a valuable asset, particularly inside cities boundaries. Farming is, under this framework, a conflicting and frequently contested urban land use. However, city planners and democratic governance are increasingly aware they cannot ignore the persistence of food gardens, illegally tended vacant plots and peri-urban farms existent in extensive agglomerations and therefore standard research is underway with information collection. The application of remote sensing techniques to study land uses on cities and towns is one of the most complex, yet rewarding, ways to analyse urban and peri-urban spaces. Geo-information systems are frequently considered expensive, time-consuming and hard to learn technologies. Notwithstanding, the continuous evolution of satellite imagery is opening new perspectives in the monitorization process of geographical spaces, in all possible scales, while improved computer design and more efficient education on GIS are making accessible to an increasing number of people tools and methodologies till recently reserved to a few.

Using two Lisbon Metropolitan Region Summer Landsat images we have generated unsupervised and supervised classifications over land uses in two significant years, with quite simple IDRISI 32 software. The resulting digital images provided a clear, realistic and pedagogically helpful view of recent metropolis evolution, displaying mainly 3 categories of spaces: 1. Urban continuous and discontinuous tissues; 2. Natural spaces and forests; 3. Farmed extensive areas. Research results show an obvious urban sprawl from 1987 to the year 2000; yet digital images worked out also confirm that farmed plots persevere inside Lisbon and satellite cities and evolve in some peripheral areas, most of which are recognizable for their geometry along Tagus River. Governmental interventions are important explanations for the trend, even though market proximity, favourable transportation infrastructures and facilities, as well as public and private engagement in businesses like wine production certification and marketing, in addition to good soil and water availability are encouraging prerequisites for fresh vegetable, flower and animal production right at the country's core.

1 Introduction

Remote sensing is one of the most exact and precise ways to get a land use picture on a portion of space. In case of a metropolis, due to the heterogeneity of textures involved (built, non-built spaces, forests, shrubs, farmed spaces in various stages and seasons, etc.) a certain amount of subjective judgements together with extensive field work are necessary for digital image interpretation, even using a very sophisticated software, particularly if you limit the number of classes or clusters in order to concentrate on the urbanized areas versus peripheral green belt dichotomy, questionable as it might be. In fact, recent literature stresses that urban and rural

areas are no longer distinct and differentiated land structures due to increasing interpenetration movements, dense information flows and networks, which makes the categorization process even more difficult (Jaquinta and Drescher, 2000; Weber 1995; Donnay, Barnsley & Longley 2001).

In order to study land use evolution in Lisbon Metropolis, we have used two summer Landsat multispectral images, 30 metres spatial resolution and 13 years time differentiated, using the methods and techniques of digital interpretation made possible by means of low-cost hitherto technologically correct IDRISI 32 software. The main objective was to get a spatio-temporal analysis of farmed peri-urban spaces, which persistence we consider essential in an environmentally sustainable European capital. One should be aware that this research has not been undertaken by a mathematician or computer analyst, but by a geographer, trying out ideas and playing with the software's capabilities rather than theorizing on earth observation through remote sensing.

