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Editorial

The publication of the *European Journal of Geography (EJG)* is based on the European Association of Geographers' goal to make European Geography a worldwide reference and standard. As a result, the papers published in the EJG, including those on this issue, are focused in promoting the significance of geography as a discipline, in resolving global issues or applying geography, complementing, of course, the fundamental goals of improving the quality of research, learning and teaching of Geography. In other words with the EJG the European Association of Geographers provides a forum for geographers worldwide to communicate on all aspects of research and applications of geography with a European dimension, but not exclusive.

As a result, every issue of the EJG provides a glimpse of the important role Geography can play in helping researchers, academics, professionals as well as decision makers and politicians in resolving a wide spectrum of problems. In other words, EJG following Geography which connects the physical, human and technological sciences is aiming at enhancing teaching, research, and of interest to decision makers, problem solving. That is, in every issue of the journal a reader can find answers of how aspects of these sciences are interconnected and are forming spatial patterns and processes that impact on global issues and thus effecting present and future generations.

The goal of the editorial team, which up to now has been achieved to a great extent, is that the papers of the EJG by dealing with places, people and cultures, will explore those issues ranging from physical, urban and rural environments and their evolution to climate, pollution, development and political-economy. Thus, your contributions to the EJG are not only desirable, but necessary for Geography and Science as a whole.

Kostis C. Koutsopoulos
Editor EJG

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THE BRAIN AS A MULTI-LAYERED MAP. SCALES AND REFERENCE POINTS FOR PATTERN RECOGNITION IN NEUROIMAGING

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Abstract

In this paper, we provide an overview of brain mapping in neuroscience and describe the application of spatial data processing techniques to represent the brain as a multi-layered map.Anatomical reference points (landmarks) are determined from the topological properties of the brain, including the shapes of sulci, gyri, and fissures. Functional reference points are calculated by measured parameters of brain activity. Linking experimental results with spatial and temporal reference points is a necessary step for performing a comparative analysis of heterogeneous data regarding brain structures and activity. Using reference points helps define coordinate systems and scales, highlight points of interest and regions of interest, create templates, and classify data. The paper shows that spatial analysis is a convenient approach to pattern recognition in neuroimaging. We also discuss the role of extrinsic behavior landmark stimuli and intrinsic brain structural elements such as place cells and grid cells in navigation tasks.

Keywords*: Brain mapping, neuroimaging, pattern recognition, positioning systems in the brain.*

1. INTRODUCTION

The brain can be represented as a spatially distributed multi-scale and multi-level structure in which continuous dynamic processes occur.

Two main blocks of spatial data processing tasks in neuroscience are shown in Figure 1. Studies of brain mapping generally focus on addressing the question, “What is the space of the brain?” (Figure 1A). Thus, analyses of the brain’s structure at different levels – ranging from individual cells to the entire brain’s architecture – are practiced by scientific researchers as well as by specialists in the fields of medicine and neuroradiology.

On the other hand, studies of brain activity during orientation in space generally focus on addressing the question, “How does the brain navigate in space?” (Figure 1B). This block of study includes the investigation of spatial perception, navigation, and the brain’s positioning functions.

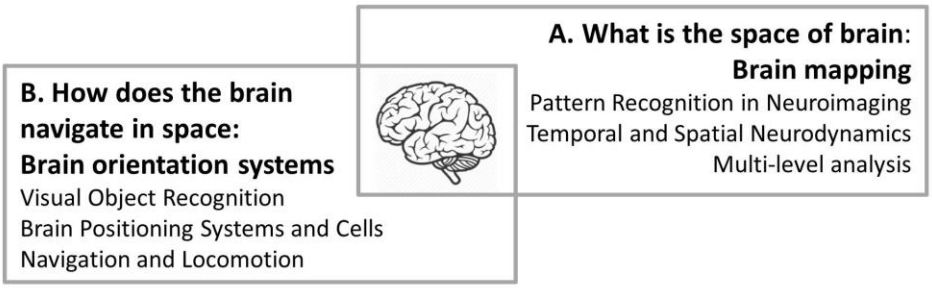

Figure 1. The two main blocks of spatial data processing tasks in neuroscience. Block A addresses the question, "What is the space of the brain?" Block B addresses the question, "How does the brain navigate in space?"

The remaining sections in this paper are organized as follows:

Section 2 provides a brief description of the subject areas and common interests between brain mapping and geomapping. Section 3 provides an overview of the techniques used in brain mapping. Section 4 describes how to use the scale and reference points for analyzing multi-level data in brain mapping. Section 5 contains the report about pattern recognition in neuroradiology with application of geographic information system technologies. Section 6 discusses the perception of spatial information and positioning systems in the brain. Finally, we provide conclusions in Section 7. Additional information about the standards and software, which typically applied in brain mapping, is contained in the Appendix.

2. COMPARISON OF SPATIAL DATA PROCESSING BETWEEN NEURO-INFORMATICS AND GEOINFORMATICS

Although geoinformatics and neuroinformatics deal with materially different objects, the tools for spatial data processing are based on certainly similar methods and are designed to solve similar problems.

Integrated vector-and-raster models, which are implemented in geographical information systems (GIS), provides a representation of the outer and inner surfaces of anatomical structures and enables the identification of anatomical structures and spatial analyses (Barbeito et al., 2015). Brain-mapping software and GIS technologies use a common set of instruments, including measure of distances and areas, coordinate representation system, multi-layer datasets, metadata storing, and metadata sharing.

GIS technologies can be valuable in brain mapping due to the processing of raster data and vector data. GIS technologies are also applied in the collection and analysis of heterogeneous spatial data, organization, and publication of maps. Moreover, GIS tools are applied for tasks that involve a large number of images. Suitable applications have already been developed in advanced geographic information systems, such as ArcGIS: (http://www.esri.com/software/arcgis) and QGIS (http://www.qgis.org).

Brain mapping techniques would help GIS cartographers analyze dynamic processes. Due to the relatively fast processes that occur in the brain, phenomena such as pacemakers and oscillations are often recorded and studied in neuroscience. However, similar phenomena can also be observed in the relatively slow dynamic processes that occur at the Earth's surface, for example in environmental studies. These similarities serve as an additional bridge between GIS and brain mapping. In both cases, the mapping techniques should be flexible with respect to the essential characteristics of the space, its connections, and its inherent dynamics.

To visualize similarities in mapping technologies, consider a typical brain map (an example of multi-layer dataset based on the Interactive Multiresolution Brain Atlas (Mikula

et al., 2007) is shown in Figure 2A), and compare this map with raster or vector map in a typical GIS (an example is shown in Figure 2B).

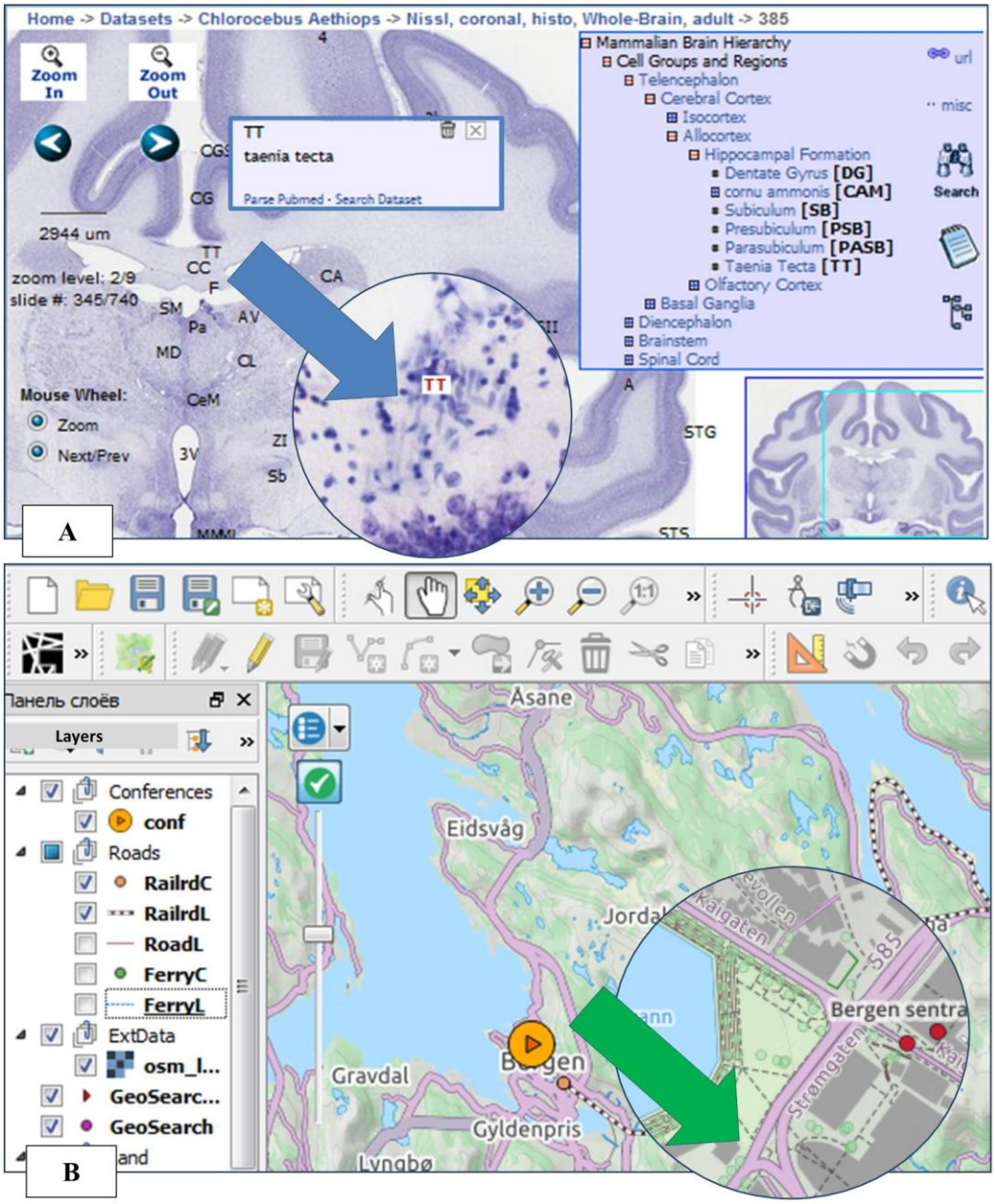

Figure 2. A. Multi-layered brain map of the grivet monkey *Chlorocebus aethiops*. Figure shows the map of brain slice at a wide scale, and zoomed part near the taenia tecta (TT) area. The individual layers are represented by functional brain units (reproduced from http://brainmaps.org). B. Multi-layered map in QGIS. Figure shows the terrain map at a wide scale, and zoomed part near the railway station.

Nowadays, location-specific geodata are provided in large quantities by both industrial equipment (for example, remote sensing devices) and personal media tools (for example, smartphones). Similar situation is occurring with respect to brain mapping, in which radiologists typically view hundreds – or even thousands – of images. For example, advanced multidetector computed tomography produces several thousand images during a single examination (Andriole et al., 2011).

Table **1** summarizes the similarities between brain mapping and GIS mapping.

Table 1. Comparison of subject areas between brain mapping and GIS mapping

Subject area	Brain mapping	GIS mapping
I. Primary data processing		
Selection of coordinate systems. Configuring sets of layers. Spatial measurements: calculation of geometrical parameters (length, area, volume). 2D/3D transformations. Vectorization. Spatial database. Data compression.	Primary data sources: Magnetic resonance imaging (MRI), functional magnetic resonance imaging (fMRI), single-photon emission computed tomography (SPECT/CT), electro-encephalography (EEG), magnetoencephalography (MEG), optogenetics.	Primary data sources: Remote sensing, land surveying.
II. Recognition and classification		
Finding of surface specific points and lines. Contouring. Generalization. Data classification.	Pattern recognition in neuroimaging.	Pattern recognition in geoimaging.
III. Multi-scale data integration		
Data standards.	Digital Imaging and Communications in Medicine (DICOM) standards (http://dicom.nema.org), DICOM Files, XML.	The Open Geospatial Consortium (OGC) standards (http://www.opengeospatial.org/standards), WMS, GML, KML, XML.
Combining data from different sources.	Brain atlases.	Geodata integration.
IV. Spatio-temporal processes and connectivity		
Dynamic processes and connectivity.	Area's connectivity. Brain activity.	Engineering communication. Urban planning. Ecology.
V. Positioning systems		
Orienteering by reference points. Wayfinding.	Place cells and grid cells. ROIs, POIs.	Natural or manmade landmarks. ROIs, POIs.
Navigation. Movement control.	Route selection. Visual object recognition. Locomotion.	Route selection. Logistics.

3. SPATIAL DATA PROCESSING IN BRAIN MAPPING

The basic mission in brain mapping can be summarized as follows (Frackowiak & Markram, 2015): the aim of cerebral cartography is to generate atlases that use anatomical frameworks to organize and convey spatially and temporally distributed functional information regarding the brain at all organizational levels ranging from genes to cognition and at all relevant spatial and temporal scales.

Thus, ideal brain atlas should provide a comprehensive multi-scale spatial representation of the brain at both the structural and functional levels.

3.1 Basic components and datasets

3.1.1 Neuroimaging data

Neuroimaging is used to collect and process images, thereby allowing researchers to visualize the structures and functional characteristics of the brain.

Tomography produces a series of brain images in the form of two-dimensional (2D) slices, allowing researchers to measure the brain's activity in response to external stimuli and to identify tumor-containing and/or diseased areas of the brain. Neuroradiologists obtain these original 2D slices, which are then could be converted into 3D data.

Digital Imaging and Communications in Medicine (DICOM, http://dicom.nema.org) is the current standard for handling, storing, printing, and transmitting medical imaging information.

MicroDicom (http://www.microdicom.com) is an application for the primary processing and preservation of medical images obtained in DICOM format. MicroDicom user interface is depicted in Figure 3.

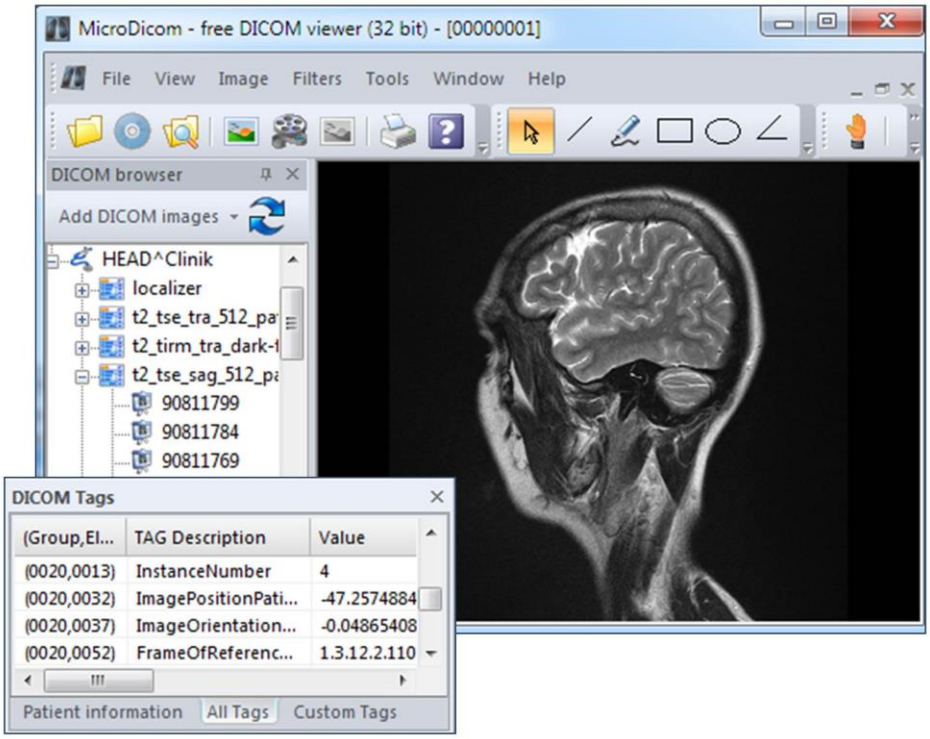

Figure 3. Data representation in MicroDicom.

3.1.2 Functional magnetic resonance imaging

Functional magnetic resonance imaging (fMRI) is a neuroimaging procedure using technology that measures brain activity by detecting changes associated with blood flow. FMRI provides information regarding the brain's functions with spatial reference for the brain's response.

Despite its advantages, fMRI has limited temporal resolution. Specifically, regions in which the blood oxygen level-dependent (BOLD) signals changes in fMRI may not necessarily correspond with regions of neural activity (Baillet et al., 2001).

3.1.3 Brain activity

Magnetoencephalography (MEG) and electroencephalography (EEG) provide a non-invasive measure of neural activity by measuring electromagnetic signals. In EEG, electrical potential differences are measured between pairs of "electrode – referent" placed on the scalp. The electrodes can be either glued directly to the skin at specific locations (for example, directly above cortical regions of interest) or they can be fitted in an elastic cap that can be placed easily over the top of the head, providing near-uniform coverage of the entire scalp. Because

the electrodes are placed on the surface of the head and not directly in the area being observed, the precise location of the source of activity should be determined by calculation.

Combining MEG and/or EEG with another methodologies allows researchers to better localize and separate various components in the brain's electrical responses (Baillet et al., 2001). Individual MEG and EEG source maps can be normalized to a common brain atlas, and statistical inference can be performed at the group level (Evans et al., 2012).

The recorded brain activity is typically characterized by distinct frequencies and spatial distributions, which depend on the various states of the brain (for example, sleep or wakefulness). The recorded signals are the result of superimposing the activity of large populations of neurons (neuronal ensembles). Because the number of signals per unit time is extremely large, EEG data is generally analyzed using established statistical methods.

A spatial-temporal representation of activity of neuronal ensemble can be described by oscillatory dynamics. Thus, oscillatory brain activity can be displayed as a map of wave distribution.

3.2 Data structures in brain mapping

3.2.1 Layered structures

Radiologists typically work with sets of images (two-dimensional slices) taken at intervals of few millimetres.

Subsequently, the sets of 2D projections can be arranged in a 3D representation. This is very similar to the construction of three-dimensional terrain model based on satellite imagery data (Figure 4).

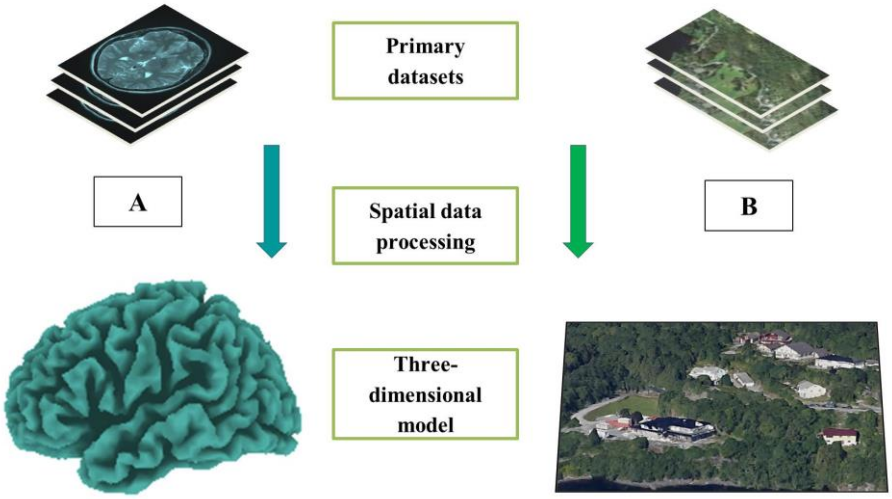

Figure 4. Spatial data processing: from sets of slides to the three-dimensional model in neuroimaging (A) and in satellite imagery (B) (map reproduced from https://www.google.com).

In practice, organization of layers in terms of separate functional areas is often provided, and is used in tasks of connectivity. For example, Robinson and Rolls reported the integration of layers in invariant visual object recognition (Robinson & Rolls, 2015).

3.2.2 Default mode network

The default mode network is a distinct brain feature that is activated when an individual engages in reflexion (Razi et al., 2015).

The concept of the default mode network was discussed by Simony et al. (Simony et al., 2016), in which the authors introduced the concept of inter-subject functional correlation, which isolates stimulus-dependent inter-region correlations between brains that are exposed to the same stimulus.

3.2.3 Multi-level structural and functional brain atlases

Multi-layer neuroimaging data obtained from various brain regions can be grouped within atlases. Multi-level atlases include numerous reports which combined into a single atlas.

One of the brain atlases is shown in Figure 5. This Brainnetome atlas (http://atlas.brainnetome.org/brainnetome.html) was generated in order to identify brain networks using multimodal neuroimaging techniques ranging from the highest-resolution scale (microtechniques, ultramicrotomy) to the most macroscopic scales (EEG, fMRI, and diffusion MRI), thereby allowing researchers to investigate the relationship between these scales (Fan et al., 2016).

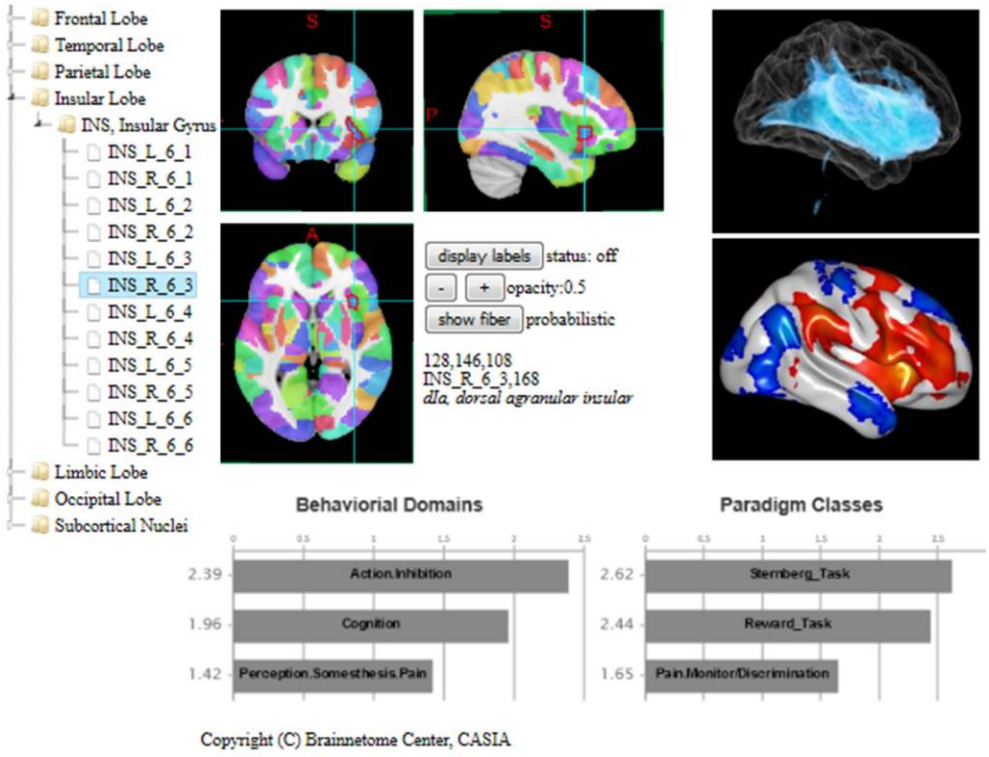

Figure 5. Brainnetome web-interface (reproduced from http://atlas.brainnetome.org/bnatlas.html).

Evans et al. summarized the brain atlases that are currently available (Evans et al., 2012). In review, they summarized the evolution of stereotaxic space, the creation of brain atlases, and future trends that can be expected in upcoming atlases.

3.3 Classification and parcellation of brain areas

Classifiers of brain areas are typically used for generating a brain atlas. For example, Glasser and colleagues delineated 180 areas in each hemisphere based on sharp changes in cortical architecture, function, connectivity, and/or topography (Glasser et al., 2016); in addition, they characterized 97 new areas by training a machine-learning classifier to recognize the multimodal "fingerprint" of each cortical area. The following criteria were used for parcellation: *I*) spatially overlapping gradient "ridges" between each pair of areas for at least

two independent areal feature maps; *II*) similar gradient ridges present in roughly corresponding locations in both hemispheres; *III*) gradients that are not correlated with artifacts; and *IV*) robust, statistically significant cross-border differences in the feature maps.