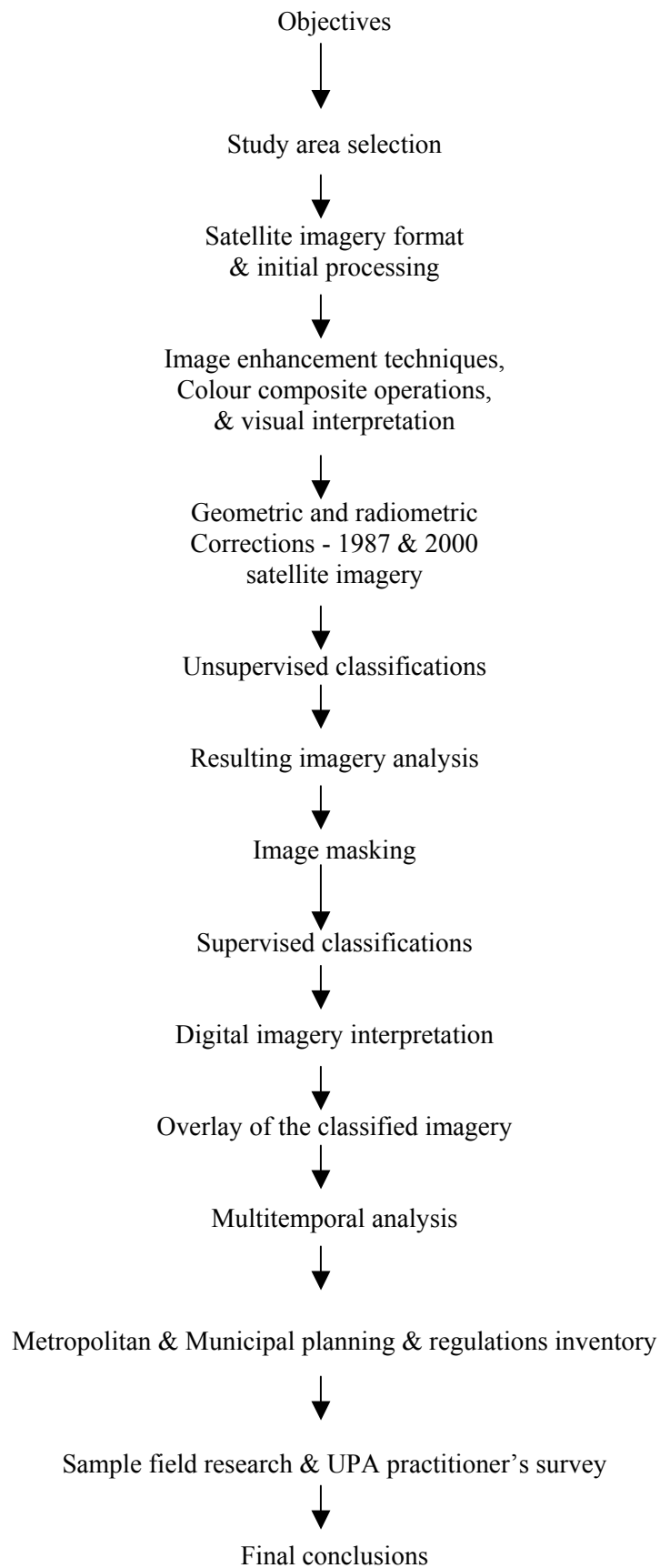
2 Lisbon Metropolis geography and recent history

Lisbon Metropolis is about 2 569 Km² large and can be divided into two main portions by deep Tagus Estuary, wider to the East, a bottleneck toward the Atlantic Ocean: 1. Northern margin municipalities, best known Great Lisbon, are densely populated; 2. Southern margin or Setubal Peninsula are underdeveloped and biodiversity thriving spaces. The highest metropolitan expansion rate was registered from the 1970's onwards, particularly after the Carnage Revolution (1974). Conurbation process was particularly intensive along three main road and railway axes, namely - Lisbon / Cascais (W); Lisbon / Sintra (NW); and Lisbon / Vila Franca de Xira / Santarem (NE) - once these transportation infrastructures produced a relative decrease in indirect and direct costs for in- and migrant families, because soil and construction are cheaper in successive and concentric fringes surrounding the capital-city.

By contrast, southern river areas had a lower and gradual growth following the first big bridge conclusion in 1966 (Salazar), suburban sprawl took longer to get to the opposite margin and was either discontinuous or linear shaped, settled along river liaisons to Lisbon, the mother-city located in the opposite margin, and lately following Lisbon – Setubal highway, the southernmost metropolitan city. Nevertheless, because of difficult accessibilities eastwards, most peninsula's spaces remained rural till the end of the 20th century. In 1998, after a new bridge construction (Vasco da Gama), and eastern Lisbon urban development for the Universal Exhibition called EXPO 98, left margin paradises were shaken. Fortunately, Southern metropolitan municipalities like Montijo and Alcochete, formerly agriculture dominated for they were isochronously 60 minutes away Lisbon central business district (C.B.D.), have elected green nature and farmed spaces mayors, reason why year 2000 satellite image gave a still colourful land use perspective.