Although most structural brain atlases are delineated manually by region of interest, it is possible to automate these operations. For example, Wang et al. proposed a method for parcellating the brain into regions of interest based on connectivity by multi-class Hopfield network algorithm (Wang et al., 2016).

Data classifications generally apply "machine learning" methods, for example Support Vector Machines (SVMs) or Ensemble Tree Learning Techniques (Martinez-Murcia et al., 2016).

Mandelkow et al. compared several algorithms for classification, including Nearest Neighbor, Gaussian Naive Bayes, and Linear Discriminant Analysis; high accuracy in terms of discriminating fMRI response patterns is achieved using a large number of natural visual stimuli (Mandelkow et al., 2016).

3.4 Consolidation of temporal and spatial data in brain mapping

Modern studies performed comparative analyses between stationary data (MRI, fMRI) and dynamic data (EEG). To analyze EEG data all of the images are typically superimposed on an "average" brain, without taking into account topological features unique to individual brains. Such an approach often leads to systematic errors that can be eliminated with computational methods. Averaged static EEG maps can be overlaid on anatomical MRI-based maps.

Such a comparison between temporal and spatial data usually reveals that the computed EEG response is correlated with – but does not necessarily coincide with – active areas identified using fMRI. Recording fast EEG signals with high temporal resolution provides a higher level of detail than MRI and fMRI.

Therefore, combination of techniques can provide valuable information regarding the temporal structure and spatial distribution of the resting state networks under specific experimental and/or clinical conditions (Lehmann, 2010). For example, Yuan et al. reconstructed networks from high-resolution EEG data and performed spatial and temporal comparisons with fMRI data (Yuan et al., 2016).

There are two basic approaches to attenuate artifacts due to volume conduction: spatial filtering in combination with standard connectivity methods, or connectivity methods such as the weighted phase lag index that are blind to instantaneous connectivity that may reflect volume conduction artifacts (Cohen, 2014a).

Cohen reported that temporal fluctuations in oscillation peak frequency (also known as "frequency sliding") can be used for analyses at multiple scales within neuroscience (Cohen, 2014b).

Oscillation frequency appears to be a general principle that regulates brain function on multiple spatial and temporal scales, ranging from modulating spike timing in individual neurons to whole coordinating brain networks during cognition and the resting state.

Simultaneous multiscale study of brain activity signals leads to the detection of time lag (delay interval) between the signals (Figure 6).

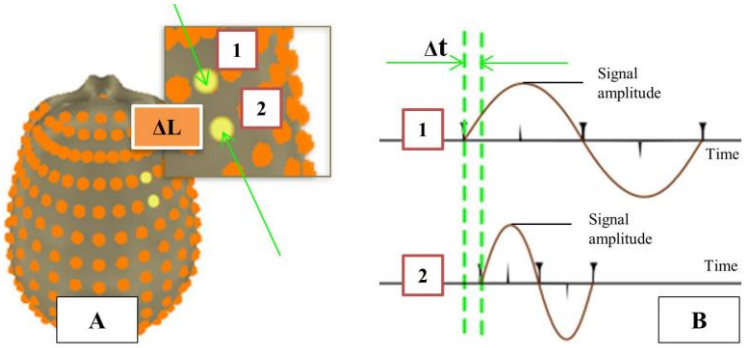

Figure 6. A. Distance between electrodes 1 and 2 (ΔL). B. Time lag between electrodes 1 and 2 (Δt).

3.5 Topography and connectivity in spatio-temporal processes

3.5.1 Effects of topography in the measurement of brain activity

Vertebrate brains generally contain two kinds of tissue: grey matter on the surface, which contains local networks of neurons that are wired by dendrites and mostly local axons, and white matter inside, which contains long-range axons that implement global communication (Wen & Chklovskii, 2005).

Shapes of brain curves, such as sulci, gyri and fissures, should be explored in 3D modelling, similar to how mountain topography is considered in 3D.

Subsurface connections improve level of communications, similar to tunnels in the hills (Figure 7 A).

Plane model of the brain shapes is shown in Figure 7B. Model of the interaction of neurons is shown in Figure 7C: convergence of curved surfaces could modify a possibility of connection.

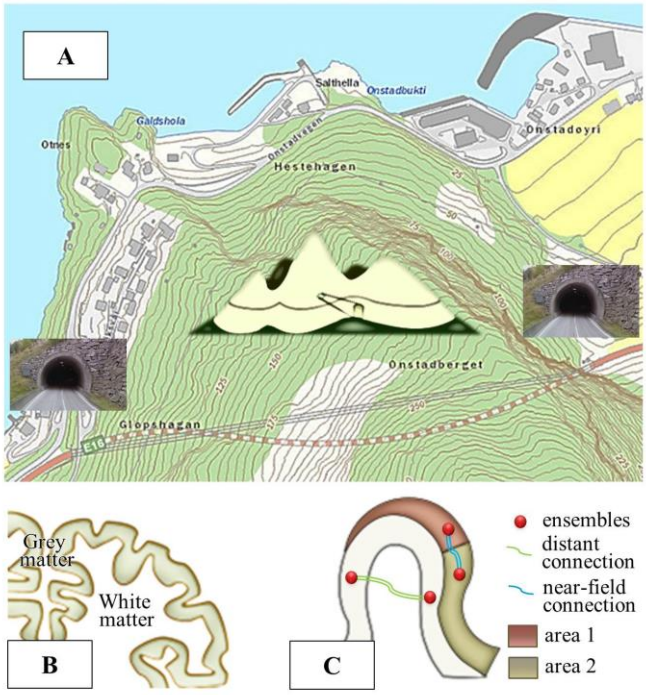

Figure 7. A. One-level objects tend to join together by topography (map to the underlying layer reproduced from https://www.visitnorway.com). B. Plane model of the brain shapes. C. Ensembles from different brain areas can support distant and near-field connections.

3.5.2 Sensor positions

To define the reference points are often used computational methods. For example, the software package LORETA (http://www.uzh.ch/keyinst/loreta) calculates the density distribution of sources using raw data in the form of electric potentials recorded at the scalp (event-related potentials, and cross-spectra EEG recordings).

The fact that the brain surface is curved has a significant strong impact on the overall measuring activity of ensembles of different segments. Figure 8 shows that measurements of activity are carried out with the scalp, and the electrodes are located distantly from the active sources.

Brain without electrodes and arrangement of the electrodes on the scalp in LORETA software are shown in Figure 8A, 8B, and arrangement of the electrodes relative to the slice is shown in Figure 8C.

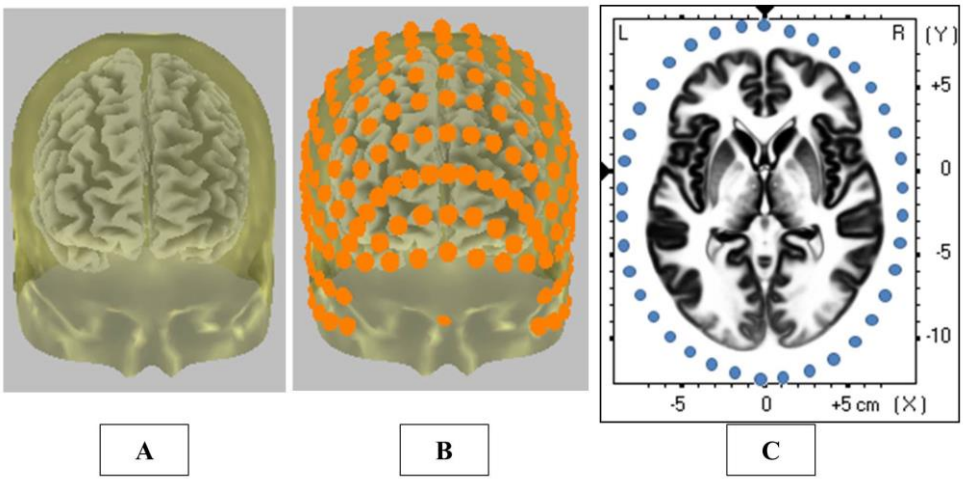

Figure 8. A. Brain without electrodes and B. Arrangement of the electrodes on the scalp in Loreta software. C. Arrangement of the electrodes relative to the slice.

To interpret brain activity various models are used, ranging from a representation of the brain as a sphere to the most accurate representation of the brain's topographic surface. Understanding the impact of neural topography on the resulting measure of brain activity is essential in analyzing interactions and connectivities between various areas of the brain (Thivierge & Marcus, 2007; Guntupalli et al., 2016).

3.5.3 Tractography

Fiber tract trajectories are coherently organized pathways of white matter in the brain. Tractography allows researchers to calculate contiguous fiber tract trajectories using discrete diffusion tensor MRI data (Basser et al., 2000) and to visualize the orientation and integrity of these pathways in the brain.

A map of structural connectivity can be generated as a combination of diffusion imaging and probabilistic tractography. A map of functional connectivity can be generated based on spatio-temporal correlations derived from resting-state fMRI data (Van Essen et al., 2014).

Maps of brain connectivity are being developed in order to reproduce the direction of anatomical and functional connectivity between distinct units, as well as 2D and 3D geomaps are constructed for visualizing the movements (Figure 9).

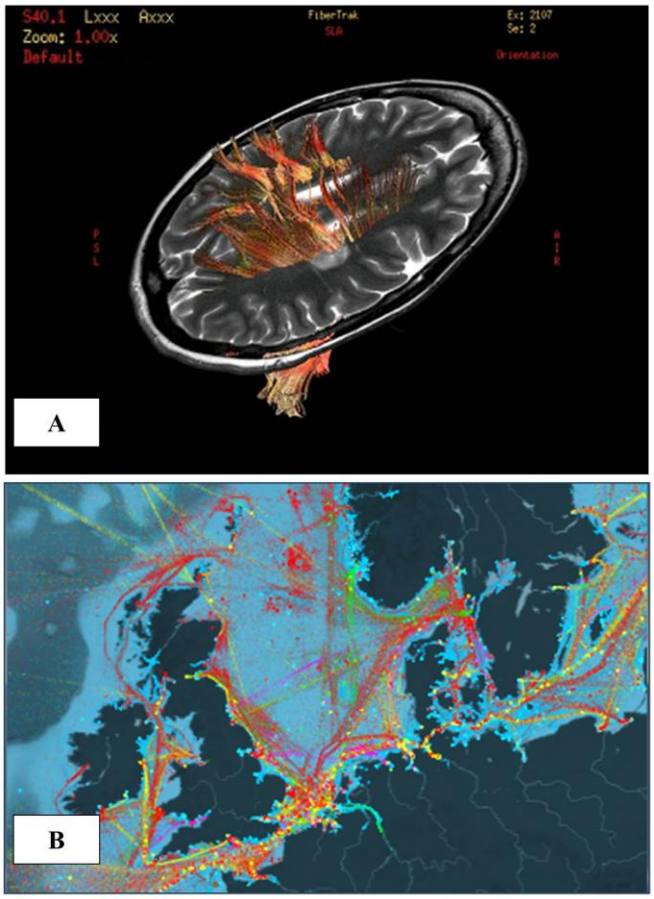

Figure 9. A.Brain fiber tract trajectories. B. Shipping Tracks (reproduced from https://www.shipmap.org).

4. SCALES AND REFERENCE POINTS IN BRAIN MAPPING

4.1 An analysis of spatially distributed brain activity

An analysis of spatially distributed brain activity should include the following considerations:

- The choice of coordinate systems for describing the observations;
- Multi-scale data properties;
- Individuality factors;
- The quality of the measurement techniques; and
- The specificity of the brain areas being analyzed.

The coordinate systems in brain activity measurements (EEG, MEG, etc.) are usually defined in terms of anatomical landmarks on the surface of the head; in contrast, the coordinate systems for neuroimaging (MRI, fMRI, CT) are usually defined in terms of slices inside the head.

The most commonly used coordinate systems are the Talairach Atlas (http://www.talairach.org) and the MNI (Montreal Neurological Institute) stereotaxic coordinates (for more details, see the Appendix).

MNI coordinates in Loreta software (http://www.uzh.ch/keyinst/loreta) shown at Figure 10, coordinate conversion MNI/ Talairach also is possible in this software.

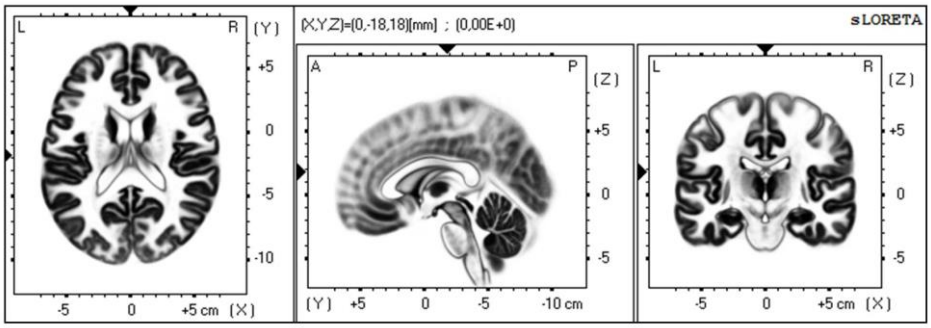

Figure 10. MNI coordinates in Loreta software.

Toro & Burnod introduced representations of the cortical anatomy with the intention of simplifying visualization of the principal sulci and other anatomical landmarks that serve as the axes of the geometric model (Toro & Burnod, 2003). Van Essen used a surface-based coordinate system to visualize the cerebral cortex (Van Essen et al., 1998).

A thorough overview of coordinate systems is available at FieldTrip (Oostenveld et al., 2011) (http://www.fieldtriptoolbox.org).

Coordinate grids for Allen Human Brain Atlas (http://www.brain-map.org) are shown in Figure 11.

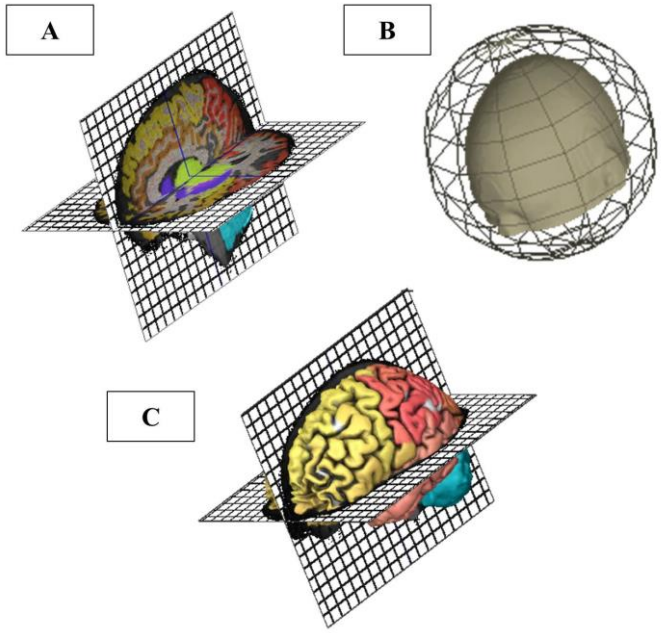

Figure 11. Coordinate grids for Allen Human Brain Atlas in Brain Explorer 2: A. Grids of sagittal and horizontal sections. B. Compass. C. 3D Atlas.

Multi-scale data properties lead to the necessity of generalization of the signals during transitions to wide scales. In addition, part of the observed signal is considered to be noise by the statistical analysis; typically, most of EEG signals can be filtered out as "random noise" and ignored in the subsequent analysis. The ratio of signal-to-noise is defined for each scale.

With respect to individuality factors, it is usually not possible to use a generalized brain map for all participants; a particular map must be compiled for each participant. However, with studies that do not require high precision (for example, to identify the onset of an epileptic seizure), a generalized brain atlas is generally acceptable. Individual brain structure can be considered invariant within a single set of measurements, and these data can be used as the basis for analyzing dynamic data.

In brain mapping, it is necessary to consider the features of the measurement, including the accuracy and relative location of the sensors. In addition, systematic errors may occur due to changes in physiological factors such as heart rate, blood oxygen saturation, and blood pressure (Ghosh Hajra et al., 2016).

Some brain areas can duplicate the cortex function. The majority of the human cerebellum maps to cerebral association networks in an orderly manner that includes a mirroring of the prominent cerebral asymmetries (Buckner, 2013).

With regard to all of the above-mentioned problems, GIS technologies may provide a suitable solution, including methods for working on various scales and with various reference points.

4.2 Scales

4.2.1 Sets of scales

The major sets of scales (and their dimensions) for brain mapping can be defined as follows: cells (10^{-6} m), ensembles (groups of cells; 10^{-4} m), and brain regions (10^{-2} m); the appropriate research methods should be used for each of these scales.

A complete multi-level map of an individual human brain – at the resolution required for mechanistic explanations – will need to represent the morphology, physiology, subcellular, and molecular architecture of neurons (and a similar number of non-neuronal cells) (Frackowiak & Markram, 2015).

4.2.2 Measurement accuracy and noise

The scale is determined primarily by the resolution of the measuring device. Thus, the spatial resolution of fMRI studies is defined by the ability of the equipment to distinguish between boundaries in the brain. Spatial resolution is measured by the size of the voxels, ranging from 4-5 mm to 1 mm (for example, in MRI). Scanning time increases directly with an increasing number of voxels and number of slices. One voxel typically includes approximately a few million neurons.

Marblestone et al. outlined the physical principles governing brain activity mapping using optical, electrical, magnetic resonance, and molecular modalities of neural recording (Marblestone et al., 2013). The authors noted that the recording of activity is limited by the low multiplexing capacity of electrodes and by their lack of intrinsic spatial resolution. In addition, optical methods are constrained by the scattering of visible light in brain tissue, and magnetic resonance is hindered by diffusion and relaxation time scales of protons.

When resolution is improved, noise typically increases. Moreover, noise can be noticed as a phenomenon, which is associated with different scales. Indeed, the choice of scale determines the filter settings to reduce noise. The ability to distinguish between noise and the true signal can affect the amount of data included in the final analysis. Consolidation data in multi-scale project allows researchers carefully to filter or to reduce the noise.

4.3 Reference points

4.3.1 Significance of reference points

In the brain, reference points are biologically significant points with coordinate description. Reference points are essential for integrating datasets obtained from different sources.

Individual anatomical and physiological reference points can be allocated based on the spatial and functional features of an individual brain and are based on characteristic surface features and/or measured activity. Lines of interest and areas of interest are identified using a similar approach.

Individual reference points can be mapped to an existing general brain atlas in order to specify functional locations or to update coordinates. Thus, points of interest, lines of interest, and regions of interest (often abbreviated POIs, LOIs, and ROIs, respectively) can serve as a basis for linking disparate data and for generalizing.

The various types of reference points are summarized in Table 2.

Table 2. Types of reference points

Type	Description
I. Internal reference points	
Anatomical points	Internal anatomical points (landmarks) are based on the structure of parts of the brain
Functional points	The points identified using blood oxygen level-dependent (BOLD) contrast imaging show changes in the brain's state
Dynamic points of brain activity	The "point of neuron activity" is a group of brain cells with stable, detectable activity
II. Sensor position	
Points of observation (can be used as the relative origin of coordinates)	Locations of the electrodes and sensors are taken into account when determining the relative coordinate system
Biomarkers	Biomarkers provide a selection of places of interest in the tissue microstructure
III. Brain cells for coordination and navigation	
Place cells, grid cells, head-direction cells, and boundary cells	Positioning systems in the brain

4.3.2 Anatomical and physiological landmarks

Landmarks are generally used to describe the shapes of brain structures and for parcellation. The shape of sulci is used to measure brain variability (Durrleman et al., 2007) and topological components of sulci are used as landmarks (Mangin et al., 2015). Functional reference points for brain activity are calculated using robust and similar values of measured parameters.

Zhang et al. formulated the detection of anatomical landmark and boundaries as a classification problem (Zhang et al., 2012) in which a shape repository/dictionary is constructed using manually delineated organ contours and/or surfaces.

Liu et al. presented algorithms to automatically detect and match landmark curves on cortical surfaces in order to obtain optimal parameters of brain conformation (Liu et al., 2006). The authors proposed an automated landmark curve-tracing method based on the principal directions established by the local Weingarten matrix.

Sergejeva et al. proposed a standardized set of anatomical landmarks for registering whole-brain imaging datasets obtained from mouse and rat brains, in particular for integrating experimental image data in the Waxholm Space atlas (Sergejeva et al., 2015).

New parcellation system for the orbitofrontal cortex using automated anatomical labeling was described by Rolls (Rolls et al., 2015).

4.3.3 Points of neuronal activity

To solve the dynamic problems associated with neural activity, it is essential to know the location of neurons or neuronal ensembles that are being measured. In many types of biological experiments, researchers simply operate with aggregate data, without providing any reference to coordinates.

An accurate method to overcome this issue is the registration of "points of neuron activity" by electrodes that are implanted in the brain. However, even with such registration, interference from neighboring units of activity can distort the detected signals, making it difficult to locate the precise source of the activity. EEG electrodes are spaced rather widely apart; the source of the signals recorded from neuronal ensembles can be determined only by computational methods (see section 3.5.2).

5. PATTERN RECOGNITION IN NEUROIMAGING

In this section we present the possibilities of GIS applications for the pattern recognition and comparative analysis of electronic medical records.

5.1 Primary data

Primary electronic medical records for analysis were obtained from the period 2012 through 2015. These data contain images obtained using various CT and MRI equipment.

View of primary images is shown in Figure 12.

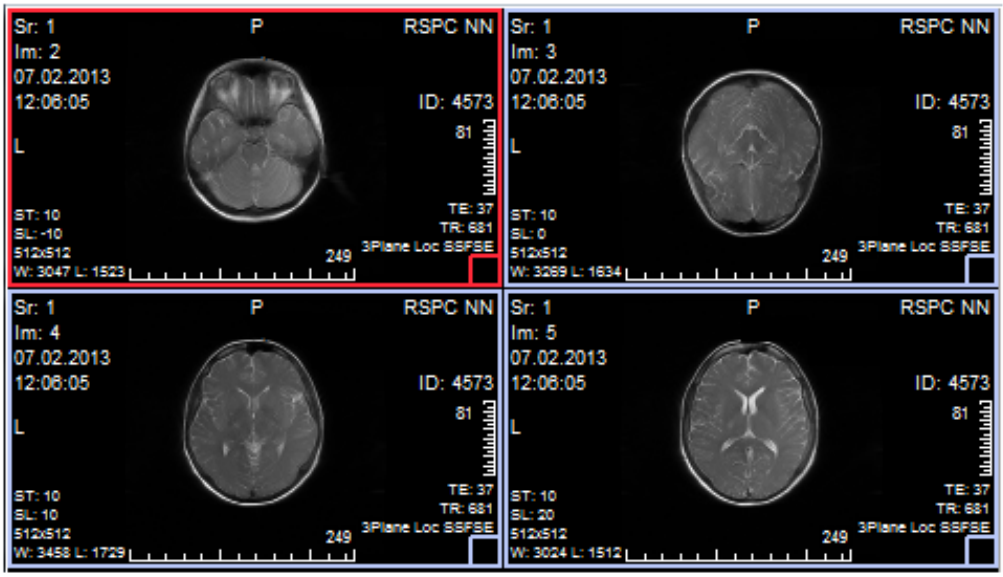

Figure 12. Primary neuroimaging dataset.

5.2 Methods

Control primary image series were grouped by date and type of observation in MicroDicom (http://www.microdicom.com).

The data were processed with open source software, including additional analysis modules. The GIS methods applied in the data analysis are shown in

Table **3**.

Table 3. Data processing methods

Methods	Description	Tools
Contouring	Contouring allows converting raster data to vector. Isoline calculation with a given tolerance is performed using Gdal_contour plugin.	**Gdal_contour** generates a vector contour file from the input raster http://www.gdal.org/gdal_contour.html.
Selection of reference points	Plugin allows extracting nodes from isolines and polygon layers and then outputting extracted nodes as reference points.	**Extract nodes** is a tool for nodes extraction: http://docs.qgis.org/2.6/en/docs/user_manual/processing_algs/qgis/vector_geometry_tools/extractnodes.html.
Georeferencing of image series	To georeference an image, one first needs: to establish reference points, input the known local coordinates of these points, choose the coordinate system and other projection parameters and then minimize residuals. Residuals are the difference between the actual coordinates of the reference points and the coordinates predicted by the spatial model (Figure 13).	**Georeferencer Plugin** is a tool for snapping rasters to single coordinate system with help of reference points: http://docs.qgis.org/2.0/en/docs/user_manual/plugins/plugins_georeferencer.html.
ROIs identification	Subsets of samples of the tumor area are selected as regions of interest (ROIs). Vector ROIs are the basis for next template creation and classification.	**Semi-Automatic Classification** (https://fromgistors.blogspot.com/p/semi-automatic-classification-plugin.html) is a plugin for the semi-automatic supervised classification of images (in the work modified version was used).
Data Classification and Template Creation	DTclassifier helps to allocate data on the image with the same characteristics. How it works: (1)Selecting training datasets, (2)Selecting data to classify, (3)Refining templates.	**DTclassifier** (http://nextgis.com/projects/dtclassifier) is a plugin that allows classification of data in QGIS. It uses a particular classification algorithm - “decision trees” (Murthy, 1998).
Multilayers Comparison	To compare parameter data from different layers the analytical tools of fTools Plugin are used. It provides a growing suite of spatial data management and analysis functions that are both fast and functional.	**fTools Plugin** for analysis functions: http://docs.qgis.org/2.8/en/docs/user_manual/plugins/plugins_ftools.html.

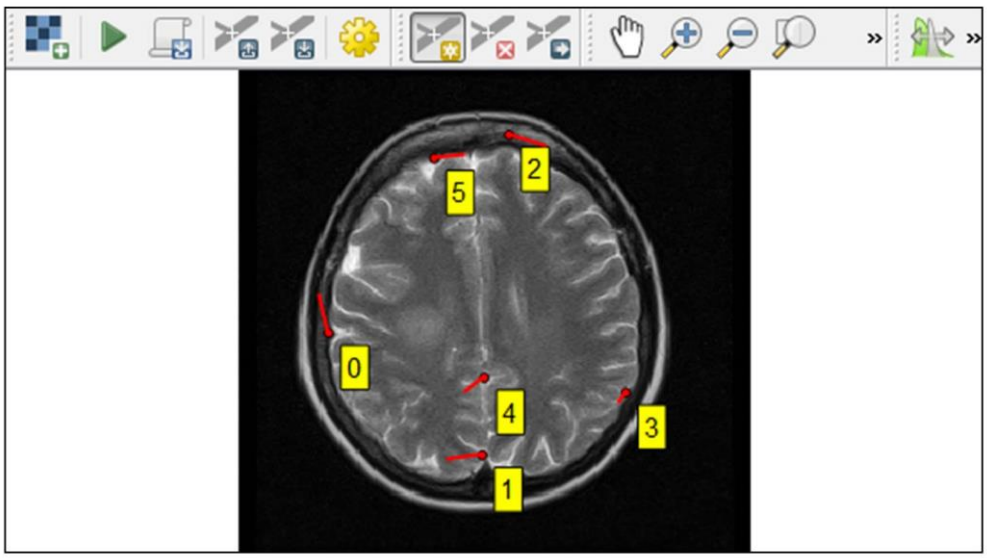

Figure 13. Georeferencer Plugin in QGIS.

5.3 Results

Example of selected ROIs (tumor areas) and comparison of tumor sizes at different times is shown in Figure 14.

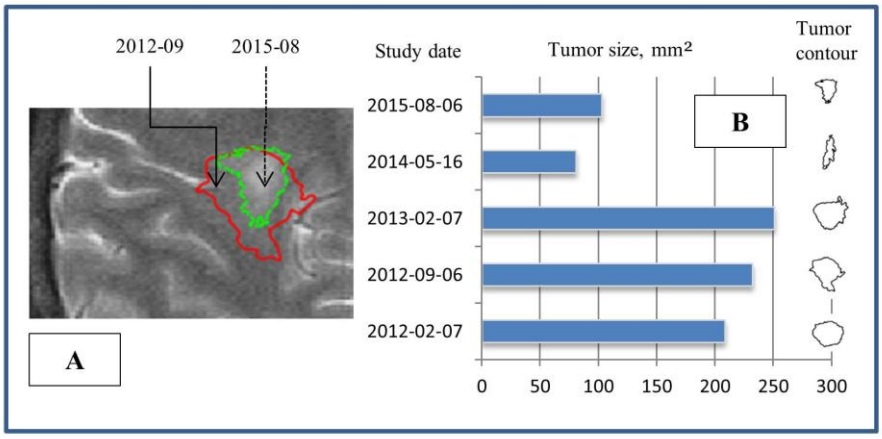

Figure 14. A. Example of selected ROIs (tumor areas). B. Comparison of tumor sizes at different times (tumor contours with maximum section square are shown in the right column).

6. PERCEPTION OF EXTERNAL ROUTES AND INTERNAL TRACTS

6.1 Perception of spatial information

Neuroscientists and geoscientists can actively interact in researching of the brain's perception of external space and the brain's orientation in space.

The study of the brain's perception of spatial information includes a wide range of tasks, including visual object recognition and locomotion.

Using high-resolution fMRI scanning, Peer et al. found that mental orientation in space and time produces a sequential posterior–anterior pattern of activity in each participant's brain (Peer et al., 2015).

Guntupalli et al. presented a linear model of shared representational spaces in the human cortex and models of cortical patterns of neural responses with individual-specific topographic basis functions (Guntupalli et al., 2016).

Neural responses in the visual cortex are governed by topographic mapping from retinal locations to cortical responses. At the voxel population level, early visual cortex activity enables the accurate decoding of stimuli locations (Roth, 2016).

6.2 Positioning systems in the brain

Grid-based methods are well-knowing in geoinformatics. 2D or 3D grid lines define the coordinate system and provide a unique reference to space features (Figure 15).

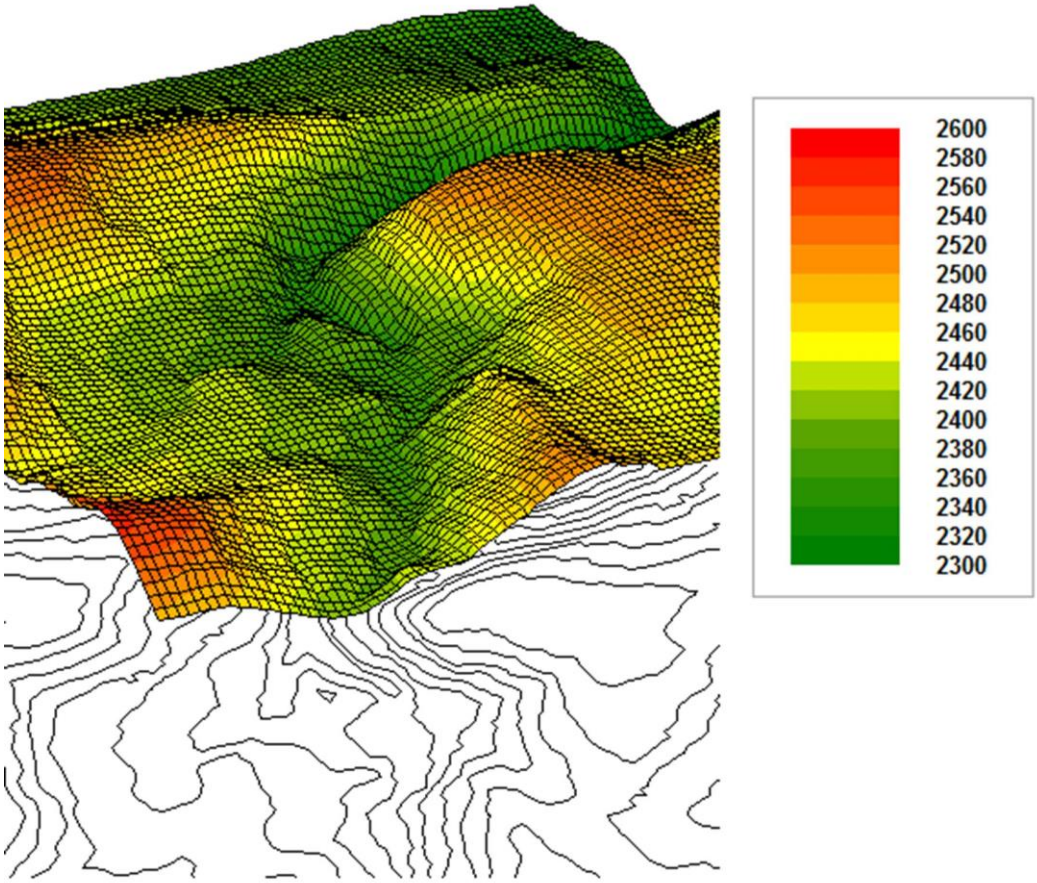

Figure 15. 3D grids and contour lines**.**

Grid reference tools are usually applied in a large number of GIS. These methods seem artificial and invented exclusively for calculations. But as shown in recent studies, the brain itself contains biological structures that are directly responsible for both navigation and recognition (Moser et al., 2014; Stemmler, et al., 2015).

The types of brain cells associated with navigation were summarized by Chersi and Burgess (Chersi & Burgess, 2015). In their review, the authors described the following four cell types: *I*) place cells, which typically fire in a restricted portion of the environment; *II*) directional grid cells or ‘‘conjunctive’’ cells, whose grid-like spatial firing is also modulated by head direction; *III*) head-direction cells, which typically fire in a narrow range of allocentric directions; and *IV*) boundary cells, which typically fire at a specific distance from an environmental boundary along a specific allocentric direction.

In 2014, the Nobel Prize in Physiology or Medicine was shared, with half of the prize awarded to John O’Keefe, and the other half awarded jointly to May-Britt Moser and Edvard Moser “for their discoveries of cells that constitute a positioning system in the brain” (http://www.nobelprize.org/nobel_prizes/medicine/laureates/2014).

O’Keefe concluded that the hippocampus generates numerous maps that are represented by the collective activity of place cells. Results obtained by May-Britt Moser and Edvard Moser confirmed that grid cells are activated in a unique spatial pattern, and collectively these cells constitute a coordinate system that allows for spatial navigation.

Border cells, grid cells, and head-direction cells form the elements of a metric representation of local space, and are likely used when an animal navigates through its environment (Moser & Moser, 2011). In the hippocampus, place cells are remapped when the environment changes (Miao et al., 2015; Colgin et al., 2008).

Unlike place cells, grid cells have several properties that facilitate navigation (Bush et al., 2015). Grid cells recorded at the same electrode location share several metric properties, including spacing, orientation, and field size (Hafting et al., 2005).

The grid cell network is intrinsically organized, with the grid cells clustered in separate, independent grid maps with distinct scales, orientations, and asymmetries (Moser, 2016).

Grid cells provide a metric of the neural representation of space, similar to the way in which head-direction cells provide a directional frame of reference. As a result, each environment is represented by a unique combination of active place cells and place fields (Buzsaki & Moser, 2013).

Model of grid- and place-cells' activity is shown in Figure 16.

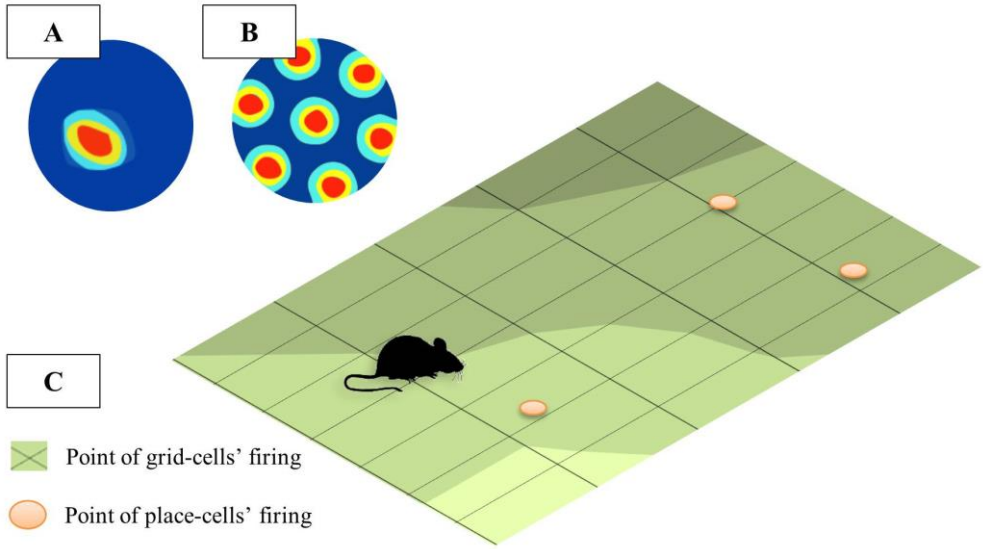

Figure 16. A. Model of place cell firing. B. Model of grid cell firing. C. Model of grid and place cells' activity.

The optimal configurations of spatial scales for grid cell firing in the context of noise and uncertainty were reported by Towse et al., who concluded that such configurations can be changed (Towse et al., 2014).

Oscillatory dynamics and place field maps reflect the processing of sequence and place memory (Cabral et al., 2014). Oscillatory dynamics of grid cells contribute to the processing of space-time, including the speed of movement. Theta-band oscillatory dynamics of grid cell were also described by Towse (Towse et al., 2014).

Optogenetics and pharmacogenetics techniques are used to study individual cells, including grid cells (Miao et al., 2015). Optogenetics uses light to alter neural processing at the level of single spikes and synaptic events, providing a widely adaptable tool for genetically targeted optical control of neural activity (Boyden et al., 2005). These technologies apply light to control biological processes within targeted cells *in vivo*, with high temporal precision, thereby allowing researchers to develop generalized strategies for targeting cells based on morphology and/or tissue topology (Gradinaru et al., 2010).

But results of Krupic et al. provide compelling evidence for the idea that environmental boundaries compete with the internal organization of the grid cell system to drive grid firing. Grid cell activity cannot provide a universal spatial metric in all environments (Krupic et al., 2015).

6.3 Reference points and interpolation in navigation tasks

Our brains are continuously engaged in the selection and construction of a route. Poucet et al.

focus on the information carried by grid cells, their relationship to place cells and the role of grid cells in navigation and also discussed a framework provided by landmark stimuli or by information about motion of animal (Poucet et al., 2013).

To create a generalized representation of space, one must create a cognitive map of the environment by integrating observations over extended periods of time and by inferring spatial structure from perceptions and the effects of his/her actions (Kuipers & Levitt, 1988). The Wayfinding Scale route strategy (Kremmyda et al., 2016) can be used in both spatial navigation and spatial anxiety.

To solve navigation tasks, reference points determine the behavioral strategy for the route, and the perceptions of "place" and "object" are interrelated in navigation. In other words, the parameters of "object" vary depending on the position, and the parameters of "place" vary depending on the objects included.

In 1970, Waldo Tobler introduced the first law of geography (Tobler, 1970), which states "everything is related to everything else, but near things are more related than distant things." This principle can serve as the basis for the spatial analysis of continuous data on the same scale.

Points with well-known attributes can serve as reference points in tasks that lack – or have excess – information. These points can also serve as a basis for creating a generalized coordinate system.

In geostatistical interpolation techniques (for example, kriging), well-known attributes of reference points can be transferred to nearby points.

Deterministic interpolation techniques create surfaces from measured points, (http://desktop.arcgis.com/en/arcmap/latest/extensions/geostatistical-analyst/deterministic-methods-for-spatial-interpolation.htm) based on either the extent of similarity (inverse distance weighted) or the degree of smoothing (radial basis functions).

The interpolation of data regarding the space between points with well-known attributes allows one to create new routes or modify existing routes.

7. CONCLUSIONS

As a result of analogous experiences in spatial data processing, researchers in the neuroscience and geoscience fields communicate in nearly the same language and use similar tools and techniques.

In this review, we summarized the areas of interest common to brain mapping and GIS mapping, including:

- Processing large numbers of images;
- Rapid conversion of coordinates in individual brains;
- Precise positioning of brain activity and neuroimaging data in the map of an individual brain;
- Optimization of classifiers using existing GIS classifiers;
- Modelling of dynamic brain maps and investigating brain connectivity; and
- Positioning and navigation tasks.

8. APPENDIX

8.1 Basic standards

Digital Imaging and Communications in Medicine (DICOM) is a standard for handling, storing, printing, and transmitting information in medical imaging. The DICOM Standard

now specified a network protocol utilizing TCP/IP, defined the operation of Service Classes beyond the simple transfer of data. DICOM was also structured as a multi-part document in order to facilitate extension of the standard. Additionally, DICOM defined Information Objects not only for images but also for patients, studies, reports, and other data grouping (http://dicom.nema.org).

The MNI Coordinate System originated at the Montreal Neurological Institute and Hospital and is used to normalize anatomical 3D datasets.

Talairach coordinates (http://www.talairach.org) is a 3D coordinate system of the human brain, which is used to map the location of brain structures independent from individual differences in the size and overall shape of the brain.

Bias between MNI and Talairach Coordinates is shown in (Lancaster et al., 2007).

A perennial source of confusion in brain mapping has been the small but significant differences between stereotaxic spaces owing to the different strategies for creating the template. The origin of the MNI152 templates is shifted approximately by + 3.5 mm in Z and + 2.0 mm in Y relative to Talairach space. Various methods have been proposed to minimize these differences (Evans et al., 2012).

During the measurements, the sensors occupy a certain position, which can be calculated, for example, in Subject Coordinate System (SCS / CTF) – (http://neuroimage.usc.edu/brainstorm/CoordinateSystems), where coordinates are specified relative to the calculated characteristic points of participants.

8.2 Data exchange standards

The brain is a complex organ consisting of various areas with specialized functions. The cartographic representation provides a conceptual framework for understanding the unique roles of cognitive systems in facilitating behavioral adaptability (Mattar et al., 2015).

Flexible standards regarding data exchange and data sharing are essential for creating robust and meaningful convergent neuroimaging data obtained from different sources. Integration projects such as BrainMap (Laird et al., 2011) have been developed in response to the needs of researchers in the fields of structural and functional neuroimaging.

Gorgolewski et al. attempted to organize and describe the output of neuroimaging experiments (Gorgolewski et al., 2016). Specifically, the authors used the XML-based Clinical Experiment Data Exchange (XCEDE) scheme to provide standards for describing neuroimaging data.

The same group published a practical guide for neuroimaging research (Gorgolewski & Poldrack, 2016). In this guide, the authors cover three major topics in open science (data, code, and publications), and they propose using the Brain Imaging Data Structure to organize data.

8.3 Brain mapping software

FSL (FMRIB Software Library) (http://fsl.fmrib.ox.ac.uk) is a comprehensive library of analysis tools for fMRI, MRI and DTI brain imaging data. It runs on Apple and PCs (both Linux, and Windows via a Virtual Machine), and is very easy to install. Most of the tools can be run both from the command line and as GUIs ("point-and-click" graphical user interfaces).

SPM (Statistical Parametric Mapping, http://www.fil.ion.ucl.ac.uk/spm) software package has been designed for the analysis of brain imaging data sequences. The sequences can be a series of images from different cohorts, or time-series from the same subject. The current release is designed for the analysis of fMRI, PET, SPECT, EEG and MEG.

Loreta (http://www.uzh.ch/keyinst/loreta) is a software for analysis of low resolution brain electromagnetic tomography.

Brain Explorer 2 (http://community.brain-map.org/display/BrainExplorer/Home) is a desktop software application for viewing brain anatomy and gene expression data in 3D.

NeuroVIISAS (neuro Visualization, Imagemapping, Information System for Analysis and Simulation) (http://139.30.176.116/neuroviisas.html) is an open framework for integrative data analysis, visualization and population simulations.

AAL (Automated anatomical labelling) (http://www.cyceron.fr/index.php/en/plateforme-en/freeware) is a software package dependent upon the Matlab and SPM programs, typically used in functional neuroimaging-based research.

NEST (The Neural Simulation Tool) (http://www.nest-simulator.org) is a simulator for spiking neural network models that focuses on the dynamics, size and structure of neural systems rather than on the exact morphology of individual neurons.

Brainstorm (http://neuroimage.usc.edu/brainstorm/Introduction) is a collaborative, open-source application dedicated to the analysis of brain recordings: MEG, EEG, fNIRS, ECoG, depth electrodes and animal electrophysiology.

BrainVISA (http://www.brainvisa.info) provides a complete, modular, infrastructure for neuroimaging software. It helps organizing heterogeneous software and data and provides a common general graphical interface for users.

FreeSurfer (http://surfer.nmr.mgh.harvard.edu) is an open source software suite for processing and analysing brain MRI images.

3D Slicer (https://www.slicer.org) is an open source software platform for medical image informatics, image processing, and three-dimensional visualization. Built over two decades through support from the National Institutes of Health and a worldwide developer community, Slicer brings free, powerful cross-platform processing tools to physicians, researchers, and the general public.

8.4 Brain Mapping organizations

The Organization for Human Brain Mapping (OHBM) (www.humanbrainmapping.org) is the primary international organization dedicated to using neuroimaging to discover the organization of the human brain.

The Human Brain Project (HBP) (www.humanbrainproject.eu) aims to collect, explain and simulate the functions of the human brain at different levels of hierarchical complexity. The HBP idea is to federate and integrate the data, thus making use of an abundance of biological information from the different levels of brain organization. Data mining will be used to extract sets of rules that constitute definitions of homogeneous groupings of patients or subjects (Frackowiak et al., 2016).

The goal of the Blue Brain Project (http://bluebrain.epfl.ch) is to build biologically detailed digital reconstructions and simulations of the rodent, and ultimately the human brain. The project's novel research strategy exploits interdependencies in the experimental data to obtain dense maps of the brain, without measuring every detail of its multiple levels of organization (molecules, cells, micro-circuits, brain regions, whole brain).

International Neuroinformatics Coordinating Facility (INCF) (https://www.incf.org) develops collaborative neuroinformatics infrastructure and promotes the sharing of data and computing resources to the international research community.

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PLANNING, URBAN SPRAWL AND SPATIAL THINKING

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Abstract

The main goal is a reflection on the urban model (urban sprawl). We analyze the most desirable and feasible development model. From the perspective of some commentators, planning is merely a set of relatively narrow regulatory functions concerning the use and development of land. For others however, planning is a much broader creative activity, starting by developing and delivering visions for places, often captured in the term 'spatial planning'. The methodology of spatial planning goes beyond traditional land use planning and seeks to integrate policies for the development and use of land into other policies and programmes which influence the nature of places and how they function. Therefore the result of spatial thinking is the knowledge, skills, and habits of mind to use spatial concepts, maps and graphs, and processes of reasoning in order to organize and solve problems.

Keywords: *Expansion, densification, urban model, urban development, sustainability.*

1. INTRODUCTION

Urban sprawl began in the 50s in the United States during the car boom. Its ideologist was the architect and urban planner Ludwig Hilberseimer, who, like Le Corbusier, proposed separate housing uses (garden city) and offices. A great defender of this model was Frank Lloyd Wright. At that time the car was a symbol of freedom, courtesy of the American dream, and the oil crisis and the harmful effects of CO_2 emissions in the atmosphere were unknown.

In Europe, cities traditionally have complex compact structures, especially due to the existence of a dense historical core formed before the advent of modern transportation systems. Compared to US cities, European urban systems remain relatively compact in many cases. However, European cities have grown rapidly and this has led to the spread of urbanization since 1970. It is a fact that urban sprawl currently affects all European cities (Arellano and Roca, 2010).

Increased spatial mobility in the urban area has become a hallmark of contemporary society.There have been major territorial changes and new residential settlement patterns that have led to urban sprawl (Mejías Vera, 2013).

Rural and urban areas are losing autonomy and territories that reflect a new social reality are being created (Alberdi Collantes, 2013). New forms of semi-urban life are created in the form of residential areas sometimes with golf courses, shopping centers and other amenities (Herce Vallejo, 2015).