Methods and techniques used for landscape evaluation were synthesised in fig. 1. Satellite imagery selection aimed recent metropolitan evolution and focused two recognisable decisive events for Lisbon revitalization and ultimately for Metropolis reorganization: the 1986 European Union membership and the aftermath of Expo 98. Accordingly we took the option for a 1987 multispectral Landsat image, digitally treated with a methodology that would permit us to overlay it with a 2000 Landsat image, on the same surface. The choice of Summer days was due to potentially better weather conditions, even though for vegetation and particularly farmed spaces location, we recognize it would have been better to work with Spring and Autumn satellite imagery.

Fig. 1 – METHODOLOGY & TECHNIQUES



Regarding mother-city demographic evolution, whereas most peripheral municipalities know dispersion, space fragmentation and rural areas urbanization or peri-urbanization, (typical centrifuges movements), Lisbon municipality knows increasing population loss (-14.7% 1991-2001), and continuous demographic ageing (*INE, 2002*). In spite of the urban reclassification and revitalization permitted by new Master Plans, devised accordingly to EU directives, the financial resources invested ever since, and greatly enhanced in the wealthier 1990's, green and farmed spaces stubbornly remained inside the capital-city, where the elders carefully tender inner and backyards. Simultaneously there has been a public investment in pedagogical gardens and farms, intended to get the youngsters acquainted with biological agriculture principles considered essential for an effective environmental education. Suburban municipalities such as Oeiras (W) and Loures (NE), have adopted similarly protectionist policies, destined to preserve micro-farms which are associated at times to old historical houses, their architecture being national or municipal heritage, turning the property (usually private) multifunctional, for it is as much farming as tourism oriented.

Unfortunately not all mayors are urban farming interested, as is the case of Cascais actually, an exception only confirming the rule. Along the southern Tagus margin peri-urbanization process is increasing in riverside areas these days, with small houses, apartment blocks construction, big peripheral malls and hypermarkets development, pending menaces over subsistence level gardeners, swelling conflict from land uses with better returns than farming. One has to accept metropolitan evolution always obeyed this pattern of change and that's exactly why municipal intervention, through environmental education, by means of peoples' awareness on higher living standards advantages under less dense urbanisation trends, as well as regulation and control over contending parts will be essential in the incoming years, providing elder residents always have their saying.

3 Urban land uses in Lisbon municipality

Interpretation of urban patterns, shapes, textures is quite difficult with a Landsat satellite composition for if one can easily identify the density of buildings, continuous urban tissue size and spread, the presence of green spaces, the geometrically unmistakable agricultural land uses, the location of ports and airports, bridges, even highways, avenues and larger linear roads, with a simple 3 spectral band composite image, its impossible to recognize demographic and socio-economic characteristics without resource to complementary data or field work (Donnay, Barnsley and Longley, 2001).

A digital image is an ordered set of numeric values, which are related to the radiance from a ground area represented by a pixel or cell. The radiance attributable to each pixel is the sum of the contributions of the different land cover components within the pixel, plus the radiance contribution emanating from adjacent areas (Mather, 2001). That's why either supervised or unsupervised classifications on Landsat 5 and 7 images can be worked at different scales, and some objects recognized with zoomed mapping, while others escape our observation and close scrutiny (take Fig. 2 as an example). Of course if one would like to map the trees existent in most inner and backyards in Lisbon municipality the choice would be a 1m x 1m pixel size resolution, possible with some aerial photography and panchromatic IKONOS images. However current work objective is not the sheer recognition of crops in small plots but the study of metropolitan-scale land uses in two distinctive and representative years in order to detect urban versus farmed spaces evolution on a wider or more global environment.