Currently, there are two competing models of cities, the compact city and the dispersed city. Examples of the former are Madrid, Barcelona, Paris... cities with a high density and different uses (residential, offices, shops...) (Roca Cladera, Arellano Ramos, and Moix Bergadà, 2011). At the other extreme, in the sprawling city, we have the American city model

with huge residential neighbourhoods of detached houses (Sung, Yi, and Li, 2013). Between the two extremes there are many nuances, as might be the case of Stockholm and its historical city center with multiple uses, connected by railways or tramways to multiple residential neighbourhoods of lower density.

There is consensus on the disadvantages generated by uncontrolled urban sprawl (ADEME, 2001). It can be seen that the lack of planning for growth produces disastrous effects on the city: lack and / or disruption of public transport in different areas of cities, insufficient and inefficient public services, the invasion of land and natural areas; loss of identity and social integration; discouraging urban landscapes; etc (Lahoz Rodríguez, 2010). Thus, in the face of so many examples of urban failure due to uncontrolled horizontal expansion, the premise that expansion ought to be planned is accepted (Lambert, Catchen, and Vogelgesang, 2015).

The assessment of interdependencies between different scales and spaces of a particular area must be one of the basic foundations of any coherent proposal for the planning of a municipality. During recent decades the compact city model has gradually been replaced.

We reflect on two urban models: urban sprawl and the compact city, on the model of urban development and visions of the city we want. We analyse different options to try and find the most desirable and feasible development model for cities.

These two models have multiple effects on the lifestyle of the inhabitants of a city, its economy and the environment. The biggest impact is on the territory itself. A compact city occupies much less than a sprawling one to accommodate the same type of people, both because of the city itself and the infrastructure they need (Burge, 2013). Mobility is an indispensable part of the development of urbanised areas. Due to population density in a compact city, it is economically viable to have a dense network of public transport.

Besides, individual transport, with high fuel consumption (and CO_2 emissions), is made more complicated by lack of parking space. In addition, compact city uses are mixed, so that commuting between home, work and leisure may be shorter (Lavadinho, 2014).

In the sprawled city, a dense transport network is not profitable, so an individual car is essential, with the known environmental impacts (Litman, 2003).

The future calls for Smart Cities –cities where information technologies help reduce the impact on the environment, being more economically viable, and improving the quality of life of their inhabitants (Sultana and Weber, 2014).

1.1 State of the Art

The changes that have occurred in the industrial city and agriculture as a traditional way of life will cause rural land to be used for different purposes (Daghini, 1999; Camarero, 1993).

In Europe in the 50s, there were already examples of this phenomenon. For example, in Germany when large car factories began to function, thus reducing distances between the countryside and cities. In the 60s, there was progressive abandonment from the centers of large cities to the outskirts of cities called periurban areas (Banzo, 2005).

At the end of the twentieth century the urban labyrinth of cities became saturated and thus a revaluation of the peripheral areas occurred, creating both inter-rural and inter-urban mobility. Urban planning of the outskirts of our cities creates a series of bases and strategies for forming the territorial model, in an effort to identify the scenarios in which it operates and territorial and urban planning of municipalities tends to achieve harmonious integrated development (Simón, Zazo, and Morán, 2012).

The main objective of planning is to order the territory (Benabent Fernández de Córdoba, 2016) and this implies, of course, its assessment both as a resource for planning needs and also as a condition of the planning of the city.

Metropolitan processes, defined as those in which close functional and strategic links over a territory that go beyond the narrow municipal limits, require planned implemented and coordinated action between the towns involved (Yamu and Frankhauser, 2015).

2. SPATIAL THINKING AND METODOLOGY

The main goal is a reflection on the urban model (urban sprawl). We analyze the most desirable and feasible development model.

Since the late 1970s, Geographic Information Systems (GIS) have been used by planners, engineers, geologists and others for spatial analysis. Researchers are using data to generate new insights into how the nature of places affects people and communities. Places need to be at the forefront of our responses to these challenges, and so at the heart of policy and decision-making in the twenty-first century (EC, 2010; EC, 2011). Politicians and decision-makers can learn much from the theory and practice of 'spatial planning'

From the perspective of some commentators, planning is merely a set of regulatory functions concerning the use and development of land. For others however, planning is a much broader creative activity, starting with the development of visions for places, often captured in the term 'spatial planning'. Spatial planning goes beyond traditional land use planning and seeks to integrate policies for the development and use of land into other policies and programmes which influence the nature of places and how they function (Saint-Julien, 2001).

Spatial thinking is the knowledge, skills, and habits of mind to use spatial concepts, maps and graphs, and processes of reasoning to organize and solve problems (Gersmehl, 2005). Spatial thinking skills (see Gersmehl and Gersmehl, 2006) are important for investigating a range of environmental issues including land use management in urban environments.

The most important question that a spatial thinker asks is not where? But why? To nurture spatial thinking, we must couple where with why. Most urban areas face the growing problems of sprawl that may result in a loss of natural vegetation, agricultural lands, and open space due to commercial, industrial, and residential development that often occurs because of population growth and expansion. Such growth is often accompanied by a general decline in the extent and connectivity of wildlife and wetland habitat. Land cover and land use changes can be substantial but are difficult to grasp when they occur incrementally (Lagrandeur-Bouressy, 1999). The availability of satellite data and aerial photographs from different periods of time dramatically illustrates the rates at which these land use changes are occurring in urban areas. Analyzing such spatial data over time provides one with a visual depiction of geographic growth patterns, and conveys how changes to the landscape occur.

Many welcome this new attention to spatial thinking and are hopeful for the future. Without spatial thinking, the complex issues facing our world cannot be effectively and completely dealt with. Without spatial thinking, scale may be critical to a problem but ignored.

3. SPATIAL THINKING AND DIFFERENT APPROACHES FOR PLANNING THE URBAN MODEL

We need to assess whether there is any structure or series of spatial structures that maximises fairness and efficiency within an urban system; whether one kind of urban density is more desirable than another, considering the cost/benefit ratio to society (Pelletier and Delfante, 2000).

The most appropriate form of urban growth will be sought for achieving sustainable development of urban societies. It is therefore necessary to rethink the notion of space, and whether it is limited or scarce.

Places of residence and work, as well as other daily activities, are increasingly distant from each other. Therefore, increasingly bigger spaces are experiencing a renewed demographic dynamism as a result of the resettlement of urban families or of newly created households moving to new residential areas. This process has a clear urban and territorial incidence due to the transformation of host areas as a result of urbanization, building and construction of urban infrastructure (Hernandez-Rejon, 2014).

These new spaces have acquired an increasingly greater role in the process of settlement of new population strata, which have either sought uncongested residential environments or have been forced to do so due to the higher price of housing in the city centre (Guglielmo, 1996). In this scenario, the new concept of urban sprawl appeared on the international scene with force; a term used with the original English meaning to encompass all these territorial realities involving the dispersion and diffusion of urban uses for territory (García-Lopez and Muñiz, 2013).

The architects of the Modern Movement foresaw a vertical model and to some degree, a dense city—vertical buildings, embedded in a large public space and as green as possible. A vertical city integrated in nature (López de Lucio, 2000), for example Toronto.

However, European experts now see the *vulgarization* of the ideas of the Modern Movement, which favored the dramatic "housing megacomplex" and the separation of urban functions (zoning) as a major cause of degradation to the model of European city and peri-urban expansion.

In Europe, the periurban agrarian spaces are subjected to the greatest urban pressure: between 1990 and 2000, 77% of the new artificial uses grew in agrarian areas. When analyzing the evolving objectives of spatial planning in the European Union, it is evident that agrarian systems have been given lesser significance. This is neither a consequence of the environmentalist discourse nor the scenario created by the energy crisis, but the consequence of global change and depletion of resources (Hennig et al., 2015; Oueslati et al, 2015). Neither does the Common Agricultural Policy help to preserve periurban agrarian spaces that will play an important role in the future viability of our cities. The establishment of adequate forms of protection, their reconsideration within the planning tools and the enhancement of agricultural activity would reduce urban expectations, slowing down their transformation (Talen, 2013).

Many cities have tried to react to explosive and chaotic metropolitan development generated largely by country–city migration. Each metropolis has even experienced several models over time. Cairo, Egypt, is a good example of the search for various planning solutions to respond to an explosive metropolization (Chaline, 1996): lack of planning, Malthusian logic and rejection of territorial expansion, ordered expansion and densification of alternate poles.

It is necessary to consider the dynamics of peripheral land, speculation both in urban centers and in new areas of urban development, the instruments available to the public sector to influence these decisive trends in the creation of the metropolitan spatial form. For example, the incorporation of privately owned land on the outskirts usually dispersed in low surface land and many owners' hands. This has consequences for urban spatial expansion (Ramirez, 2003).

Suburbanization in the case of Paris, for example, is partly due to the expulsion of the middle class to the suburbs, due to inaccessible rents for housing this population (Comission Européenne, 1999; ADEME, 2001). The great advantage of peripheral metropolitan areas in

every city in the world for both private housing and businesses and industries is not only space, but space at an affordable price.

In recent years and in reaction to both forms of urban expansion that were occurring, and to the degradation of the existing urban fabric, a consensus among European planners about the need for densification, urban recycling and the need to remake the city, was formed. This consensus has gradually spread in global urban media.

In France, the concept was formalized with the law of December 2000, under the name of "renouvellement urbain" (urban regeneration), whose main objective was to "redevelop the city on top of existing urban areas". It consists of guiding urbanism towards the improvement and revitalization of the existing urban areas. The essence of this new urban concept presented in the law is: a new model of development and running of the city, looking to save space and energy, regenerating degraded urban spaces and increasing socio-spatial integration (Journal Officiel, 2000).

This cultural change in urbanism is common throughout Europe. The European Union has been supporting this trend since 1999 in its "European Spatial Development Perspective". The conclusions of analytical work groups emphasized the need to contain uncontrolled suburbanization, that is, a horizontal urban sprawl, and translated the recommendations into the concept of polycentric spatial development (Ascher, 1995, 2001). Territories must be organized into balanced groups rather than a few large metropolitan cities (Hiernaux, 2003).

According to experts, the benefits of a compact city model are: improved public transport services, better provision of public services; reuse of infrastructure and socio-functional mixture; sociability and urban vitality; a favorable business environment, preservation of green areas, saving agricultural land and less complex governance (Wheeler, 2002).

This urban pattern has generated numerous operations both in medium-sized towns and large cities resulting in densification and successful urban renewal i.e. the Guggenheim Museum Bilbao. The Guggenheim Museum Bilbao was conceived as a symbol of the urban renewal process. The building is listed as one of the 20 most beautiful and representative buildings of the twentieth century, stimulating Bilbao to become a major destination for tourism and culture in Spain in only two decades (Fernandez Milan and Creutzig, 2016).

In 1980, Bilbao began a process of urban renewal with important infrastructure such as a public transport system (underground) and the Guggenheim museum as a symbol of access to global culture in brownfields in the city center, so cities in this way attract movement of people and economic activities.

Many cities have followed suit, using striking architectural creativity to densify and reconvert degraded and/or abandoned urban areas, and at the same time position themselves (Powel, 2000). Densification in its vertical expression is a change for innovation in techniques of rehabilitation of old buildings; in terms of harmonious blends between modern architecture and historic architecture; in insertion taking into account the existing urban fabric. The example of the famous tower of the Hongkong Bank by architect Norman Foster (1979-1986) is expressive. The decision to air condition the building with sea water taken from the port, instead of the classic circuits of air conditioning, allowed 25,000m^2 to be saved and compensate for the additional costs incurred in the work in 10 years, as well as substantial environmental benefits in the long term (Pearman, 2002).

In Chicago, the transfer of middle and upper class populations to outlying areas surrounding the metropolis occurred from the 1950s. The intention was to create true urban centres with independent and attractive city centres. In the north, Evanston developed as a result of the introduction of the Northwestern University; Lake Forest was a new city with 35,000 inhabitants following the English model. In fact, the spatial model of university campus, outside cities but near them, extensive, green and closed, is a typical example of this form of urban territorial expansion (Lahoz Rodríguez, 2010).

The new distribution of economic functions tends to promote policentrality in the city, through the emergence of new dynamic urban spaces around shopping malls or modern tertiary economic activities. This is a metropolitan trend that occurs on a global scale. It can be a sustainable way to address metropolitan development and planning. It is essential that the expansion is planned: the same precautions as with the compact model are required (Lambert, Catchen and Vogelgesang, 2015).

The recent urban history of Madrid is interesting because it shows both the negative effects of unplanned expansion poles, as well as a possible way to redirect growth while maintaining the model of growth poles. Since the 1950s urban expansion has been very rapid and uncontrolled because it was extended in all directions except to the west where the Retiro Park served as a border to contain the anarchic urbanization. The peripheral nuclei were born spontaneously, poorly linked to the center, lacking amenities/facilities and made of large housing complexes. This urban system has not been organized and has resulted in the lack of accessibility and services for peripheral poles (Pelletier and Delfante, 2000). Currently, the main axes of the metropolitan planning to limit the negative effects of this phenomenon and simultaneously use the potential of this peripheral expansion are: fewer new housing programs in the satellite nuclei, creation of industrial poles of medium size in suburban Madrid, the implementation of infrastructure (water, sanitation) and a network of fast roads and periphery trains (Roca Cladera, Arellano Ramos, and Moix Bergadà, 2011).

The opponents of the expansion emphasize certain advantages of the compact city model and criticize a form of particular expansion: chaotic and uncontrolled expansion, when the metropolis faced a mass migration. The way in which this type of urban growth took place was very negative and unsustainable—self-construction, land invasion, lack of basic services, socio-territorial segregation. Planners are now more and more in favor of metropolitan development through structured periphery poles (Allmendinger and Haughton, 2010).

In 1961, Jean Gottmann described the emergence of a new urban model he called megacities—a number of cities that were casually contiguous and could merge with the passage of time. The Gottman concept could be applied today in Japan in the urban regions of Tokyo, Nagoya, Kyoto and Osaka. However, there is a fundamental difference between the urbanized northeastern United States (Boston, New York, Baltimore, Washington) where the Gotmman phenomenon occurred spontaneously, whereas in Japan it was carefully planned as the focus of national development. One of the instruments used in Japan was the bullet train linking the mentioned cities which reaches an average speed of about 200km/h.

Spatial thinking must evolve from a culture of urban sprawl towards a culture of management of the buildings. We must move from the negative view of devalued neighbourhoods to a positive view of the opportunities generated by existing neighbourhoods despite their poor condition. Also we have to clearly associate the concepts of socio-economic revitalization with those of urban policy. And finally, it is vital to integrate both private and social sectors into the implementation of the policies designed. It is also important to convince developers of the importance and feasibility of urban development policies.

3.1 Smart growth on the rise

Smart growth promotes a shift in conventional development patterns, and reaches out across disciplines. It is surprising the extent to which a wide variety of professionals, elected officials and individuals recognize that the ability to address development challenges and serious contemporary problems is dependent on a new vision of metropolitan and regional cooperation and an interdisciplinary process.

In response to the increasing popularity of smart growth, several organizations have emerged across the nation. In the mid-1990s The American Planning Association joined 60 public interest groups across the United States to form Smart Growth America, a nationwide coalition that coordinates efforts to promote smart growth. After its debut in October 2000, it rapidly became the focal point for advocacy in a series of issues confronting communities nationwide. Today, it advocates better growth policies and practices at local, state, and federal levels to promote farmland and open space protection, neighborhood revitalization, affordable housing, and the creation of liveable communities. The University of Maryland, in cooperation with Former Governor Paris Glendening and the State of Maryland, created the National Center for Smart Growth. It endeavors to lead the nation in research-based knowledge and education by tackling a wide range of growth, preservation, and development problems (Gavinha, and Sui, 2003).

The ills caused by urban sprawl, both in residential suburbs and in the rehabilitation of important degraded downtown areas, are alleviated by using the "smart growth" formula which sets out the principles for sustainable development and entails a critical review of traditional urban design.

In 1994, as in the Clinton administration, the Department of Housing and Urban Development approved national funding for a seven-year project. Among the main results of the project are two major publications, the guide The Growing Smart Legislative Guidebook (1996) and a collection of working papers Modernizing State Planning Statutes. The Guidebook was intended to be a manual, and practice became the main reference for future initiatives of states. Not only did it include all the recommendations of the federal Advisory Committee, but also provided alternative models of by laws for implementation at state level (Johnson et al., 2002).

Based on the experience of communities around the world that have used smart growth approaches to create and maintain great neighbourhoods (for example, in the state of Massachusetts), the Smart Growth Network developed a set of 10 basic principles to guide smart growth strategies:

- Mixed land uses.
- Taking advantage of compact building design.
- Creating a range of housing opportunities and choices.
- Creating walkable neighbourhoods.
- Fostering distinctive, attractive communities with a strong sense of place.
- Preserving open space, farmland, natural beauty, and critical environmental areas.
- Strengthening and directing development towards existing communities.
- Providing a variety of transportation choices.
- Making development decisions predictable, fair, and cost effective.
- Encouraging community and stakeholder collaboration in development decisions.

Many of the ideas on which smart growth is based are not new. In the past, they were already included in concepts such as "regional growth coordination", "sustainable development", historic preservation and conservation" or even "new urban model". The words "smart growth" suggest less dogmatic action and quickly grew in popularity in an era when the public interest in a problem also depended on a memorable expression (Krieger, 2001).

4. CONCLUSIONS

The development of a city is more than just property management. We cannot manage a city by thinking in terms of a product or the market share. Due to the revolution of communications, a city is nowadays a space for relationships, very often virtual. Urbanism is more than management on paper and should seek an increase in the sense of belonging in citizens and their involvement in the development process of a city.

Importing urban models such as townhouses or terraced houses entails dispersion and fragmentation together with the difficulty to manage the local infrastructure and services let alone assessing its difficulty to coordinate with the principle of social cohesion. Therefore, these models should not be encouraged.

In this regard, it is important to note that new developments should be maintained by all, and conservation agencies (Private), are not a valid or culturally acceptable solution for our cities, therefore when starting a new development, we must not stop at the mere equal distribution of benefits and burdens, we must also contemplate the future management and maintenance of the new development, which will be paid for by all citizens, many of whom probably do not enjoy the same standards of urban quality. It will also be important to consider environmental management criteria on which the urban technique currently counts, for example, minimizing energy expenditure or encouraging water saving.

Another problem is the need for improved relations in the intermunicipality field, or beyond. Neither the territory nor the problems that affect it know administrative boundaries. However, we find that on the other side of the line separating our municipality from our environment, there is a void……nothing. Administratively, our area of responsibility is limited exclusively to the boundaries of our municipality, but from the perspective of planning, our problems and needs cross them significantly.

Most problems affecting sustainability are caused by society as a whole and we must take measures to solve them. This unveils planning as an effective tool since it may be able to establish indicators to diagnose a situation and enable us to monitor it. They must arbitrate financial measures that allow us to act on the problems detected.

It is important to note that many of the mentioned problematic or unsustainable aspects could be overcome through environmental education that leads to concrete actions, thus making planning activities more acceptable to the population.

Smart growth is the development that supports economic growth, strong communities and environmental health. “Smart growth” covers a range of development and conservation strategies that help protect our health and natural environment and make our communities more attractive, economically stronger, and more socially diverse.

Development decisions affect many of the things that touch people’s everyday lives — their homes, their health, the schools their children attend, the taxes they pay, their daily commute, the natural environment around them, economic growth in their community, and opportunities to achieve their dreams and goals. What, where, and how communities build will affect their residents’ lives for generations to come.

Communities of all sizes across the country are using creative strategies to develop in ways that preserve natural lands and critical environmental areas, protect water and air quality, and reuse already-developed land. They conserve resources by reinvesting in existing infrastructure and rehabilitating historic buildings.

They design neighbourhoods that have homes near shops, offices, schools, houses of worship, parks, and other amenities, giving residents and visitors the option of walking, cycling, taking public transport, or driving as they go about their business.

They enhance neighbourhoods and involve residents in development decisions, creating vibrant places to live, work and play. The high quality of life makes these communities economically competitive, creates business opportunities, and strengthens the local tax base.

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THE ROLE OF GEOGRAPHICAL MAPS IN TERRITORIAL DISPUTES BETWEEN JAPAN AND KOREA

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Abstract

Geographic maps and cartographic representations have become the new battle arenas where countries contest claims regarding territorial ownership, the exact location of borders and the names of disputed places. This paper analyzes the role of traditional and digital maps in asserting national identity and reinforcing claims of ownership by examining the case of *Dokdo Island* (South Korean name) or *Takeshima Islands* (Japanese name). According to the research findings, both countries understand that maps from earlier imperialistic periods have no legal value in proving their claims of sovereignty. Nevertheless, both make extensive use of historical maps as perceptual and propaganda weapons in order to gain a moral advantage in presenting their territorial claims as well as to shape the collective national consciousness.

Keywords*: Geopolitics, Google Maps, cartography, border disputes, political maps.*

1. INTRODUCTION

National identity and defined territory are two important components in establishing a sense of nationalism. The myths of a particular nation emerge from the association between these two components, and its maps serve as a tool for expressing this association.

Geographic maps, and particularly political maps, are educational tools (Leuenberger & Schnell, 2010; Pickles, 1992) that exert a great deal of influence in shaping or changing worldviews. Maps help create national narratives and affect how national images, power relations and values are formulated. Moreover, they influence knowledge perception and interpretation and the cultivation of distrust in the other in the context of territorial claims. Thus, the appearance of a nation's maps is of prime importance in how readers interpret these maps (Austin, 2012).

Critical cartography research began to develop toward the end of the 1980s. Geographer J. Brian Harley was the first to develop theories regarding the significant power of cartography as well as the subjectivity of cartographers, who cannot avoid representing their own worldviews and social and cultural values in the maps they produce (Harley, 1988). According to Harley, "maps are the products of power and they produce power." In contrast to the scientific view that sees maps in essentialist terms, Harley cast maps as social constructions and as expressions of power/knowledge (Kitchin & Dodge, 2007).

Today cartography is based on aerial and satellite photographs and on engineering and mathematical calculations. For this reason, people think of it as an exact science and tend to trust maps (Monmonier, 1996; Wood, 1992; Wood, 2010; Leuenberger & Schnell, 2010). Yet research by geographers, historians, cartographers and political scientists who have continued

to develop Harley's theories has cast doubts on the ostensible objectivity of cartography (Collins-Kreiner et al., 2006; Crampton, 2001; Kosonen, 2008).

Research studies have attempted to examine maps in the cultural context of their producers them according to the mappers' motives, the publishers' interests, the sponsors' policies, the public's expectations and the balance of powers in the society that produces and uses them (Wood, 1992; Agnew, 1999; Harley, 2001). These studies led to increasing recognition that not only are maps culturally misleading, they also must be understood as part of a deeper ideological-political reality (Leuenberger & Schnell, 2010; Pickles, 2004). Maps provide a point of departure for interpretations of reality. The cartographers who explain this reality are subjective human beings whose work is influenced by their political and cultural perceptions (Harley, 1990; Monmonier, 1996; Crampton, 2001; Pickles, 1992).

The term "map" has also been used in psychological and intellectual contexts. Mental or cognitive maps reside in our emotions or in our minds and are therefore not visible. These maps have a major impact on determining how individuals make vital decisions, such as how to choose a place to live and or work, how to decide where and how to spend their leisure time, how to navigate through the city and how to plan their morning route to work (Portugali, 1996).

While cognitive maps are personal and generated in the mind of each individual, some groups share similar cognitive maps. For example, the collective maps shared by national groups, ethnic groups, social groups and the like resemble a common language, and members of different groups are likely to build different maps describing the same phenomenon or the same territory. Collective maps usually that are an integral part of the culture in which people live. These stereotypes are indeed influenced by distinctions between groups, but their primary influence derives from the ways groups relate to one another. When the interests of two groups are at odds, negative stereotypes will emerge (Ager, 1978; Pickles, 2004).

To reiterate, maps describe power relations and worldviews (Culcasi, 2006). Maps can convey "made to order" reality that transcends physical reality, thus turning maps into powerful political tools. This conveyed reality encompasses demands of civilian or military authorities to censor or cover up certain topics or to stress national, economic, political or social issues (Andersson, 2013). National states, the supreme sovereign bodies in the modern age, understood the constructivist power of maps so that until recently cartography was nationally administered (Meishar-Tal, 2014).