The attentive observation of Fig. 2, a 2000 Landsat bands 3+4+5 colour composite, gives us not only the international airport (Portela) exact location, but also Expo 98 newly rebuilt area, in the whereabouts of Vasco da Gama bridge (NE). In between the houses are mingled with green backyards and farmed plots. We can also identify the river, irrationally wider to the interior and narrower in the Atlantic direction (W), and the elder bridge connecting Alcantara valley in Lisbon municipality with Almada sited in the Southern margin. Extraordinarily evident is Monsanto Park, western Lisbon, a natural protected green space, about 1000 ha dimensioned,

which forestation dates back 1939, having been institutionalised as an ecological domain 40 years later.

To the North, the greenery is obvious, in Lumiar and Telheiras neighbourhoods, where pedagogical gardens are beautiful (Madaleno 2001). Whereas the first still has 2 000 to 5 000m² home gardens, some of them testimony of a somewhat brilliant greener past, for palaces, parks and churches are quite numerous, Telheiras (NW) has recently been urbanized with domineering high and middle-class buildings. Strangely, low-income croppers that sell their produce on the streets of Lisbon, live in an undesired but tolerated connivance with wealthier families, and illegally occupy most of remainder idle lands.

Fig. 2 – Colour Composite from a LANDSAT 2000 Image



Madaleno, I. M.

1:80,000

Ensuing methodological logic exposed before, common in digital imagery work, after geometric and radiometric corrections, we produced isoclustering classifications with the IDRISI 32 software using 6 of the 7 bands (1 to 5 and 7). Following histogram analysis the option were 8 clusters, and subsequent palette application to the resulting image. Fig. 3 shows the result for Lisbon Metropolis in 1987, while Fig. 4 portrays a shorter area in the year 2000. Even though it remains quite difficult to distinguish discontinuous urban tissue from idle land, as well as the continuous urban tissue from highly mineralised soil, for these are summer images, and most of the fields had already been cropped, greenery associated either to small parks or to farmed spaces it's still visible within the numerous built structures, for even with a 30 metres geographic resolution, discrimination between green and urbanized spaces is possible. Imagery analysis shows that Lisbon has suffered an urbanization process in some specific neighbourhoods, but it's visible that most ecological and agriculture areas remain untouched. The urban sprawl is far more evident in neighbour municipalities, like Oeiras (W), Amadora (NW), Odivelas, Loures (N), and in the Southern part of the metropolis, where discontinuous urban tissue looks like an oil growing spot. Being aware of this fact, we preferred to shift the metropolis images southwards in the 2000 classification, depreciating some of the northern municipalities. The most admirable farmed spaces are associated to alluvial river beds and mostly located in Vila Franca de Xira and Montijo municipalities, where one can even distinguish rice paddies in yellow, for they have the same spectral resolution as river sandy alluvial deposits. The river islands found northwards are mostly occupied by a public enterprise – Leziria Company – wholly devoted to agriculture, cattle and horse breeding, especially to *Lusitano*, used in Portuguese bull-fights.

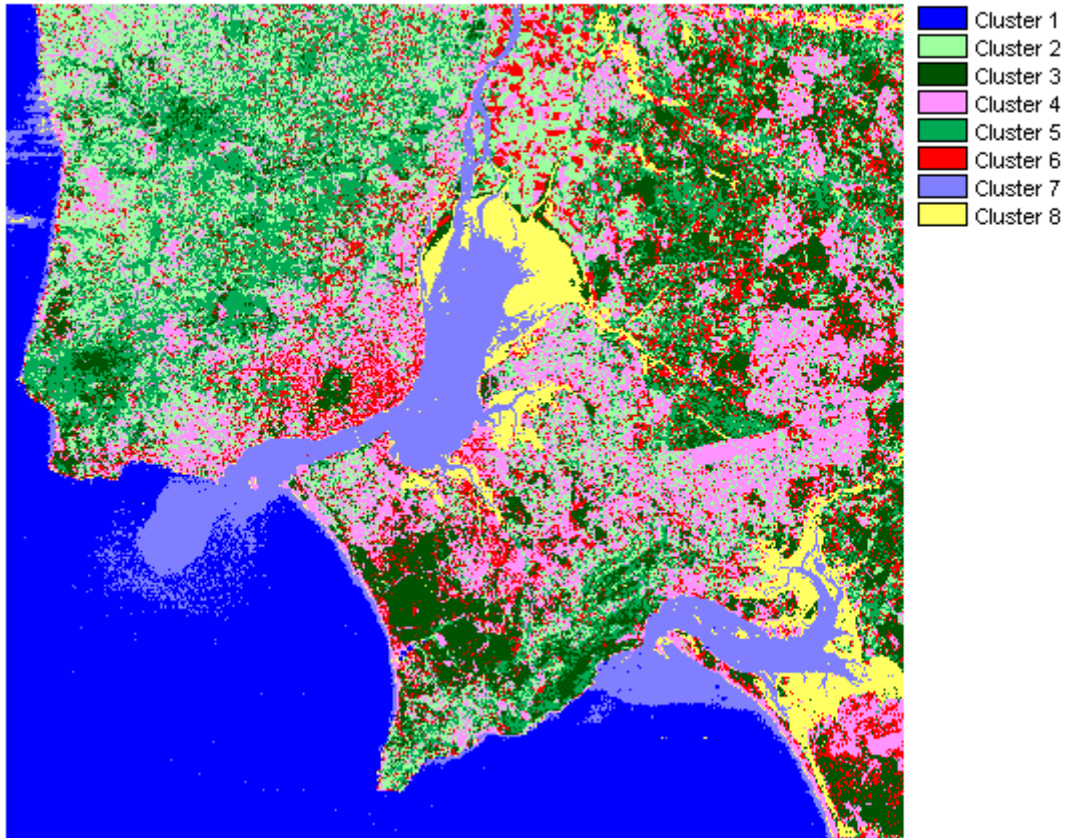
3.1 Peri-urban land uses in the Metropolis

Remote sensing is based upon detection and record of targets radiance. Again we stress that even though either Landsat 5 Thematic Mapper and Landsat 7 Enhanced Thematic Mapper sensors have merely a 30 metres spatial resolution, the presence of relatively bright or dark objects, highly reflective sources, sometimes in strong contrast with their background, such as rivers, sand or alluvial beds, even bridges, makes them detectable and therefore they can be quite effectively displayed (Weber 1995; Mather, 2001).

After the unsupervised classification phase we tried out a supervised MAXLIKE classification over Lisbon Metropolitan Region, in order to detect more accurately the green surfaces and discriminate them better. We applied a mask to the Atlantic Ocean, seas and rivers, so that the categorization would enhance the distinctive greenery while depreciating beaches, river sediments and rice paddies. As is common knowledge, the mask program allows us to generate a new image modified file according to the instructions given. Resulting digital work added a new class, related to vegetation presence and, as expected, made spontaneous green areas categorization more accurate. However, farmed spaces were not more adequately displayed than using unsupervised classification and so I chose not to display them in this paper. Being two summer Landsat images and due to software limitations it was clearly impossible to go any further (Lillesand and Kiefer, 1999).

Instead of reproducing the complex overlay process, files far too heavy and long for this paper editing recommendations, again, we will just look into numbers from multitemporal analysis: 1.Mixed vegetation surface increases 2%; 2.Continuous urban tissue 1.66%; 3.Discontinuous urban tissue augments 1.02%; 4.Herbs and farmed plots decrease 3.11%. Brief analysis confirms the urban sprawl registered between 1987 and the year 2000 in Lisbon and outskirts. In general, forests register small decrease in surface (-0.78%) whilst mixed vegetation proliferates. Apparently, farmed spaces shrink, but again we emphasize that the phenomenon is not as appalling as it seems due to season choice of imagery, because harvested surfaces have the same behaviour as concrete. In synthesis change was not disastrous as far as UPA is concerned.