In disputes, maps serve as perceptual and propaganda weapons in putting forth the territorial claims of each party. Those who commission the maps deliberately exploit cartographic tools to design maps intended to deliver their messages and create their own “truth.” These maps focus only on those facts or apparent facts likely to shape the observer's worldview or those in line with the direction desired by the one who commissioned the map (Herbert, 2011). Mark Monmonier’s iconic book *How to Lie with Maps* (Monmonier, 1996) demonstrates how and why mapping is manipulated.

Conflicts over territorial ownership, the exact location of borders and the labeling of places on maps exist almost everywhere in the world and constitute one of the most sensitive geopolitical issues in international relations. Google's technical adviser notes that the company has received at least 250 complaints from various countries regarding where borders should be placed and how place names should be marked on Google Maps (Jones, 2008). Often the parties involved in a conflict argue over the exact location of a borderline or over territorial ownership, each basing its legal arguments on maps they believe prove the legitimacy of their claims (Weissberg, 1963; Turnbull, 1993). The parties to the dispute tend to use maps as evidence of their ownership over disputed land/territory or as evidence of the exact location of borderlines between countries (Hyung, 2005). Hence, maps can constitute a decisive legal factor in settling international disputes (Kaikobad, 2002).

International courts and courts of arbitration are aware that in many cases the "reality" represented on maps is not objective and consequently tend to disregard map-based evidence as proof of territorial ownership. Official maps prepared and certified by official government bodies receive similar treatment. Therefore, in every case where a written agreement between countries contradicts what is shown on the map, the written agreement is binding (Hyung, 2005; Austin, 2012).

Most research involving geopolitical analysis of maps has considered traditional maps drawn on paper. Today, however, the public gets most of its information from online maps available on the internet (Andersson, 2013). Cartography has shifted to a digital environment and the internet now makes it possible to produce and disseminate maps easily and quickly. These maps are more current and include information from new and diverse fields. In contrast to traditional maps, the digital environment also enables users to use interactive tools and other functions (Meishar-Tal, 2012). In addition, capabilities for enlarging maps and adding additional layers of information have eliminated limitations on the amount of information displayable on printed maps. Digital maps therefore have a greater impact on people's worldviews and opinions. Moreover, digital maps have made people more aware of their geographic surroundings and thus increased their regional geopolitical consciousness.

Google Maps and Google Earth were first launched in 2005. With over one billion users each month, they are now the world's most predominant source of cartographic knowledge (Gravois, 2010; Google, 2011; *The Economist*, 2014). Now that maps are online and can take advantage of satellite imagery, they are more detailed, accurate and multi-dimensional than ever. Recent studies (Crampton, 2009; Sheppard & Cizek, 2009; Gravois, 2010) show that Google has taken over map production from sovereign nations and is undermining their authority in mapping their territory (Meishar-Tal, 2014). Google, a US-based company, must conform to United States security regulations, such as rules regarding the resolution of its maps. Yet the company has autonomy in making decisions with respect to marking borderlines and labeling place names (Quiquivix, 2014).

The entry of Google and similar companies into the field of mapping constitutes a new milestone in the development of power relations deriving from changes in the sources of map production. Google’s cartographic technology, which enables the creation of information layers on maps, provides countries, organizations or stakeholders with the possibility of tagging information on maps and even of using the layers as a platform for political propaganda by creating maps displaying virtual conveyed reality. Thus, digital maps have become a new battle arena between nations embroiled in territorial disputes, with each party to the dispute submitting maps compatible to its point of view (Quiquivix, 2014).

The issue of labeling names on maps requires cartographers to be particularly sensitive (Azaryahu & Golan, 2001). In many cases, place names symbolize independence and are a source of national pride. They express ownership and a sense of belonging and serve as an ideological tool for establishing sovereignty (Pickles, 1992). Indeed, names express power relations and the labeling of places on the map makes a political statement. Mappers seek to win the trust of map users and hence cannot avoid references to places that are the subject of sensitive geopolitical disputes.

Since the launch of Google Maps, circumstances have forced its creators to provide multiple interpretations of the Earth’s geography and to adjust these to the sensitivities of global geopolitics (Google, 2009). Google's technical advisor notes that Google must seek cartographic solutions for approximately 250 international conflicts regarding borderlines and place names (Jones, 2008). Of these, Google is having difficulty finding cartographic solutions for 32 border disputes (Yanofsky, 2014).

Google claims it attempts to maintain neutrality and objectivity in the hope of meeting the expectations of most map users (Google, 2009). Yet this is not always possible. As a result of

Google's attempt to remain neutral in international geopolitical disputes, 32 countries today do not have clearly delineated borders on Google (Yanofsky, 2014). Moreover, in an attempt to avoid taking sides in sovereignty disputes, Google tries to use only local names recognized by certified international bodies, such as United Nations publications (though many countries also suspect the UN of having political interests) (Mclaughlin, 2008). Another Google solution is to mark the borders between countries using a special line indicating disputed borders. Sometimes Google even refrains from marking the border, as in the case of the map of China appearing on local servers in China (Jones, 2008).

This paper examines the political use of geographic maps in struggles over territorial ownership and national identity, as well as the solutions Google has chosen to avoid being party to territorial disputes. To exemplify this point, the paper discusses the case of the dispute between Japan and Korea over ownership of *Dokdo Island* (South Korean name) or *Takeshima Islands* (Japan's name) and the disagreement between these two countries over the name of the Sea of Japan.

2. THE DISPUTE BETWEEN JAPAN AND KOREA OVER OWNERSHIP OF *DOKDO ISLAND* (SOUTH KOREAN NAME) OR *TAKESHIMA ISLANDS* (JAPANESE NAME).

The disputed area is a group of islands situated between Japan and Korea. Both countries claim ownership of this small group of volcanic islands (total area 0.2 square kilometers) located in the Sea of Japan (Japanese name) or in the East Sea (Korean name). This group, situated 215 kilometers from Korea and 250 kilometers from Japan, contains two large islands and around 30 small islets. The region is abundant in fish and apparently has natural gas reserves as well. Today the islands are under Korean rule and constitute the last territory remaining in dispute between Korea and Japan since the peace treaties signed at the end of World War II.

The two countries' conflicting claims of territorial ownership of the islands find expression in three areas: contrasting interpretations of historical facts regarding ancient historical ownership of the islands; contrasting interpretations regarding the legality of Japan's annexation of the islands during its war with Russia in 1905; and contrasting interpretations of the peace treaty signed between Japan and Korea in San Francisco in 1951.

Both countries claim long-lasting historical ties to the islands. Both corroborate their major claims through a variety of documents and historical maps. Moreover, each country attempts to undermine the historical claims of its opponent.

The Japanese base their territorial claims (Ministry of Foreign Affairs of Japan, 2013) on documents dating back to the 17th century showing that the islands were part of Japanese territory and were used for fishing and as hunting grounds for sea lions (Hyung, 2007). From the cartographic perspective, Japan offers a variety of historical maps to prove its ownership of the islands. The oldest such map, drawn by Japanese cartographer Nagakugo Sekisui, dates back to 1779 (Ministry of Foreign Affairs of Japan, 2015). Japan claims that the Japanese government reaffirmed its sovereignty at the beginning of the 19th century and subsequently when Japan re-annexed the islands to the Empire in 1905. Therefore, according to Japan, Korea's annexation of the islands in 1952 violates international law because the islands are not included in the territory returned to Korea according to the 1951 Treaty of San Francisco (Sean, 2005).

The Koreans base their historical claims on documents dating back to the sixth century CE, on maps describing the borders of Japan in 1667 (Barber, 2015) and on a wide range of maps, mainly from the 18th and 19th centuries (Van Dyke, 2007). Korea demands international recognition of its sovereignty over the islands since it gained political

independence in 1945. For Korea, the Dokdo/Takeshima conflict can only be understood from the perspective of its experience as a Japanese colony. Japan formally annexed the Dokdo/Takeshima islets in February 1905, five years before Korea was effectively forced to surrender its entire territorial sovereignty to Japanese colonial control. The period of Japanese rule lasted 35 years, from 1910 to 1945, when Japan surrendered after World War II (Bowman, 2014). Korea questions the legality of Japan's annexation of the islands during the 1905 Russo-Japanese War, stressing that Japan's ownership claims derives from a continued tradition of Japanese colonialism and imperialism.

In 1952, Syngman Rhee, president of South Korea, unilaterally decided to extend Korea's territorial waters and its economic borders (Ministry of Foreign Affairs of Japan, 2015b). The new border, marked on the maps as the Syngman Rhee Line, in effect annexed the chain of islands to Korea (Ministry of Foreign Affairs of Japan, 2013). This boundary line gave rise to the current territorial dispute between the two countries (Sakamoto, 2013), which after 65 years only appears to be getting stronger.

Several times since 1954 Japan has asked to bring up this territorial dispute for discussion in the International Court of Justice (ICJ) (Miller, 2014), but Korea has consistently refused (Ministry of Foreign Affairs of Japan, 2015C). The official Korean position is that there is no dispute about the islands since they are an integral part of Korean territory both for geographical and historical reasons and by international law. Over the years, Korea has taken a number of steps intended to increase its effective control over the islands. It stationed security forces there, built a lighthouse and a pier, issued stamps with a map of the islands, registered residents as Korean citizens, built a museum and developed tourism to the islands.

In response to these Korean actions, in 2005 Japan began celebrating Takeshima Day to mark Japan's 1905 annexation of the islands. Textbooks are also a weapon the propaganda war between the countries (*Japan Times*, 24/11/2014). In April 2014, the Japanese Ministry of Education issued a directive (*Nikkei Asian Review*, 07/04/2015) mandating the development of new geography and history curricula by 2016 to expand and underline claims that the islands are an integral part of Japanese territory (*Japan Times*, 07/04/2015). This directive immediately aroused sharp protests and anti-Japanese demonstrations in Korea (Reynolds, 2015).

As noted, in recent years digital maps have also become a new field of battle between these two countries. The conflict focuses primarily on how the islands are labeled on maps. Mappers' choice of which name to use for the islands reinforces or weakens the parties' claims of territorial ownership. Maps are seen as perceptual and educational weapons in the territorial claims of each of the parties to the conflict. As such, they are intended to influence worldwide public opinion regarding the territorial dispute. Hence, the foreign ministries and activists in both countries are engaged in mutual attacks regarding the naming of the islands on maps.

As noted, Today Google is the world's largest provider of online maps, and Google's decision to label a place with a particular name is seen as siding with one party to the conflict. Google claims that it strives for neutrality and has recently developed a creative solution: the names of the islands that the citizens of each country see on the maps are in line with their geopolitical perspective. Thus in the case of the territorial dispute between Korea and Japan, Korean citizens see the Korean name Dokdo (Figure 1) on Google Maps, while Japanese citizens see the Japanese name Takeshima (Figure 2). In contrast, those who open the international site for Google maps (google.com) see the name Liancourt Rocks (Figure 3). This name is ostensibly neutral because French whalers gave it to the islands in 1849 and therefore it does suggest the territorial ownership of either of the disputing countries. Both countries object to Google's creative solution and its attempt to remain neutral in the dispute, claiming that the name on the map must represent the sovereignty over the islands.

Unlike Google Maps, Microsoft's search engine Bing Maps attempts to overcome the dispute and maintain neutrality by labeling the islands with all three names (Figure 4).

Figure 1. Map of the islands on Google Korea[1].

Figure 2. Map of the islands on Google Japan[2].

Figure 3. Map of the islands on Google International[3].

Figure 4. Map of the islands on Bing Maps[4].

The Japanese government's dissatisfaction with how Google labeled the place names on its maps led it to officially ask local government authorities and universities to stop using Google Maps and to use only maps produced by the Geospatial Information Authority of Japan on which the names were compatible with Japanese Foreign Ministry policy (*Japan Times*, 28/09/2013). The Japanese Ministry of Education also warned teachers not to use unauthorized study materials, among them maps that labeled disputed territories with names that are not Japanese (*Japan Times*, 04/03/2015).

The government of South Korea sharply protested against the Apple Corporation for labeling the islands on its iPhone maps using both the Korean and the Japanese names (*Korea Times*, 11/01/2012). It also launched an extensive public campaign against Google, which decided in 2012 to replace the Korean name Dokdo on its American portal with the name Laincourt Rocks (*Korea Times*, 11/01/2012). In 2012, diplomatic tensions between the two countries worsened when the president of South Korea visited the islands. This first visit of a South Korean president to the islands underscored the country's increasingly nationalistic trends. Some claim that this visit was primarily to boost the president's popularity before the elections. A document prepared by the United States Department of Defense claims that the visit was also a Korean protest against Japan's unwillingness to take responsibility and pay

[1] https://www.google.co.kr/maps/@37.2404575,131.8632536,6010m/data=!3m1!1e3?hl=iw (10/09/2015)
[2] https://www.google.co.jp/maps/@37.2377873,131.8686318,3103m/data=!3m1!1e3?hl=iw(10/09/2015)
[3] https://www.google.com/maps/@37.2415623,131.8658815,15.24z?hl=iw-IL (10/09/2015)
[4] https://www.bing.com/maps/#Y3A9cTY3dHpwdnpzY2czJmx2bD0xMyZzdHk9YiZxPSVENyVBMSVENyU5QyVENyVBMiVENyU5OSUyMCVENyU5QyVENyU5OSVENyU5MCVENyVBMCVENyVBNyVENyU5NSVENyVBOA(10/14/2015)

reparations for using Korean women as comfort women prior to and during World War II (*Japan Times,* 04/03/2015B). In response to this visit, Japan recalled its ambassador from Seoul.

Korean Airlines has also taken an active role in the national effort to represent the Korean narrative to the dispute, using maps to reinforce the national ethos and create a perceptual map of the political space. On flights from Seoul to Tokyo, the airline makes sure to show the disputed islands on the flight map using the Korean name (Dokdo), even though they are insignificant based on their physical size (see Figures 5-6).

Figure 5. Asiana Airlines flight map.

Figure 6. Korean Airlines flight map.

3. DISPUTE OVER THE NAME OF THE SEA OF JAPAN

Japan and Korea also disagree about the correct name of the sea separating the Korean peninsula from Japan (see Figure 7). The Japanese refer to this sea as the Sea of Japan, while the Koreans call it the East Sea. North Korea uses an even more nationalistic name: East Sea of Korea (Lewis, 2012). This dispute is not connected to security or territorial issues or to economic interests but rather to matters of historical memory and national pride.

Source: Sizemore 2014.

Figure 7. Location of the Sea of Japan.

As of today, most international maps and documents use the name Sea of Japan. The International Hydrographic Organization (IHO), an international organization whose main purpose is "to ensure their countries' charts and maps are up to date and compliant with international standards" (Hayashi & Ramstad, 2012), determined this name, which is now internationally accepted.

In 1992, Korea launched an extensive international campaign to change the name from Sea of Japan to East Sea, or alternatively to mark both names on international maps. This campaign continues until today. Japan rejects the Korean demand, claiming that the name Sea

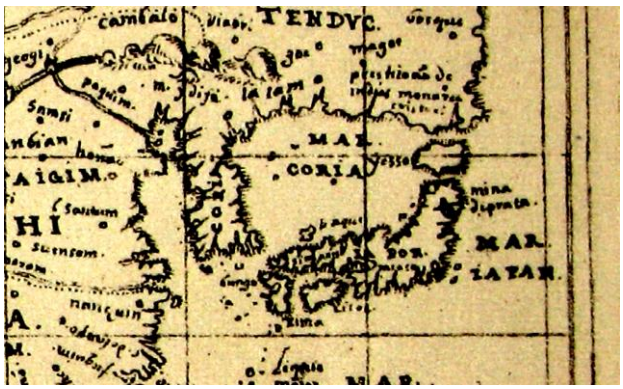
of Japan is the only recognized and authorized international name (Ministry of Foreign Affairs of Japan, 2009).

According to Korea, the Japanese demand to refer to the East Sea as the Sea of Japan arose only at the beginning of the 19th century with Japan's increasing military strength, colonial expansion and control over Korea in the period 1910-1945 (Ministry of Foreign Affairs of Japan, 2003a). For the Koreans, the use of the name Sea of Japan symbolizes a period of colonial humiliation. In contrast, the government of Japan claims that the name Sea of Japan was used in China and in Europe from the 16th century. By the end of the 18th century, when Japan was still an isolated country, the name Sea of Japan was commonly accepted in Europe. In support of its arguments, the Japanese government presents historical maps dating back to 1602 using the name Sea of Japan (see Figure 8).

Source: Ministry of Foreign Affairs of Japan 2003.

Figure 8. Map printed in China in 1602, with the name Sea of Japan printed in Chinese characters.

According to Korea, Matteo Ricci's 1602 map of the world (Roshstein, 2010) already uses the name East Sea and a map from 1615 uses the name Sea of Korea (see Figure 9).



Source: Korean Ministry of Foreign Affairs 2014.

Figure 9. Portuguese map from 1615 with first use of the term Sea of Mar Coria (Korea).

To establish their claims, both countries use historical geographical evidence based mainly on research on ancient maps, though research results yield contradictory data. Korea claims that it examined 228 maps in the American Library of Congress and that 66% of these maps used the name East Sea (Hayashi & Ramstad, 2012; Korean Ministry of Foreign Affairs, 2014). According to the Ministry of Foreign Affairs of Japan, its survey of historical maps covered many more maps than the Korean survey and therefore is more reliable (Ministry of Foreign Affairs of Japan, 2002). The Japanese survey examined 1728 historical maps, and 77% of these used the name Sea of Japan (Hayashi & Ramstad, 2012).

Korea made its first demand to change the name on maps in 1992 at the Sixth United Nations Conference on the Standardization of Geographical Names (United Nations, 2007). Since then, Korea has raised this issue at every possible international forum. In 2012, Korea brought up this issue at the International Hydrographic Organization conference. The IHO decided to defer the Korean request and to discuss it again at its next meeting in 2017 (*Japan Times*, 03/05/2012).

According to the Ministry of Foreign Affairs of Japan, the name Sea of Japan is the only internationally approved name. Beginning in 2004, the United Nations also recognized this name as the official geographic term. Moreover, the UN objects to using both names—Sea of Japan and East Sea—at the same time (Ministry of Foreign Affairs of Japan, 2009).

The U.S. Board on Geographic Names (BGN) officially recognizes the name Sea of Japan and objects in principle to the use of two different names for one geographic region in order to avoid creating confusion (North Pacific Ocean, 2008). The State Department also adopted this decision (NEXTGOV, 24/04/2012).

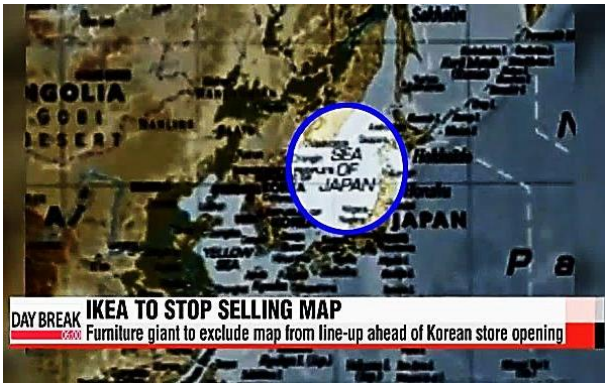
Since the end of 1990, the Koreans have been the publishers of atlases, maps, dictionaries and encyclopedias as well as on travel guides and newspapers to use the name East Sea or to use both names. This Korean pressure seems to be having an impact (Lewis, 2012). In recent years, more and more maps and atlases have added the name East Sea alongside the name Sea of Japan (Figure 10) (Korean Ministry of Foreign Affairs, 2009).

Source: worldatlas

Figure 10. Use of both names has become more common.

Korea has applied additional political pressure in regions of the United States with large Korean communities, for example the state of Virginia. The residents of this state used their political power to pass a bill requiring that new textbooks printed in the state use the Korean name East Sea instead of the name Sea of Japan. The name East Sea reflects the Korean perspective because in Japan the sea is on the west. This is based on the claim that the name Sea of Japan was unfairly imposed when Korea was under Japanese occupation (Bidwell, 2014). Supporters of the name East Sea also claim that exclusive use of the name Sea of Japan undermines Korean claims of ownership of the Dokdo Islands.

Korea chalked up another victory in 2014 when the Swedish company IKEA stopped distributing a large wall map of the world because it used only the Japanese name of the sea (see Figure 11).



Source: *Korea Times* November 18, 2014

Figure 11. Map of the world that IKEA removed from the shelves.

In the current political climate, it is unlikely the two countries will reach a consensus regarding the name of the sea, thus making it difficult for cartographers to draw the maps. Google found a creative cartographic solution to this conflict, similar to the one used in the dispute over the name of the Takeshima/Dokdo Islands. Citizens of each of the countries see the name of the sea according to their geopolitical worldview (see Figures 12-13). In contrast, on Google's international site (google.com) the sea is labeled as the Sea of Japan.

Figure 12. East Sea as labeled on Google Korea[5].

Figure 13. Sea of Japan as labeled on Google Japan[6].

4. SUMMARY

Territorial disputes between countries seem more compatible with 19th century history than 21st century diplomacy. Yet such disputes have the potential to threaten relations between nations. Such is the territorial dispute between Japan and Korea over a small group of islands. This dispute may seem petty in that it focuses primarily on control over territorial waters, fishing rights and perhaps natural gas, but when taking into consideration the harm it has caused to the bilateral relations between these two nations, the conflict is definitely significant. These two groups live in the same geographical area, and each has created its own cognitive map. Each is aware of the existence of the other entity, but pays no attention to the other because each embraces and abides by its own nationalistic social order.

[5] https://www.google.co.kr/maps/@39.8151133,127.5244424,2968935m/data=!3m1!1e3?hl=iw
[6] https://www.google.co.jp/maps/@35.8713311,128.76793,3106473m/data=!3m1!1e3?hl=iw

Geographical names often have serious implications for the perception of a nation's identity, culture, language and history. Thus, finding a proper name for the body of water between the Korean peninsula and the Japanese archipelago is not just a question of changing the name of a geographical feature. It is rather a part of Korean national efforts to erase the legacy of the colonial past and to redress the resulting unfairness. The emotional weight that South Korea attributes to the issue of territorial ownership of the Dokdo Islands exemplifies the strength of historical memory. This memory unites the Korean people without regard for their political leanings, a rare occurrence in a country that itself is embroiled in ideological and political disputes. Indeed, the hatred for Japan seems to be the only topic on which the two parts of the divided country agree.

Both sides to the conflict present a variety of geographical maps, some hundreds of years old, to prove the justice of their claims, despite their understanding that these maps in essence have no legal value. Moreover, both sides understand that modern perceptions of sovereignty and borders cannot be based upon maps from former imperialistic periods. International courts and arbitration courts also are aware that modern maps are not always objective in presenting reality because cartography has the ability to represent conveyed reality. Thus, courts tend to disregard maps when discussing countries' territorial claims.

In view of this understanding, the two countries' widespread use of historical maps has several other objectives. Maps serve as perceptual and propaganda weapons. They offer a significant moral advantage in presenting the territorial claims of each of the sides. Moreover, they serve as a tool for influencing world public opinion regarding territorial disputes. Maps are also intended to establish an internal political sense of creating historical justice. In a conflict, maps also serve as an ideological tool for educating and shaping ideological perceptions and the collective national consciousness. Thus, the countries make sure to use the "right" maps in their educational systems.

This paper has focused on the sensitivities of Japan and Korea in labeling the names of the Sea of Japan and the Dokdo Islands on maps. The two countries understand that the choice of toponyms appearing on maps is of dramatic geopolitical significance. For each country, these names are major symbols of independence and national pride. For each, the names express ownership and belonging and serve as an ideological tool for establishing a perception of sovereignty. Naming places on the map is also a political statement, for names express the balance of power in a particular space.

Circumstances have forced Google's mappers to offer multiple interpretations of the Earth's geography and to adapt these to global geopolitical sensitivities. Google's policy is to attempt to avoid taking sides in disputes by labeling places using local names and displaying the maps in each country in accordance with its citizens' perspective. Thus, in the dispute over the names of the islands, Google offers three different versions of the map, with each version geopolitically appropriate to the residents of the country that open the digital map. Yet the solution of providing several versions of the map is not acceptable to the countries claiming complete ownership of the territory. Both Japan and Korea strongly object to Google's cartographic solution and have reservations about providing two names on the map. This objection derives from their unwillingness to compromise on territorial matters. Thus, both sides see Google, which chooses the names shown on the map, as the enemy.