Fig. 3 – Land Use in Lisbon Metropolis, summer 1987 (Landsat TM 26/07/1987)

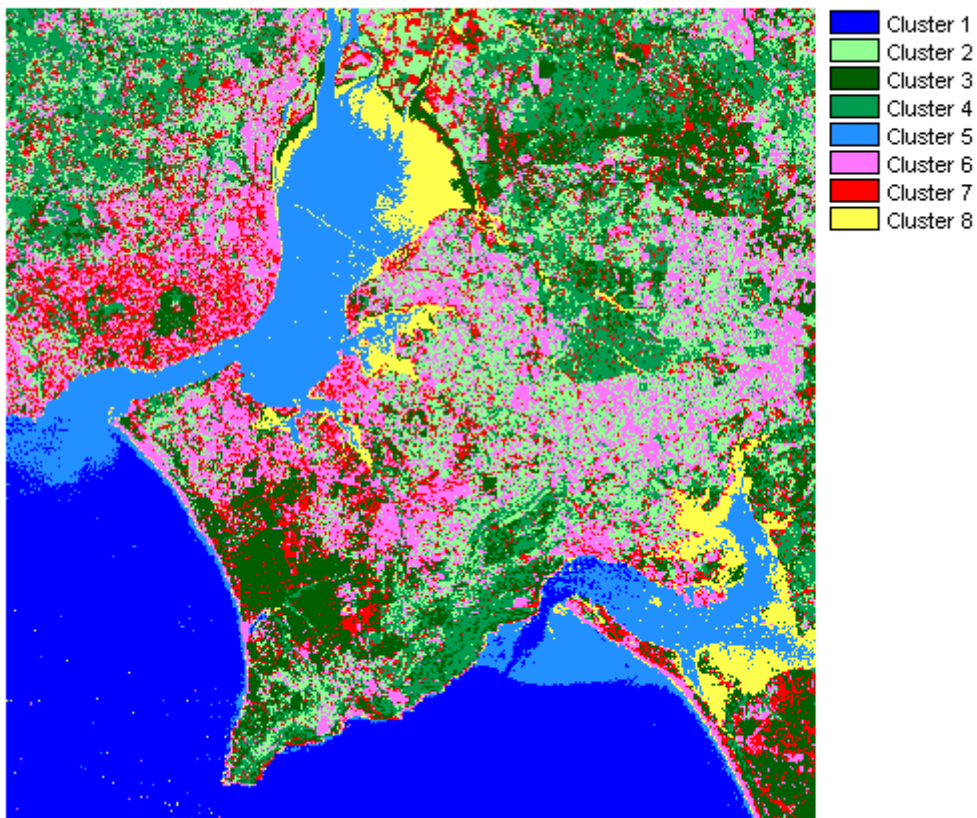


Madaleno, I. M.

1: 500 000

- Cluster 1** – Atlantic Ocean
- Cluster 2** – herbs and farmed plots
- Cluster 3** – *Pinus* forests
- Cluster 4** – discontinuous urban tissue, idle land
- Cluster 5** – bushes and trees (mixed vegetation)
- Cluster 6** – continuous urban tissue, highly mineralised soil
- Cluster 7** – estuaries, rivers, and littoral sea
- Cluster 8** – *sapal* (alluvial areas), beaches and rice paddies

Fig. 4 – Land Use in Lisbon Metropolis, summer 2000 (Landsat ETM 24/06/2000)



Madaleno, I. M.

1: 400 000

- Cluster 1** – Atlantic Ocean
- Cluster 2** – herbs and farmed plots
- Cluster 3** – *Pinus* forests
- Cluster 4** – bushes and trees (mixed vegetation)
- Cluster 5** – estuaries, rivers, and littoral sea
- Cluster 6** – discontinuous urban tissue, idle land
- Cluster 7** – continuous urban tissue, highly mineralised soil
- Cluster 8** – *sabal* (alluvial areas), beaches and rice paddies

4 Farmed spaces typology and legal protection

Sample field research and UPA practitioner's surveys indicated there are 5 categories of farmed spaces in Lisbon Metropolis, these days:

1.Home gardens, existent in backyards and around small houses or apartment blocks, ranging from scarce 50 m² to 1 ha. They might be found either in the mother-city or in satellite towns.

2.Pedagogical gardens are used for environmental education and pullulate all over inside public and private school patios, museums, prison yards and in City farms as the one existent in Lisbon, where biological produce is grown with the help of handicapped and behaviour troubled children. The biggest we've researched has about 11 ha.

3.Shifting farmed plots, fresh vegetable, spices, medicinal herbs specialized and market oriented are more common in peri-urban environments but one gets amazed realizing they can easily survive in front of a municipal building without eviction or taxation.

4.Peri-urban farms (*quintas*) ranging from 5 to hundreds of hectares, are animal and vegetable farming properties, good businesses for middle class agriculture friendly people, mere recreation for the wealthy ones. Vineyards, flower culture, horse breeding are just some of the favorite options.

5.Finally, public property is adamant the most profitable being Leziria Company easily noticed up Tagus River (total surface registered are 20,000 ha), which alluvial soils produce rice, maize, and fodder where bulls and horses share the lovely planes with migratory birds.

Last census to agriculture and husbandry recorded about 1,165 ha of public farmed land inside Lisbon Metropolis, (excluding Leziria Company), and about 48,000 hectares cared by small farmers, household plots and micro-farms corresponding to 47% of metropolitan farmed spaces. Private landownership is therefore the rule even as municipal laws and regulations tend to be highly protective towards natural parks (REN) and farmed spaces (RAN), included in municipal planning. Those areas can only be developed after several publicized demarches and after majority in Municipal Assembly, where the owners and all residents have a saying.

5 Conclusions

The use of multispectral imagery led to a higher discriminating power than any single band would have produced, and even though the reflectance spectra of vegetation, idle soils, farmed soils, urbanized areas was not always totally and conveniently classified with digital work, using IDRISI 32, we consider that the main research objective was achieved. And that objective was to get a spatio-temporal analysis of farmed spaces, which persistence in peripheral areas is contended and difficult nonetheless essential for an environmentally sustainable European capital. The option for summer Landsat images was limitative, for part of the land had already been cropped and therefore surfaces were mineralised, which positioned them in a different class than they would have, had we worked with a spring set of spectral bands, for instance. Images we display in the paper are a pale example of the complex and far deeper methodological phases that systematically permitted us to get feature selection and some classification accuracy, but they prove that farmed spaces persist inside Lisbon Metropolis, even within the urban tissue, either for subsistence purposes or for commercial reasons often protected through national and municipal planning.

Acknowledgements

Thanks are due to Prof. Dr. J.A. Tenedorio, Universidade Nova de Lisboa, for having provided the Landsat imagery as well as helping me discover the admirable new world of remote sensing. For his availability and commitment I am very grateful. Nevertheless, I take full responsibility for all errors or omissions.

Bibliography

Donnay, J-P., Barnsley, M.J. and Longley, P.A. (2001): Remote Sensing and Urban Analysis, Taylor & Francis, London..

Iaquinta, David.L. and Drescher, Axel, W. (2000): Defining Periurban: Understanding Rural-Urban Linkages and their Connection to Institutional Contexts. Tenth World Congress of the International Rural Sociology Association, Rio de Janeiro (www.ruaf.org/fullpapers)

INE (2002): Atlas das Cidades de Portugal, Instituto Nacional de Estatistica, Lisboa.

Lillesand, Thomas M. and Kiefer, Ralph W. (1999): Remote Sensing and Image Interpretation, John Wiley & Sons, New York.

Madaleno, Isabel M. (2001): Cities of the Future: urban agriculture in the third millennium. In Food, Nutrition and Agriculture, 29, FAO, Rome, 14-21.

Mather, Paul M. (2001): Computer Processing of Remotely-Sensed Images, John Wiley & Sons, New York.

Weber, Christiane (1995): Images Satellitaires et Milieu Urbain. Hermes, Paris.

Author

Isabel Maria Madaleno
Ph.D. in Human Geography
M.Sc. in G.I.S. (Remote Sensing)
Tropical Institute (IICT)
Lisbon
Portugal
Email: Isabel-Madaleno@clix.pt
Website: www.iict.pt