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LANGUAGE AWARENESS IN GEOGRAPHY EDUCATION: AN ANALYSIS OF THE POTENTIAL OF BILINGUAL GEOGRAPHY EDUCATION FOR TEACHING GEOGRAPHY TO LANGUAGE LEARNERS

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Abstract

The current migration and refugee flows and increasing linguistic heterogeneity in German social science classes has changed teaching. It is a change towards language-aware teaching. The article assesses the question of how bilingual geography teachers' language perception could help to develop language-aware geography education. The hypothesis is that bilingual teachers, due to the simultaneous teaching of content and language, develop and use detailed language awareness in geography. A model of the language in geography classrooms, which defines requirements of language actions there, is presented. 16 bilingual geography teachers in secondary schools in Germany were interviewed over six months to assess their language awareness by a qualitative analysis referring to the model. The results show that bilingual geography teachers assume key values related to language-awareness in geographic language. These results strongly allow discussion of language-aware implications, particularly in terms of structuring, visualization and transparency of discourse functions.

Keywords: *Geography education, language awareness, bilingual geography.*

1. INTRODUCTION: THE IMPORTANCE OF LANGUAGE AWARENESS

The Europe, and particularly the German-bound, global migration process has led to a recent increase in the number of pupils of all levels with a migration background. The German government estimated that at least 800,000 refugees arrived in Germany in 2014 and 2015 (BAMF, 2015), which included 300,000 children. These child refugees are now attending school in Germany (BAMF, 2015), a right they have according to Article 28 of the Convention on the Rights of the Child (United Nations, 1990). In 2014, one third of all pupils in Germany had a migration history, which is expected to continue increasing (BAMF, 2015).

In the flow of refugees into the country there is a new degree of responsibility to integrative thought. Integration and successful participation happens through language. A lack of supportive language tools in schools for teachers and pupils discriminates against children arriving and already living in the country, in terms of chances in education and life

(Becker-Mrotzek et al., 2013; Vollmer & Thürmann, 2013; Budke & Weiss, 2014, Gogolin et al., 2011).

As a consequence, the concept of language education in schools has undergone a paradigm shift from language support to consistent language education in all school subjects (Gogolin, 2007; Kniffka, 2010; Gogolin et al., 2011). Formerly, it has been the responsibility of language subjects such as German or English to establish basic language competences. In consistent language education these subjects specify their language requirements in order to develop appropriate language-aware teaching methods. This tendency towards a special awareness of language in subjects has found its way into didactical term of language-aware subject teaching, which positions itself within integrational and educational goals. Some didactical thinking can be found in other national teaching and curricular studies such as teaching social studies for English language learners (Cruz & Thornton 2013; Cruz, 2014; Becker-Mrotzek et al., 2013; Vollmer & Thürmann, 2013; Budke & Weiss, 2014; Gogolin et al., 2011; Weber, 2010).

Budke and Weiss define language-aware geography teaching as "teaching which considers requirements in language regarding the understanding and responses to geographic issues in the lessons based on the pupils' learning conditions" (Budke & Weiss, 2014, p.14). Geographical education is a language-based process. Language is the core medium through which geographic content is received, processed, and produced, and therefore how it is learnt. Due to the mainly monolingual curriculum in Germany Geography is taught almost entirely in German. The meaning of language and the importance of linguistically support for pupils who need language will not decrease. Increasingly this leads to classroom in which highly differing learning conditions, particularly in terms of communicative skills, are present (Becker-Mrotzek et al., 2013). Teaching geography with language awareness becomes a pivotal issue when reflecting, reviewing, and planning geography lessons. Consequently, we need to specify what geographic language is.

2. RESEARCH QUESTION

The goal of this article is to analyze competences in one area of geographical education; bilingual, content and language integrated learning (CLIL) in geography teaching, an area that has already been used and proven in terms of its effectiveness to simultaneous teaching of content and language in geography.

In this article the language awareness of bilingual geography teachers is analyzed to identify specific language requirements in geography education and practical ways to support pupils with relatively poor language skills to satisfy these. The work therefore provides answers to the research questions: to what extent do bilingual teachers have language awareness of language in the geography classroom? To what extent can language awareness be used to structure requirements and support strategies for language-aware teaching in monolingually taught geography lessons?

After a short analysis of research in bilingual geography teaching, in order to introduce the beneficial potentials of bilingual teaching for language awareness (Section 3), a model of language in the geography classroom is presented in Section 4. This theory-based model intends to structure the requirements of language, pupils need to achieve in the language-aware geography classroom. The model is based upon communication and language research in geography, educational standards in geography and language in the subjects' research. Finally, the empirical work and results are presented, in which the language-aware concepts of the model are referred to in order to give implications for teaching with language awareness in geography.

3. INTEGRATION OF LANGUAGE AND CONTENT LEARNING: BILINGUAL GEOGRAPHY IN THE GERMAN SCHOOL SYSTEM

In Germany, geography lessons are generally taught in the official language of German. However, some secondary schools offer bilingual geography education. The CLIL (Content and Language Integrated Learning) approach has widely been accepted (in the European) context as a concept of language mediation in subjects, and has been researched relatively extensively for 20 years (Kniffka & Roelcke, 2016; Dalton-Puffer & Smit, 2013; Haataja, 2010). Dalton-Puffer and Smit 2013 maintain that a central characteristic of CLIL is that it is a foreign language approach packaged into content teaching. The foreign language is not a traffic and every-day language beyond the institution. It is a dual-focused approach in which an additional language is used for learning and teaching both content and language (Marsh, 1994).

Bilingual subject teaching is an integrative language and content learning approach in German schools, which is not clearly distinguished from CLIL approaches, since it bears many similarities (Werlen, 2006; Kniffka & Roelcke, 2016). Bilingual geography is defined as teaching and learning in two languages, in which parts of the geography subject is taught in a foreign language, primarily English or French. The foreign language develops to be the main working and learning language, the profile language, although L1 languages can be used for some units (Meyer, 2010). Bilingual teaching builds on pupils' prior knowledge of the foreign language and leads them in a step-by-step process to subject-specific, methodical, and communicative skills in the foreign language. Teaching a foreign language in this manner stabilizes the language learning process, expanding language skills, vocabulary, learning strategies concerning authentic texts, and competences in methodical geographic work. Although the subject's content is the decisive element, language is learned naturally, alongside speaking and writing about relevant themes, without omitting content.

The essential target of bilingual geography teaching is that pupils gain the same geographic skills and satisfy requirements during the bilingual teaching as they would during a monolingual (German) subject teaching (Ministry of Schools and Education, 2012; Müller & Falk, 2014). Since there might be units that demand the full use of German as the language of education and work, pupils gain a terminological bilingualism, which is a central guideline of (German) bilingual subject teaching (Meyer, 2009; Ministry of for Schools and Education, 2012; Meyer, 2010).

Previous research in Germany and throughout Europe (e.g., DESI, 2008), have investigated bilingual programs in schools. Longitudinal comparative studies of learning outcomes, such as DESI, state how effective bilingual education is in fostering communicative competence. The results of a survey by the European Council among graduates of bilingual classes confirmed the positive results and a high degree of satisfaction among participating pupils and schools (DESI, 2008; Breidbach & Viebrock, 2012; Ministry for School and Education, 2012). Increased competency in a foreign language through the use of CLIL was unambiguously confirmed by the DESI study. Pupils in classes taught bilingually gained a foreign language competence that was more than two years ahead of that of fellow pupils who had only been taught the language in regular language lessons (Breidbach, 2007; DESI, 2008; Müller & Falk, 2014). Possible restrictions in teaching geographic content and competences in bilingual geography lessons have also been analyzed (Golay, 2005; Passon, 2007), whilst Viebrock (2007) and Meyer (2003) identified the benefits with regards to intercultural learning.

Research on bilingual geography therefore either focuses on the extent to which the content of the subject matter is equally acquired in both mono- and bilingual lessons (Golay, 2005; Passon, 2007; Meyer, 2003), or on the development of foreign language competences

(DESI, 2008; Kniffka & Neuer, 2008). Consequently, language competences are improving in CLIL teaching and the content is integrated with a high level of confidence. This characteristic makes the CLIL lessons an appropriate tool in which to search for competences in the integration of migrant pupils in regular, monolingual classes in German, where they will face the challenge of learning German, the language of geography and geographic content simultaneously.

To date, a desideratum for using bilingual geography teaching concepts to specify geographic language requirements regarding consistent language education has occurred. These requirements are needed to plan and change monolingual lessons and will be assessed in the following model.

4. THEORETICAL FRAMEWORK: MODEL OF LANGUAGE REQUIREMENTS IN THE GEOGRAPHY CLASSROOM

What does communication and language mean in geography classes? The model (Figure 1) provides an overview and visualization of language registers and concepts of language competences relevant in schools and beyond, and which are considered in consistent language education. The model illustrations how these registers connect to language in geography classrooms. This overview of registers is necessary since language in geography is not an entirely new language register or competence, but rather arises out of given registers with certain geographic specifics explained subsequently.

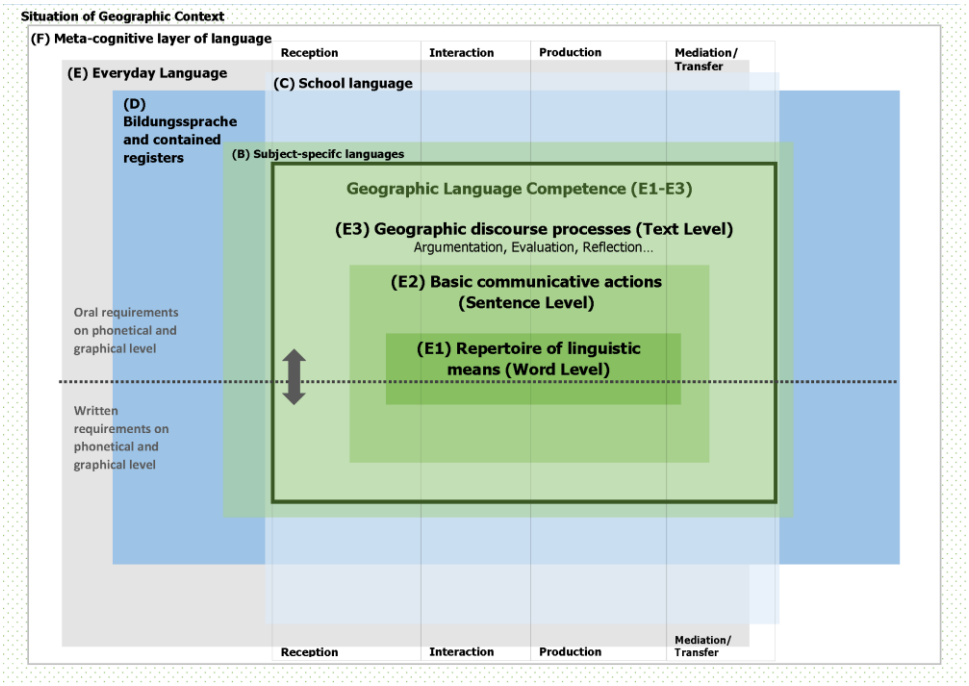

Figure 1. Model of Language Requirements in the Geography Classroom

4.1 Structure of the model

The model can be seen as a profile of a cube. The outside layers contain the areas of layers inside them. The area of space the layers assume represents the theoretical extent of the registers in school usage. All layers are placed on the basic ground layer visualized with small dots (Geographic Content Layer). This means that all language requirements in

geography and their connection to characteristics of other registers happen in the action of geographic context.

Another decisive element in the model apart from the register layer is the four columns of receptive, interactive, productive and mediation, and transfer skills (CEFR, 2011). These aspects structure the language requirements in terms of their executive performance in the classroom, explained subsequently.

The model intends to structure language requirements in geography classes. It allows identification of communication skills pupils need to satisfy language requirements. This structure will enable planning and use of suitable teaching strategies, for example the integration of scaffolding processes (Gibbons, 2002). The explanation starts with the utmost layer (F) and ends with the concept of geographic language competence in the core of the model.

4.2 Meta-Cognition of Language (F)

Layer (F) represents the encompassing layer of meta-cognition in language awareness. This area contains both skills necessary to describe characteristics of different language registers used in school and beyond, skills to mediate between them, and the awareness that different requirements are connected to these registers. Furthermore, meta-cognition of language awareness in the geography classroom includes the analysis in a cultural context in the classroom, a particular teaching situation, discourses in the class situation, and knowledge of the structures of languages in classrooms (Vollmer & Thürmann, 2013; Becker-Mrotzek et al. 2013; Kniffka & Roelcke, 2016).

4.3 Everyday language (E)

Everyday language is relevant in geography education because geography is concerned with a number of socially relevant problems (Budke et al. 2016; DGfG, 2016). These problems are also discussed in everyday life and through everyday language beyond school life. Moreover, words, particularly in human geography, can be considered closer to everyday language than key words in other subjects (Budke et al. 2016; DGfG, 2016; Morawski, 2016).

Everyday language can be helpful in supporting a speaker's intentions and can add precision to speech, especially for younger pupils in geography. Wygotski and Rincke consider that subject-specific language cannot simply be seen as accomplished and developed everyday language (Wytgotski, 1979; Rincke, 2010), and everyday language can and should be developed independently. Examples of highly developed everyday language could be obtained through a populistic scientific approach, where a documentary or presentation of another domain makes it understandable (Wytgotski, 1979; Rincke, 2010).

Cummins (1991) offered another approach for the connection between everyday language skills and language in subjects and in the context of schools. He used his BICS (basic interpersonal communicative skills) and CALP (cognitive academic language proficiency) concept as a distinction of competences, not registers, to make teachers aware of and reflect upon challenges migrant children meet in school. Further, he pointed out that the acquisition of CALP takes longer than the acquisition of everyday language, and that a high fluency in everyday language or BICS does not ultimately mean high cognitive skills in subject-specific language.

4.4 Bildungssprache (D)

The term *Bildungssprache (D)* has one of its origins in educational political answers to the question of how gaps, which arise from differences and disparities due to varying language performance of different social groups can be closed (Gogolin, 2007, Gogolin et al., 2011). Habermas explained *Bildungssprache* as traffic language between sciences, whilst Bourdieu classified it as belonging to social, cultural capital (Habermas, 1981; Bourdieu, 2001). Our understanding of *Bildungssprache* here follow a Petersen and Tajmel (2015) explanation where *Bildungssprache* is considered to be how topics of everyday life and science can be expressed clearly, completely and reasonably alongside one another. To achieve such a combination of language pupils need appropriate vocabulary, to accomplish clarity and independence in situations, and for appropriate grammatical structures (reasonable form). *Bildungssprache* mediates between science, specific knowledge and everyday life but is not understood as subject-specific language. Since geography education is part of school and therefore language requirements are created there, it uses *Bildungssprache.*

Bildungssprache is a register based on textual actions and textuality, such as the use of the passive voice or certain modal constructions. Feilke (2012) relates how *Bildungssprache* has not been created for learning but is used epistemically; it is integrated and happens in context. Further research into the specification of linguistic characteristics and functions of *Bildungssprache* has been performed by Vollmer & Thürmann (2013), Gogolin (2011), Schmölzer-Eibinger (2013), Kniffka & Roelcke (2016), Scarcella, (2008), Bailey & Heritage (2008) and Morek & Heller (2012).

Those teaching any school subject must reflect on the implicit content and requirements of that subject should facilitate their responsibility to participate in teaching *Bildungssprache* by identifying given specific language requirements.

4.5 School language (C)

School language (C) is a communicative practice in the context of schools for L1 & L2 learners, which leads pupils to subject-specific language and Bildungssprache (e.g. Kniffka & Roelcke, 2016, Feilke, 2013). It is constructed for didactical purposes (Schmölzer-Eibinger, 2013; Feilke, 2013; Feilke, 2012) and describes the exclusive use of language specific to schools, specifically language produced in schools and used for educational purposes. Teachers decide which language is used and accepted and in which language knowledge is transferred and acquired. These decisions create specific expectations and requirements regarding the language use that lead to a function of selection purpose (Schmölzer-Eibinger, 2013; Feilke, 2013; Feilke, 2012). Therefore school language contains practical approaches, maxims and requirements, and is often influenced by teachers', often subjective, expectation of the subjects and outcomes with respect to evaluating the language performance and actions of pupils.

4.6 Subject-specific language / Language in the subjects (B)

The *subject-specific language* or *language in the subjects* (B) debate investigates coherences between all subjects and language-based learning on a meta-cognitive, language reflective layer (Michalak, 2014; Feilke, 2012; Budke & Meyer, 2015; Vollmer & Thürmann, 2013). Subject-specific language defines itself through functional characteristics such as clarity, anonymity, economy, and comprehensibility. Each subject-specific language differs from other subject-specific languages in its vocabulary, structure, thematic varieties, and characteristics of texts (Roelcke, 2010). Roelcke (2010) speaks of a general subject-specific

language competence that L1 and L2 learners can achieve, which allows pupils to overcome subject-specific barriers and challenges in everyday situations, and enables the analysis of decentralization, differentiation and dynamisation of language in subjects.

Another approach to assess language in subjects is the use of content-obligatory vs. content-compatible language (e.g. Snow, Met & Genese, 1992). Every subject has its own content-obligatory language associated with its specific content. This content-obligatory language includes subject-specific vocabulary (e.g., meander or estuary in geography) and the related grammatical structures and functional expressions needed to communicate subject knowledge and take part in interactive classroom tasks. Content-compatible language is the non-subject specific language which learners may have learned in their German classes or from everyday language.

Subject-specific language, *Bildungssprache*, school language, and everyday language all use overlapping elements. For example, in a transcribed interview by a refugee or YouTube broadcast pupils can pick up geographic information, such as pull or push factors and living conditions, and formulate this information into professional subject-specific language.

4.7 Columns of language actions in the geography classroom (Reception, Interaction, Production, Mediation/Transfer)

These columns refer to tasks involved in communicative actions in geography. These actions are based on the Common European Framework of Reference (CEFR) for Languages, which divides communicative requirements in actions of reception, interaction, production and mediation. One of the CEFR's targets is *"to promote research and development programs leading to the introduction, at all educational levels, of methods and materials best suited to enabling different classes and types of pupil to acquire a communicative proficiency appropriate to their specific needs"* (CEFR, 2011). The CEFR explains and structures requirements in language learning, concepts which are established and recognized on a large-scale throughout Europe.

What do these columns mean for the geography classroom? The first reception column, includes the reception of orally or textually received input in the language-aware geography classroom. If pupils need to orientate themselves in the given linguistic, textual, and thematic context, they need strategies to cognitively filter and decode the information they receive in order to choose certain communicated content later on. Such information includes the linguistic, visual and semiotic code of maps (Budke et al. 2016; Wiegand, 2006; Kölzer, Lemke & Michalak, 2015; Ullrich et al., 2012; Hemmer et al., 2010 DGfG, 2014) and diagrams (Michalak & Müller, 2015).

The second column, interaction, is a reminder that pupils put their filtered, chosen, communicated content into thematic and social contextualization via cooperative interaction with other pupils, their teacher and thematic correlation in the geographic context. Pupils need to address the content via reasonable language for the specific listener. This interaction is complex in terms of dialogues and dialogic teaching since it takes place on many levels simultaneously. In this dialogic structure pupils negotiate relationships and construct identities, whilst also negotiating their geographic understanding (Kane, 2014, p.463).

The third column, production, encompasses skills needed for pupils to produce oral or written texts from processed geographic information. The column includes the use of geographic terminology and vocabulary, geographic relevant statements appropriate to the subject, the situation, audience/target group, and the knowledge of a linguistic coherent structure of text forms (description, argumentation, analysis), in which statements are organized and presented,

The fourth column, mediation/transfer, relates to transferring communicative content to other relevant issues, or the use of acquired knowledge to explain other geographic issues. The column is relevant to the area of communicative thematic transfer. Linguistic transfer, on the other hand, reflects how the acquired information is transformed into other forms of representation (e.g. figures into maps or diagrams). This transformation needs the linguistic and structural knowledge of components or other textual representations.

These columns should be seen as intertwined as they are dependent on one other. For example, interaction needs receptive and productive skills. The columns intend to clarify the focus of teachers' language support in particular language support situations.

4.8 Meeting the requirements: Geographic language competence (E)

The concept of language in geography (E) is concerned with the specific geographic requirements of language in geography education. Previously there has been little empirically-based research focused on specific communicative requirements in geography classrooms (Budke & Weiss, 2014, p.14; Müller & Falk, 2014; Michalak & Müller, 2015). Budke and Weiss (2014) define language-awareness in geography as teaching that considers language requirements necessary for the understanding of and replies to geographic issues in lessons, which depend on the pupils' learning conditions (Budke & Weiss, 2014, p.15). Here, language in the geography classrooms is approached in the two ways.

The first one is to structure geographic language into the level of words (E1), sentences (E2) and of whole texts (E3). Situations of supporting teaching and learning geographic language can be positioned effectively within this structure. E1 includes the acquisition and usage of geographic key words. This structure relates to occurrences and requirements in material such as key words or glossary. E2 contains the construction of sentences, what can be supported and related to by material, such as useful phrases in scaffolding processes or model texts. E3 then deals with the training of whole oral or written texts, including the coherence and characteristics of these texts in the geography classroom, e.g. normative argumentation in space conflicts or evaluation of maps.

The second one refers to geographic discourse processes, therefore how geographic language is constructed in the geography classroom which will be elaborated in the following. For that it needs to be explained that the use of language, by the teacher or the pupil, in geography can be performed conceptually written or conceptually oral. These performances are to be seen as a continuum, e.g. an example of a dialogue between pupils in a cooperative group work task on the side and the perception of a school book article on the other side. Further the way pupils medially perceive language is important and can be divided in two ways, e.g. if they perceive it phonetically via sounds or graphically in form of letters in a text or symbols and colors, such as in maps. To put that in perspective in geography education often visual information is mediated alongside textual information. It is often the case that pupils are supposed to filter information out of a material mix, such as maps, pictures, diagrams, charts, movies and texts in order to respond to the central issue of the lesson. This procedure means that students have to be able to decode and produce different linguistic codes out of different channels of perception. The model, particularly in E1-E3, illustrates this differentiated modes of performance and perception in geography. A reaction to that is necessary in terms of lessons planning and reflection to support pupils linguistically while they are dealing with the codes and channels.

In the following, as mentioned, the construction of language in geography will be elaborated:

4.8.1 Repertoire of geography-specific linguistic means (E1)

This repertoire can be related to areas of analysis such as vocabulary, grammar, semantics, pragmatics, pronunciation and spelling (also see Vollmer & Thürmann, 2013, p.47). Vocabulary means subject-related, subject-specific geographic terms. Subject-internal terms are those words that have an exclusive geographic meaning and are used exclusively in geographic contexts, for example, city model, gentrification, cash crops, desertification or shifting cultivation. Brown and Ryoo state here that science words serve as resources for understanding concepts at higher levels of specificity (Brown & Ryoo, 2008). Key words in geography often have another meaning in everyday language. For example, city; when using this term, geographers are directly referring to characteristics of cities such as building density and job opportunities, its predominantly secondary and tertiary business sector, or its internal, functional structure. In everyday language and life, pupils might be referring to cities as places to meet their friends or go shopping or to the movies.

Further relevant areas are grammar, semantics, and pragmatics. In the geography classroom, grammar contains structural subject-specific features such as the discontinuity of texts e.g., in maps or diagrams. By referring such language to the dimension of pedagogical arrangement, practices and methods of teachers are integrated into the context of the rule complexities of geographic-specific grammatical occurrences, and how verbalizing discontinuous text relate to grammatical performances (Graus & Coppen, 2015).

Semantics integrates the meaning found and created by signs and symbols, for instance in discontinuous geographic material such as maps und diagrams (Budke et al., 2016; Wiegand, 2006; Kölzer, Lemke & Michalak, 2015; Ullrich et al. 2012; Hemmer et al. 2010 DGfG, 2014; Michalak & Müller, 2015). Pragmatics could explain how the linguistic expressions in geographic content are meant and understood, for example in comparison to sociologist, how do geographers understand the term city, or when compared to the mathematics, how is converging understood in terms of graphs or plates. The use of geographic subject-specific language is bound to mental availability for geographic specific terms and vocabulary.

4.8.2 Basic communicative actions in geography (E2)

Vollmer (2011) provides a description of key speech acts linked to cognitive operations that are essential to all learning situations and social communication. They are divided in the model between E3 and E2 according to whether they function on a macro-, miso- or meso-level. The latter two levels are contained in E2. Vollmer's general discourse functions are naming, describing, narrating, explaining, arguing/positioning, evaluating, and simulating/modelling. These functions offer a framework for expected language in various oral or written school genres and for different expected complexities and characteristic function on varying levels. For geography education in Germany these key speech acts are determined by national standards and operators, with a focus on communicational structure of lessons and competence-oriented learning situations. In Germany geographic operators are structured into three criteria related to requirements, which increase in complexity simultaneously. The first is Reproduction (e.g., describe, name etc.), the second Re-organization, transfer and reflection (e.g., analyze, explain etc.) and the third Problem-solving (e.g., evaluate, judge) (DGFG, p.32; Roelcke, 2010). Fulfilling these criteria enables pupils to achieve subjective language requirements by linguistically performing in lessons. The requirements can range from topically abstract, theoretical, and general requirements (e.g. evaluation of the phase model of gentrification) to concrete, practical, and generic requirements (e.g. description of price development of real estate in parts of Berlin).

On the meso- and micro-level, basic actions can be partly related to macro-functions in E3. A micro-function such as describing, defining or summarizing, which we understand here as basic communicative actions, can be seen as an action that is partially required in the macro-function of explaining or arguing a geographic topic. Macro-functions do not necessarily need part functions from meso- or micro-actions, but stand in loose but logical and overlapping relation (Vollmer, 2011).

4.8.3 Geographic discourse processes (E3)

Geographic discourse processes is the most complex and highest requirement pupils can satisfy and it naturally requires the application and comprehension of the requirements of E1 and E2. Referring to prior, generic ideas posed by Vollmer (2011) and Budke & Weiss (2014) the following requirements determine and specify geographic discourse processes, and enable pupils to participate in the discourse of language and the construction of meaning in geography.

(I) Processing: Geography introduces learners to accepted ways of speaking and dealing with subject-related themes in a particular classroom culture, which is relevant to visual and discontinuous material. Both discontinuous texts, such as non-linear, non-continuous texts in geography classrooms, and visualizing aspects play an important role in geography education research focusing on language awareness. Discontinuous texts can be divided in logical visualizations (tables, diagrams, charts, maps) and figures (drawings, pictures) and are often used in combination with text (Huber & Stallhofer, 2010). Research that has tried to specify linguistic requirements in visual, discontinuous material has looked at competence in producing, decoding, reading and evaluating maps, discursivity of maps, reflection on maps, evaluation and decoding of diagrams (Hüttermann, 2012; Haubrich, 2010; Budke & Kuckuck, 2015; Schnotz, 2001; Michalak & Müller, 2015). This research has shown that pupils need skills to deconstruct visual, discontinuous, symbolic textuality, such as competence in reading a map, if they are to communicate (Hemmer, Hemmer & Hüttermann, 2010, Hüttermann, 2012; Haubrich, 2010; Budke & Kuckuck, 2015; Schnotz, 2001; Michalak & Müller, 2015). Consequently, language actions to decode visual, conceptual textual geographic texts and auditory, conceptual, oral geographic texts within social discourses are necessary. Important aspects of this means an understanding in terms of geographic textuality and strategies, such as elaboration or exemplifying, and the verbalization and decoding of other geographic media. Such geographic media includes development and use of linguistic strategies to compare and connect information of different media and transfer (discontinuous) cartographic, visual, symbolic, and statistic information into language.

(II) Critical geographic application: Teaching geographic discourse processes leads to a state in which pupils are able to analyze and reflect upon material that hey come across, from which pupils can decide if this given information in this particular presented medial form is appropriate to a certain discourse or for use in answering a question for which they were considering the inclusion of the material. Understanding and performing geographic discourse processes means becoming aware of the discourses and discourse functions in geography and working successfully with and in them. Skills such the ability to explain why a perception of space is articulated in a certain way are needed for language to be used in critical reflection, for example and to maintain recipients' interest. This includes the autonomous development of geographic issues and acquisition of geo-literacy as a source of inspiration to reflect upon identifications on cultural levels (Galani, 2016). Moreover, geographic argumentation skills play an important role for critical geographic application in discourses and conflicts. The subject of geography does not exclusively deal with doubtless and unambiguous content, but rather relates to various figures of argumentation. In

geography argumentations are often open in their results and normative, whilst factual arguments are relevant. Specific criteria of geographic arguments are reference to space, multi-perspectives and complexity (Budke & Meyer, 2015, Toulmin, 1996, Kuckuck, 2014).

The next chapters explain the research undertaken, in which interviews were used to analyze language awareness used by bilingual geography teachers and their concept of how content and language integration fits into the presented discourse of language in geography. Finally, implications for the language-aware monolingual geography classrooms are discussed.

5. RESEARCH DESIGN

5.1 Methodical Choice

How bilingual geography teachers interpret and analyze geographic language is part of their subjective interpretation of the subject geography. Previously, qualitative analysis involving interviews was used to understand these processes (Mayring, 2015; Rohracher, 1976; Barton & Lazarsfeld, 1979).

For intersubjective traceability, it is not technical knowledge but rather knowledge of processes and particularly knowledge of interpretation and explanation that are relevant here. Of interest here is acquiring knowledge, such as the structures of teaching actions in relation to their attitudes towards subject-specific language and even implicit patterns of perception and diagnosis. Acquiring this knowledge is where expert interviews gain empirical strength and have advantages over quantitative work (Bogner, Littig & Menz, 2005, p.21; Kaiser, 2014; Helfferich, 2011). Subjective strategies involved in teaching bilingually and the attitudes of the bilingual teachers are highly complex. Consequently, the process of monitoring alone would have been too restrictive (Bogner, Littig & Menz, 2005).

5.2 Material

Qualitative interviews are a mixture of open and structured conditions (Kaiser, 2014). A thematic basic structure alongside a research question with general, open questions specified in the dialogue was used. This meant that interview could follow the fluency and flow of the expert's replies, questions could be adapted and re-organized based on the interviewer's decisions to focus on research targets, and further questions could be created to investigate further information relevant to the research. The objectives of the research question were therefore made to be measurable, so that the results could be referred back to the theoretical requirements and concepts of the model (E1-E3, Figure 1). This objectification to practical contexts was undertaken in three steps, visualized in Table 1. The entries in the figure are to be seen as exemplary and therefore do not contain every element used. The dimensions of analysis (1) identify measurable, observable phenomena contained in the research question. These dimensions are transferred to the complex of questions (2), which lead to the interview questions (3). These questions were filtered through a theoretical system to establish how the professional subjective routine knowledge of teachers is acquired (also see: Section 3). The registers and layer of the model (Figure 1) were used to sharpen the analysis dimensions and guide the question complex.

Table 1. Processing of questions with selected examples

Research Question	Dimension of Analysis (1)	Complex of Questions (2)	Example of Operational Interview Questions (3)
To what extent do CLIL teachers have language-awareness of geographic language and communication, and to what extent can it be used to sharpen general geographic language demands?	Concepts and opinions of geographical language	Awareness of repertoire of geographic linguistic means	Explain how important you think it is for students to learn geographic terms?
	Personal attitude towards the importance of language competence teaching	Awareness of integration of discourse literacy	Could you explain how you integrate methods of teaching geographical terms in you lessons?

5.3 Sample and Pre-Test

Identical selection criteria were used to select two teachers for the pre-test and a further sixteen for the main data collection. The aim was to have a specific, closed group but with broad variation within the group: The sample contained typical cases with a maximum of differences. The group heterogeneity prevented generalizations from being made too quickly. Contrasting extremes in terms of age, experience and role in teacher training were also include in the sample. A saturation of the sample was reached when no new information could be added with regards to decoding. Only teachers who teach bilingual geography in English and German, and who have a degree in these subjects, were interviewed due to a need to obtain a reflective view on the geographic language concept. The interviews were conducted in German and translated into English by two English teachers for this article.

The following criteria were used for selection of teachers to be interviewed: 1) Recommendation from headmaster/-mistress, other teachers and/or pupils concerning excellence in terms of language education; 2) Teachers who had taught bilingual geography in secondary schools in Germany for at least two years and had English and (monolingual) Geography as subjects; 3) A balanced age level representative of experience in relation to whole sample and; 4) Inclusion of teacher trainers to benefit from their mediation and teaching experience.

The results of the pre-test, which consisted of two interviews, were presented to members of the institute on a symposium, and the number and structure of the questions were discussed. The interviewers' understanding of the questions was checked, as was continuity of the interview structure and the impact of the structure and interview duration. These pre-test result checks of the questions and the main consensual discussion led to the main framework of the question catalogue being reduced.

5.4 Categorical Decoding

The interviews ranging between 45 and 120 minutes and were fully transcribed to ensure that, the analyzing processes could be referred to and checked with reference to the original material. Complete and internally concluded statements of teachers in the transcripts were used as analysis units as they tend to be more precise and more informative than single sentences or paragraphs. Categorical decoding was performed via an initial deductive set of categories on the basis of the analysis dimension and complexity of questions, which was based on the author's and co-author's experience and on subject-specific language and foreign language teaching research. The openness of the analysis was guaranteed by inductive, text-based developed categories for decoding statements that did not fit into the

deductive categories. This openness from the inductive categories was needed for personal attitudes, institutional influences, and thematic specifiers categories that were identified during the qualitative analysis of the transcripts. The co-author and author consensually tested and agreed on the category system using two transcripts. Table two shows the final inductive and deductive set of categories and sub-categories, and the number of items assigned to these categories. Interrater reliability was then established by comparing the congruency with category assignments for all transcripts by another researcher. Statements were then connected by analysis strategy summarization by two researchers (Mayring, 2015).

Table 2. Assigning of Data

Category	Number of items congruently assigned to the category by author and co-researcher (Cohen's)	Sub-Categories
1. Teacher's understanding of and attitude to bilingual teaching of geography	375 of 447=0.83	a) Values and attitudes of teachers and awareness of geographical language b) Goals / Wishes c) Coherence of language and content
2. Creation and planning of learning and teaching arrangements	918 of 1047=0.87	a) Teaching Methods b) Didactical planning and decisions (Reception, Interaction, Production, Mediation) c) Media / Material d) Handling of difficulties e) Working with pupils (choice of topics, internal differentiation)
3. Comparison of language support strategies between subjects	215 of 280=0.76	a) English and Geography b) Bilingual Geography and German c) Language teaching and subject teaching d) Language support related to geographic topics
4. Linguistic difficulties of pupils	51 of 75=0.68	

6. FINDINGS

Bilingual geography teachers tend to specify their concept of geographic language according to the creation of communicative situations in the classroom and their values and criteria of successful language actions. The next sections deepens this assumption and the model of geographic language will help using the findings to specify geographic language requirements in the model (Figure 1, E1-E3).

6.1 Teachers' values and criteria in terms of geographic language

An essential value that guides the teachers' routine in bilingual geography lessons is the *content before language approach*. It clearly separates subject teaching from language teaching. Consequently, communicational processes and the fostering of communication competence in applying content is seen by the teachers as key in lesson planning and performance. Language functions as a service for the geographic content, with content evaluated, whilst language is not.

T1: "The linguistic amount in bilingual lessons won't be evaluated, but only the aspects that relate to subject-specific language. If one can use geographic terms in context, this is what is relevant and will be evaluated. If he or she uses it grammatically correct or the spelling is not relevant."

T6: "It is an advantage to also be the English teacher in terms of using methods or curriculum coordination but I step back from my English teacher role in bilingual geography."

The overriding belief is that subject-specific methodical work is part of geography education, whereas language subjects are responsible for the overlapping basic skills such as text structuring or naming elements of different texts. However, this content before language approach also recognizes that that the content can only be of high geographic quality when the language competence is also of high quality. So there is a two-track demand. A core ideology here is the *functional, terminological bilingualism and bilingual discourse competence.*

Another point to consider is that geography teachers tend to evaluate their bilingual lessons to be better, more structured, and more systematic than monolingual lessons. This evaluation includes, for example, that reading, writing, or presentation strategies are integrated in pre-, while and post tasks arrangements.

T7: "Indeed I often recognize that my bilingual lessons are better than the German lessons because we work with a better structure; we work with the material for longer and with reading and listening strategies."

T14: "I think that it would help pupils (in German geography lessons) if the structure was similar to the structure of bilingual lessons, where I do work with more structural elements. I could do that in German as well."

The reflection of language is considered as crucial as it allows teachers' to identify pupils' language skills more clearly in bilingual lessons than is possible in monolingual lessons. In the teachers' perception, pupils in the bilingual class tend to analyze what they want to say in more detail, and have a greater ability in expressing themselves with words, including which words they can use or which they have to check on. This reflective mental process can be described as *intensive language perception.* It bears witness to a training of reflective capability of competences and a repertoire of linguistic means, a certain openness for language that pupils can ask themselves, even in monolingual lessons, which terms do I understand and which don't I understand, where do I have a question, and how specific are these terms linguistically? What is general information, and what do I have to read in detail? This sense of language openness and linguistic understanding is seen as essential in bilingual geography lessons.

Moving on from fairly curricular and superordinate values, we now focus on teachers' more personal views and their practical ethics. These ethics could be described as a *barrier-free concept of uninhibited trying and applying within language actions.* This term means language barriers are reduced and manifold communicational situations initiated through classroom interaction strategies.

Within the core values, another aspect relevant to the construction of communicative situations, is how teachers evaluate language performances of their pupils in geography.

T11: "*Successful language action means if they (the pupils) are able to geographically and adequately present content, to formulate emotions and thoughts, opinions, when they can*

communicatively react to stimuli or impulses, when the can stay objective, interact, reflect by giving reasonable feedback…"

T8: "*…if they gain the competence to express what they cognitively intend to express and when they are able to adequately interact and react with and to each other…"*

The passage by Teacher 8 again directly refers to discourse functions to gain geographic meaning and communication competence. These functions are manifested in aspects of adequate participation and in how the pupils use geographic input and reflect on it to gain knowledge for its intended purpose.

The levels of expectations influence the way in which teachers subjectively demand and organize language situations in geography, and which performances assume higher priority in the communication processes. Here, the subjective concepts are interesting in contrast to or in combination with the standard educational concepts because they mirror the practical evaluation process. For instance, a teacher who sees flexibility in producing language and therefore task-related content as relevant would rather use model texts that include structural elements which can be transferred to other structurally comparable tasks, for example a demographic pie chart or climate graph. In following tasks, this teacher would evaluate the flexible usage and integration of structural elements by pupils as relevant in overall performance. All teachers stated that geographically appropriate and concise language performance was relevant (Table 3). By explaining and discussing their most relevant methods for establishing language situations, material, or content, teachers defined their concepts of geographical communication and language. Within these explanations, teachers specified what communicative aspects they consider valuable in performance within a language situation in geography. These aspects were categorized into criteria types (Table 3), which describe what teachers see as valuable and successful geographic language performance among their pupils. This system of criteria could be separated in two sub-criteria: one that described linguistic competences with regards to linguistically planning, reflecting, and performing geographic communicative situations. The other one specified the more content-wise level of geographic language situations, namely the adequacy of geographic language products. Consequently, there are two types of values in teachers' teaching philosophy; the very language and linguistic reflective type on general language aspects such as fluency and cognitive processes, and the geographic specification of general learning requirements.

Table 3. Teachers' Criteria of Geographic Language Performances in Bilingual Geography Classroom

Functional linguistic competences in geographic communicative situations:		**Geographic coherences and adequacy:**
Planning and reflecting of geographic language performance: ▪ Skills to formulate actual intended thoughts on geographical tasks ▪ Autonomous, self-confident reflection after language performance ▪ **Intensive language perception:** Reflection on the given geographic task and own available linguistic means ▪ Flexible transfer of linguistic means for other tasks	**Performing in geographic tasks:** ▪ Fluent, coherent speaking ▪ Flexibility and spontaneous reaction to conversation partners ▪ Skills to maintain conversation ▪ Address partners and animate them for listening	▪ **Conciseness and accuracy** ▪ **Transparency and relevancy:** Appropriateness of geographic phrases, collocations and terms according to task, spatial and topical reference ▪ Substantial structuring of answers: Connection between elements and not only adding of them

These types language criteria performances influence geographic lessons which, along with an in depth description of the criteria, is explained in the following sections.

6.2 Initiated geographic communicative situations as specifiers of geographic language

As mentioned, teachers' understanding of the requirements influences how they initiate geographic communicative situations in the classroom and support pupils in these situations.

6.2.1 Repertoire of geography-specific linguistic means (E1): Transparency of geographic terminology

The teachers claimed that pupils have problems in effective and appropriate use of geographic terms. They used two factors for explanation; pupils did not know why they should use geographic terms in certain contents and pupils had problems retaining terms so that they could effectively and appropriately choose the right term in the right situation. The teachers had strategies to overcome these problems, which included a reflective process in the introduction and use of terms, described as *geographic transparency* that specifies teachers' values of geographical appropriateness and adequacy.

T4: "When we talk about language awareness, it is relevant that pupils can imagine what is behind the geographic term. Pupils do not use a term, when they do not know why this term explains a process or a fact faster and more precisely than just circumscribing it (…), just take the term periphery. It is good to combine the learning and understanding of terms with visual material such as maps."

Consequently, pupils should be encouraged to be aware that these terms are needed to optimize language skills in geography for understanding and the reception and communication of geographic content. For the interviewed teachers, the correct contextual use of terms was an essential part of geographic learning and teaching. It seems that bilingual teachers analytically reflect on the terms used in their lessons with regards to the efficiency and meaning of the term. The concise and effective use of terms naturally belongs to geographical communication. This usage allows pupils to reach higher levels of communication because their language becomes more developed. The use of geographic terms makes pupils' interaction more valuable, which is supported by teachers' values that refer to this in their concepts of accuracy. Pupils have to bring the terminology into a network of terms that structure their geographical understanding (e.g. soil and climate that should be transferred as foundations for agriculture).

6.3 Visualization in geography and the meaning of geographic discourse processes

The concept of visualization was vital for how the interviewed teachers support language in geography. Using visual, discontinuous material and filtering it to receive information is seen as a specific characteristic of geography teaching. The handling of visual material, particularly maps, pictures or diagrams, is seen as a language-learning outcome with the required content and referred competences that pupils need. Furthermore, this visual material is seen as a support for pupils' language actions. Teachers claim that is necessary to support pupils in their language awareness, for example that pupils can develop skills to decide when they need input in the form of phrases or structural support for working with a map or diagram. Visuals help pupils to focus on specific geographic elements and offer numerous speaking stimuli and options for referring to prior knowledge concerning content or language abilities.

T14: "Graphical organizational system can be found on task sheets for instance, visualizations make sense and are provided in geography."

T9: "In this way that these visuals are verbalized first of all and this structure offers support."

T10: "When the content is clear, one can speak about optimizing language use, why this term is crucial and why it makes sense to remember and use this term. This is pretty useful when it is combined with strategies of visualizations (with a map) on transparency."

Groups of teachers stated that, within these visual materials, the reception and verbalization of information in maps, diagrams, and pictures are highly relevant language skills when working with and understanding geographic content. In this context of geographic visuals, teachers' strategies can be summarized as integration and consolidation of geographic-methodical competences and their verbalization processes. To establish pupils' language skills so that they can work adequately with the material, teachers state that transparency for competences is needed as a central goal. Pupils should understand that the capability to verbalize information in a geographical themed picture is therefore relevant for gaining geographic meaning. This capability of decoding visual material into geographic language and meaning again refers to discourse processes (E3) and basic communicative actions (E2).

7. SUMMARY OF MAIN RESULTS AND DISCUSSION OF FINDINGS

The interviews revealed that, as a result of values they are concerned with language in geography, bilingual geography teachers use concepts of geographic language in their classroom, which offers a number of implications for language aware geography education. These values in teachers' language awareness shape their concepts of geographic language and the discourse functions within it. Within these concepts of language in geography, teachers implement strategies that fit to the requirements of consistent language education in *Bildungssprache* and language in schools, such as the adequate, audience-oriented verbalization and concise expressions (Feilke, 2012). The values teachers mentioned show that there is a language awareness of geographic language that is specified by teachers themselves but can be categorized into a series of common values (Table 3). Teachers' core values such as functional linguistic competences in geographic communicative situations and criteria of geographic coherences and adequacy primarily fit to Feilke's (2012) or Gogolin's (2011) attempts to formulate criteria and characteristics of applying *Bildungssprache* (Table 3). Feilke states that speakers' skills for generalization and discussion of issues are central marks of applying *Bildungssprache*.

Table 4 summarizes the coherence between teachers' values and their strategies for teaching language in the classroom. It shows the steps for initiating geographic language in bilingual geographic classes.

Table 4. Steps of Initiation of Geographic Language Teaching in Bilingual Geographic Classes

(I) Teachers' core values in terms of language	
Criteria of Geographic Language Competence	**Goals and attitudes of lessons and classroom interaction**
(II) Initiated geographic communicative situations and support by teachers • E.g. Repertoire of geography-specific linguistic means: Vocabulary and terminology • Geographic visualization • Scaffolding strategies for teaching geographic language • Methodical thoughts on systematic structuring and cooperative tasks	
(III) Specification of geographic language competence by teachers • E.g. Role of learning and teaching geographic terms in terms of vocabulary and terminology • Geographic methods and related skills integrated to decode geographic information out of media • Transparency for pupils' of benefits of knowledge about geographic skills • Transfer of knowledge and structuring	

Teachers assume different values (Table 3) due to the language aspects they see as valuable for pupil performance (Step I in table 4). These values can be summarized as quality criteria the teachers subjectively identify on the level of language performance in bilingual geography, and as goals and attitudes they have in terms of how classroom interaction should take place (such as language feedback, inhibited atmosphere). These criteria of reflective feedback for inhibited speaking atmosphere strongly refer to Yoshida's (2010) conclusions on choices of corrective feedback in language-aware classrooms, in terms of the tension between support via teachers' recasts and actual motivation of pupils to reshape their statements.

These values influence their willingness to establish communicative situations in the geography classroom and how geographic language is integrated, what is expected of it, and how it is verbalized (Step II in table 4). How suitable situations are established identifies central key speech acts and discourse functions that the teacher considers relevant (E3, E2 in the model, Figure 1).

As a result of their understanding, teachers place different priorities on geographic material and language actions. Through describing routines in initiating geographic communicative situations, the interviewed teachers specified what they considered geographically valuable and relevant language in geography classrooms. Here it seems that teachers specify which speech acts they see as worthy in terms of geographic discourse processes and basic linguistic actions (Step III in table 4). This specification can again have influence, in the progress of further developing geographic language, on their initial values.

Regardless of their years of experience, the interviewed teachers saw motivating and authentic speaking stimuli in real cooperative tasks as essential for successfully gaining skills relevant to achievement in the E1-E3 areas. Interaction is therefore seen as the basis for establishing (geographic) language education. Interactional communicative situations in geography penetrate reception, production, and mediation/transfer skills and oral as well as written requirements.

The discourse functions and key speech acts that the teachers focus on rely on terminology (Figure 1, E1), successfully verbalizing geographic visual material such as maps, diagrams, and pictures to gain information (Figure 1, E2, E3), and verbalizing systematic structuring and therefore progressively processing information in geographic processes (E3). The understanding of phrase using in terminology touches on other areas as well since, with regards to the values of the teachers, using specific terms makes geographic communication valuable and partially separates it from other subjects (Figure 1, E1, E3; Brown & Ryoo,

2008). Teachers mentioned that methods for teaching reception of information such as listening-comprehension and working with text tasks are not ignored, although they tend to focus on situations in which pupils can perform within production-oriented tasks. The narrative approach in terms of discourse analysis and talking about space for language learners alike could be considered a fruitful approach here (Hofman, 2014). Here, the functions of discourse processes and key speech acts become visible.

Geographic discourse processes (E3) is especially relevant in tasks dealing with mediation and in those concerned with analyzing and decoding visual material. The requirements and goals of E3 are clearly shaped in a teacher's concept of pupils gaining *geographic relevancy and transparency*. It appears to be relevant for geographic discourse processes that pupils understand the beneficial consequences of using geographic methods and geographic linguistic means for acquiring geographic language and meaning. This transparency concept is manifested in the discourse functions Budke and Weiss provide for the language-aware geography classroom (Budke & Weiss, 2014). The idea of relevancy and transparency can also be applied to concepts of map competence and symbolic textuality, where meaning in given geographic visual material is deconstructed to gain transparency (Budke & Kuckuck, 2015; Hüttermann et al., 2012).

Another striking aspect here is the teachers' concept of *intensive language perception*, as it concretely describes a competence pupils should gain within the discourse processes. This reflective thought on geographic relevance in using language (also in monolingual lessons) in terms of content and linguistic aspects of geography, opens new doors for designing geography lessons.

Further work should analyze the extent to which this model and successful strategies for integrating language and subject learning in bilingual geography teaching can practically be transferred to and used in monolingual lessons. Examples such as the Arizona GeoLiteracy program on reading comprehension have shown that strategies for gaining competences in language areas and content areas can be beneficially combined (Hinde et al., 2007). It would also would be appropriate to analyze to what extent actual bilingual teaching material such as in schoolbooks fit into the concept of language as a support form in geography classrooms (also see: Behnke, 2014). These findings are a step in the right direction for geographic support in the language education debate. Geography helps to explain the world and language helps to connect the people in it. Finding answers to the effective use of geographical language is a way to achieve such an understanding.

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LEARNING GEOGRAPHY WITH UNDERGROUND MAPS

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Abstract

Underground maps have become so popular and widespread that they have transcended the function for which they were created about a century ago. These maps fulfill faithfully the duty of guiding us across the metropolitan transport network. In addition, they have become iconic elements, merchandising and brand images of many of these cities. In this paper, we propose the use of these maps in order to be applied as a teaching methodology with a dual purpose; on the one hand, for learning about cartographic design and, on the other hand, as a tool for understanding the territory through cognitive maps.

***Keywords**: Underground maps, cartographic design, geography education, cognition maps.*

1. INTRODUCTION

Nowadays, our lives are swamped with a flood of information which we must collect, organise and process. The shift from analog to digital media has meant an overwhelming amount of stimuli input, which, in turn, has made image become more relevant than ever before. In this way, image appears as both an intuitive and compact element, due to its huge ability to synthesize.

Cartography deals with a typology of images depicting an area of the territory and has been closely linked with Geography since its origins. Like photographs, infographics, graphs and all sorts of images, cartography has reached millions of users through the Internet and mobile devices. Demand and use of geographic information is on the increase, as well as a higher interest in watching and understanding the territory. There is also a wide variety of cartographic typologies, be it basic, thematic, reliable, such as ortophotos, or more abstract ones like cartograms, mind maps or choremes. Among all of these, it was London's underground map that meant a remarkable breakthrough when released back in the 1930s, currently remaining as useful and fresh as at that time. Such mapping typology has clearly gone beyond the purpose for which it was originally designed. Besides still being the best way to find your way around by metropolitan transport in lots of cities all over the world, it offers a large number of opportunities, being education just one of them. This study introduces a number of possible teaching approaches to a cartographic typology which is recognized by all. The main aim of the article involves showing an innovative way of customising learning about the territory by means of cartography and the perception which students have of a city, of a region or even of an idea, both in their personal mind picture and in the way in which they represent such elements. The study also tries to explore the potential communication and creative ability of cartographic design by linking it to more personal and subjective geographic trends such as

Geography of Perception and Choreme Geography. The same exercise, the same style, the same philosophy and rather different results, customised after work developed over the past four years. Work with underground maps is a part of the set of activities to be completed by students taking the subject named "Perception and Interpretation of Geographic Reality" within the Degree in Humanities and Social Studies at University of Castilla-La Mancha, Campus of Albacete. The student acquires knowledge of cartography and geography through a number of paradigms. Qualitative and quantitative methodologies and tools such as GIS (Geographic Information Systems) are used in this subject. All the activities make students become familiar with broader understanding of the territory through projects where multidisciplinary knowledge acquired so far is put into practice, combining Art, History, Literature and, of course, Geography.

2. CUSTOMISATION OF GEOGRAPHY LEARNING

Geography became established as an academic discipline in the mid XIXth century. Its birth ran alongside other disciplines such as History, linked to thriving nationalist feelings. Encyclopedic knowledge was chosen to enhance a number of areas, sites, borders and facts. History and past are believed, on socio-cultural grounds, to be synonyms, yet actually it is the past that constitutes the object of History. It is absolutely impossible to know all the past of all people. History means construction and selection of the past. Something similar occurs in Geography for the polysemous terms "geography" and "territory". Mastering History does not mean learning facts and dates by heart. Mastering Geography does not mean learning places and capitals by heart, either. Knowing the main elements of territory is relevant, yet it is utterly crucial to understand the interwoven relationships that arise between such elements. Encyclopedic knowledge causes the teacher or lecturer to become a mere broadcaster of information, information that is already available on the Internet. Barely enumerating place names and not generating relationships and construction means nothing but impoverishing knowledge and critical capacity of students, besides devaluating the discipline of Geography within society and everyday life, not to mention the effect on the continuous revisions of the academic curriculum.

Epistemological and methodological ups and downs have been recurrent throughout the history of the Geography discipline. Continuous changes of paradigm and object of study have led to disturbing lack of common ground among geographers themselves, their research or even a minimum of consensus on what must be studied and how it must be studied. Currently, inconsistency exists between the geographic knowledge in the classroom and the practical demands of society. The knowledge that is taught is hardly applicable to everyday life, starting from encyclopedic learning, more characteristic of past centuries than of the present background. Ever-increasing access to the Internet, together with the extended use of smart devices which enable us to be online almost everywhere results in immediate availability of an enormous range of resources. Therefore, the current century's challenge deals with information management rather than access to information, as was the case previously: a revolution which has turned out to be far more significant than printing or television. A major change which has been due to the shift in formats, media and directionality of information (Pons, A. 2011: 20).

Geography does not remain oblivious to the changes mentioned before. The territory is analysed from multiple points of view. Nevertheless, the territory and its perception become unmanageable, even today, with such an enormous array of resources supplied by geographic information technologies. Consequently, it is necessary that the student becomes able to analyse their own territory and to draw their own conclusions. Critical thinking needs to be fostered in order to be transformed into suitable knowledge; geography which is reflective, practical and customised regarding interaction between the individual and their way of

approaching the territory. Substantive content learning and strategic relationships must be taken into consideration, knowledge and skills being acquired from case study (as up-to-date as possible). More and more scholars are discussing replacing memory-based geography with a more reflective approach to it (De Miguel, R.:2013:24). Geography and geographic data go far beyond the classroom and the labs and increasingly become part of our lives. Recent examples can be found that have provoked gamification of the territory through worldwide expansion of apps such as Pokemon Go1, based on device tracking. Geography is a living science which should allow interpretation and understanding of the territory in an appealing way. Spatial information is relevant due to the fact that "almost everything that happens somewhere" (Longley et al. 2011). Geography is required to be consistent with current needs and social demands by enhancing its everyday side and, at the same time, by maintaining its scientific and methodological rigour.

Geography fits practical learning; it can become key to instilling curiosity and willingness to learn rather than being aware of the concepts themselves. Concern for discovery and research may lead to activation of students' autonomous learning as well as to overcoming the academic purpose: lifelong learning. Relationship with the territory and, for that matter, with geography, will accompany us throughout our whole lives.

2.1 Cartographic design and customised learning

The development of technological issues in which we are currently engaged has transformed us into consumers of information technology, which includes elements ranging from increasing use of electronic devices (laptops, tablet, smartphones) to all kinds of contents and interactions through 2.0 web, shifting from a sender-receiver flow to a bi-directional one where everyone can be either sender or receiver. Loads of easy-to-read and fast-to-understand information is consumed, given the flood of input which we are continuously receiving. The image, therefore, gains importance due to both so-called smart devices and the web. Information is more and more visual, with graphs, infographics and cartography filling websites and social networks- Image grabs attention and synthesise information in a more effective way than text does. It conveys a lot in little time and leaves an important memory (Resiberg, D. and Heuer, F. 2005:55). Technically speaking, everything is image, even the text seen from the interface on a screen.

Geography is mainly a visual science of the territory (Scholtmann, A. and Miggelbrink, J. 2009). It feeds off infinite typologies of images for its multiple purposes. Among all these, it is cartography that accounts for higher territorial aim. They have gone hand in hand for centuries in order to teach, analyse and explain all the spatial processes that occur in our planet. Not only does cartography enable us to depict the area surrounding us but also to imagine, create and design the perception that we have of such area. Curiosity is also fostered and spatial information is transformed into useful knowledge, applicable to the real world. Cartography has been substantially affected by the so-called Geographic Information Technologies (GIT) – satellite images, Global Positioning Systems (GPS), Geographic Information Systems (GIS), visualizers, mash up tools and a large number of improvements have resulted in the number of people making maps and using them being higher than ever before (Crampton, J.W. 2010:11). We face a society which is globalized, interconnected, virtual and mobile, which demands and consumes a higher amount of geo-spatial information, in general, and a greater number of maps, in particular. Interaction between people and the territory has significantly increased through maps and all kinds of tools as implemented in apps and mobile devices. Democratisation of access to cartography makes it possible for people with basic IT knowledge be able to depict visual information in a somewhat apparent way, systemised, homogeneous, "fordian". A lot of this cartography is underused, owing to users' lack of analytical ability and

to existing software's scarce capacity for cartography design. This leads to massive presence of low-quality and inaccurate maps. Plenty of "cartorrhea" exists on the web (Capel, h 2009). The tool is prioritised over reflection and users are more concerned about "clicking" on the software than to understand the outcome. Debate is ironically put forward about whether or not SIG has killed cartography (Vanoutrive, T. 2010).

In the quantitative paradigm sponsored by the giant technological development, confusion may be found as for the accuracy which geo-referenced maps boast. What is depicted is granted the principle of accuracy. We tend to believe in a cartographic positivism where cartography is objective, neutral and independent (Harley, J.B. 2005:25). Geographic Information Technology has boosted this perception. However, it is well known that the representation of the Earth's surface from s spherical body to a flat one involves assuming a distortion (Peters, A. 1991:7). A map is not a territory but an abstraction of the territory. Geographic space is accessible and specific. Perception of space ignores the concept of infinite and, as such perception, it is not homogeneity but diversity that exists. Sensorial space is anisotropic and space is linked to conscience (Ortega, H. 2000:357). This fact allows it to be cartographed, enabling us to locate phenomena and mapping the components of space.

Locational component is key to geography as well as in many other disciplines but, even more important are relationships established between its elements, as stated by Von Thünen, Christaller or the economist François Perroux. "Although every point in space can be located, what matters is its location with reference to a whole of which it is a part" (Dolfus, O. 1982:8). The cartographic representation of elements, as well as their topology, may be more or less accurate, becoming even a graph or a simplified geometrization of reality. Several authors claim that, on some occasions, freehand sketches or maps are more useful that computer-aided ones (Barkowski, T. & Freksa, C. 1997:348; Agrawala, M. et al.: 2011:64). This kind of maps is more and more disused, facing countless diversity of technological apps. However, they are more intuitive, user-friendly and of high pedagogic effectiveness.

Cartography has undeniably an educative and pedagogic side (Jerez, O. 2006). Within map typology, perceptual maps are a part of analysis methods of Geography of Perception. Research done by this geographic trend has ranged from the psychological paradigms in the earlier works of the trend, led by urban planner Lynch and his vision of the city (Lynch, D. 1969) to sociological principles which have approached geography (Vara, J.L. 2008). They have been less successful than others which have been more largely sheltered by late 20th century's technological development, one of which higher values being how easy it makes geography popular with students by means of practical and entertaining activities where they feel they are the protagonist. Such activities allow unwavering knowledge of our immediate background in a practical and constructivist way, having the further advantage of a diverse, easy-to-implement methodology. Opponents argue about complicated systematisation and difficulty to reach homogeneous results.

Several proposals deal with learning through conceptual maps, which allows structuring information from relationships between perceived elements (Escobar, F.J.:1992; Boira, J.V. et Al: 1994; Gieseking, J., J. 2013; Tversky, B. et Al, 2006; Vara, J.L. 2010; Rodríguez, Mª A. 2014; Berthier, A. 2006). The relevance has neither to do with the datum itself nor even with its geometrical location but, rather than that, with its interaction with neighbouring elements and with how such elements are structured and laid out. Major teaching interest arises because it does research into a close, down-to-earth reality. Links are constantly being created, at times in a spontaneous way, as a habit. This layout of our spatial decisions may help optimise them and improve our time management. Time is a scarce resource, neither storable nor extensible, which make spatial decisions become key cornerstones (Díaz, M.A. 15:1992).

The other theoretical methodological support on which this teaching practice is based on, besides Geography of Perception, is Chorematics and the so-called choreme (Brunet, R. 1987;

1990). Choreme is a neologism of Greek origin χώρα (Khora: space, territory, place) to which the suffix "ma" has been added (like "phonema"), imported from the French term "chorème". A word still unadmitted to main European languages, it is to some extent a contribution of geography (Martí-Brugueras, MªM. 1975:132). The term has a double meaning: it is defined as the elementary unit of a model of spatial organization and, at the same time, the graphic expression of such unit (Fernández, F. 1998). The language of choremes is closely linked to other graphic languages resulting from simplification in mapping through points, lines, areas and network. Its value does not involve a graphic method but a far more complex process including prior in-depth analysis. The definition leads to assuming that the territory has an inner structure which can be analysed and depicted. The idea generated a paradigm shift in geographic science (Ferras, R. 1993). Prior knowledge of reality to be cartographed requires establishing links between reality and its representation. Ever since it appeared in the so-called New French Regional Geography, it has received permanent criticism, especially from French scholars. Ives Lacoste, just to mention one of them, criticized its simplification, graphic manipulation, pseudo-objectivism, and, ultimately, the scientific illusion on which it is founded (García, J. 1998:6). Perhaps it is these objections, or the lack of linking to systematisation enabled by new technologies that have caused that the development of choreme has been lower than that of Perception Geography. There has been, though, not little research that has been done based on these theories (Arreghini, L. 1996; Portugal, J.A. 1996; Klippel, A. 2011; Fatto, V. 2009; Reimer, A. and Fohringer, J. 2010).

Chorematics and perception are coincident at providing a mind map of the territory. In one of them, the mental structure arises from a perception whereas, in the other one, it stems from analysis. Both have cartographic design as their core element and both are founded in qualitative analysis, completely different from cartograms, which are nearer to quantitative concepts like choropleth maps, widely spread through Geographic Information Systems. Mind maps and choreme maps are a part of the corpus of schematic maps. Among them, those inspired by London underground map can be included (Reimer, A. and Fohringer, J. 2010:6). Elaboration of perceptual maps, sketches and choreme is directly linked to humanist geography.

Geography of Perception and Chorematics are two geographic trends belonging to a theory where subjectivity and personal views are prioritised over other principles. In some cases, it is blamed for lack of rigour and homogeneity of results; in some others, it lacks digital development, which may have been the cause of its poor implementation by the geographic community. Establishing Geographic Information Technologies (GIT) fosters the use of quantitative methodologies and, consequently, improving students' technological skills. Nevertheless, the use of GITs is simplifying and unifying cartographic learning methods and outcome. Similarly, the use of navigation tools reduces the choice of routes which are offered through the territory for the sake of a Euclidean paradigm or of minimum time spent, which inevitably involves impoverishing our permanent learning about the territory. New technological tools are beginning to appear revisiting other postulates' predetermined optimization2 (Quercia, D. et Al. 2014; 2015). Technology is an element which currently fosters learning about the territory; it does not necessarily have to mean becoming an indispensable element, though. One learns through action, autonomously, critically, functionally and constructively. The work presented herein focuses on a different way, individualized, practical and active, towards learning geography and cartography.

Applicability of theoretical knowledge is an increasingly higher requirement within the academic field, both for Universities enforcing adaptation to European framework (Plan Bolonia)3 and for students themselves, in particular within the field of Humanities (Pérez, M. R. et Al. 2013; Esteves, M. H. and Rocha, J. 2015). At the International Geographic Union (Krakow, 2014) and in the International Charter of Geography Education (Beijing Assembly,

2016) the importance of geographic learning was brought to light. (Van der Schee, J. 2014; IGU. 2016). Both refer to the idea that geographic education must be a lesson on how to think geographically, a way to watch and understand the world surrounding us. "*Building on people's own experiences, learning geography helps them to formulate questions, develop their intellectual skills and respond to issues affecting their lives.*"

2.2 Albacete underground map

In 1933, electrical engineer Harry Beck presented his new underground map inspired by contemporary electric circuits. He copied the metropolitan transportation system to that structure and sketched it through geometric simplification, giving priority to strictly necessary information (Haddadi, H. 2010). The underground lines turned into 45 º and 90 º lines, and the stations into interconnected dots (Grima, C. and Berry, R. 2012). Underground maps are synthetic representations of the main figures and their relationship. The abstraction and simplification of the metropolitan transportation network itineraries has enabled a fast and massive implementation of this way of representation of facts in the territory, stations and their relationships: underground lines. The result was a map of quick and easy understanding for users, though not lacking a few distortions (Liu, Z., Li, Z. 2016). This image is optimal, and even turns iconic (Degani, A. 2013). This is one of the most representative examples of the universality of cartographic language. It has been implemented with few variations in basically every metropolitan transportation system (Pérez, J. 2009). It has been used to represent other transportation and supply lines (Guo, Z. 2011). The success of this underground map transcends the purpose for which it was created. It is an icon and picture in the promotional merchandising of their touristic image, being London the most commendable (Merrill, S. 2013). Many cities set their prevalence in the city system reinforcing the image of their city through its underground map and a transportation typology that only exists in cities of a certain size.

This academic activity began with a theoretical session about the origins and dissemination of the underground map[4]. A significant amount of cartographies about the metro maps of many cities in the world were compiled and reviewed. These materials can be found online on the social network Pinterest, on a board named "Mapas de metro"[5]. Formats, aesthetical compositions and finishing might vary, but in almost every picture reminiscences from Beck's design can be seen. This teaching material is completed with several manuals about cartographic design (Bertin, J. 2005) and a YouTube playlist about cartographic design[6]. All the teaching materials can be found online[7]. After these incentives and resources, the students were presented with a few simple questions. Can Beck's design be improved? Is it applicable to new contents? Can we create and design a representation that improves what we have seen so far? When teaching this content, students may be asked to elaborate their answers. In this case, the students were asked to outline their own map. This exercise aimed to explore the students' different creative –as well as cartographic design-oriented- possibilities.

In the first year, the outlining of the Albacete underground map task was given to the students. Albacete is the city where this subject is being taught and where the students are based in. The following exercises varied in topic and location. The task given in the first year has a lot to do with the geography of perception, while in the following years it leaned more towards Chorematics in an effort to represent the complexity of a certain topic through its regularities (Brunet, R. 1987)

The underground map of the city of Albacete is an exercise loaded with subjectivity in which each student writes their own proposal about the city they live in. The city is located on the eastern side of the south sub plateau in the Iberian Peninsula. It is halfway between the centre of the peninsula and the east. It belongs to the Autonomous Region of Castilla La Mancha,

being its most populated city. It is a mid-sized city at 172 121 inhabitants as of January 20158 and it has no metropolitan transportation network, as it is not really needed given its size. In this exercise students can toy with their creativity and they are allowed to break the city's scale, to over size it and plot its most iconic locations in a creative and appealing fashion. Freedom is total, which allows for a melting pot of heterogeneous answers, both creative and personal. The design, the number of lines and stations and their connections are fundamental in the network. The finish and communicative ability are significant with special attention to detail and finish of the representation. The student's own experience is shown in the shaping of the exercise. It gives value to geography knowledge that has been shelved due to its routine character and, implicitly, to their everyday activity, reflected in an organized representation halfway between a mind map and a perceptual map.

The perception of the urban structure of the city through an underground network can be interpreted as the nodes and landmarks that around the mid 1900's Kevin Lynch drew up in his image of the city and his studies for the cities of Boston, Los Angeles and New Jersey (Lynch, K. 1960). Every single station can be understood as a landmark or node according to Lynch's terminology. They are conceptual anchor points of our city, be it as places on a singular location that allow us to be seen and recognized, be it as strategic connections to organize the transit in our city. The location of a station provides some added value to the depicted area. The allocation of the stops in the map and its concentration or dispersion allows us to guess what the central areas of the city are, with an increase in activities of a certain nature: services, shops, businesses, etc. It allows for a first approach to the territorial hierarchy of the cities (Wolff, A.2007). Each student decides on the style and design they will present, the number of lines, their length, the number of stations, their location and the connections between them. In many cases it is difficult to determine their geometrical location since the abstraction from the representation does not include a background cartographic base. Besides, each of them gives it the place-name they consider most suitable to said station, newly providing the area with a subjective value.

Simplification drives out the superfluous and allows for a clearer observation of what is peremptory. The analysis of underground maps in the distribution of their stations is interesting, and at the same time it poses a creative activity, a visualization of the perception the person holds over the city they are representing. It is likely that the transposition of this exercise to cities that already have a metro network will be biased by the already existing metro network. In our case there is no such influence. The absence of existing references lets us imagine and increase the ability to decide which stops and which places are the most important inside the city. At first, such exercise could have seemed ridiculous, since it was asked of the students that they design a map for an infrastructure that is unnecessary in this city due to its characteristics, but it has become a potential value for design as well as to understand the interpretation that each student has of their own city. We are talking about an individual learning process, in which each student develops their own capabilities from their existing knowledge. Bringing together all the cognitive maps allows us to get a group idea of the city and appreciate the different anthropocentric approaches that these maps often show. The project was presented in an exhibition named "Mapas del metro de Albacete: cartografías utópicas" ("Albacete underground map: utopic cartography") (García, J.A. 2013).

In the following years, the same exercise was repeated as part of the tasks the students need to complete in order to pass the subject. It is necessary to understand that the creativity of the results would be hindered if the following year they were given a similar exercise. The maps of their classmates from previous years would be their first examples. It was decided then that the students would be given an assignment with a different topic to portrait, following the same style of the underground maps of Castilla La Mancha. The representation would stir away from the geography of perception and getting closer to Chorematics. The topics were very different

in order to have as few students as possible working on the same topic. The need for the students to compare their results to their own previous results as well as the outcome and mastery of the cartographic technique is encouraged through the whole subject, from the first of the exercises to the last in the four-month term. Comparisons must be of individual nature and not between students, favoring the creative freedom and diminishing the influences of pre-established patterns. Some examples of the assigned topics make reference to protected areas, gastronomy, road systems, historical and artistic patrimony… It should be remembered that this subject is a part of the curriculum of Humanities and Social Studies and the students have a melting pot of subjects such as Arts, History, Philosophy, Literature, as well as Geography. The choice in topics is related not only to geographic concepts but to the multidisciplinary nature of the environment the students are being trained in. The assignment strengthens the way to understand, assess and learn from oneself. They are autonomous in the search for information and its prioritizing and selection. It is important that they make their own decisions. (Vegas, E.J. 2009:2). Once all the necessary information is found, it should be represented by following the same pattern, the underground map style. This allowed us to come up with common elements for analysis. The student observes, assesses, understands, maps, designs and represents in order to create a new individual reality. Each map is a unique perception of the same area from some common design precepts. They are unique in what has been represented as well as the way it has been represented.

In the following year, 2015, the assignment was given again. In this case, only the administrative context changed. Students were assigned to create a map of the thematic underground of Spain. The topics were very similar but by changing the area of study, the amount of information available for each topic was substantially modified. Again, we are left with a new exercise of prioritizing and selection of the information. Finally, in this year 2016, a new assignment has been given and ranked as highly valued in the surveys conducted at the end of the year about the assignments. In this case, we went a step beyond and total freedom was given when it came to the topic and the environment of the representation. The result created a complex variety of topics with topics of students' own interest taken from books, television shows and video games. Their motivation increased considerably.

3. CONCLUSIONS

For a long time, the mechanisms of the education system have experienced different ways, methods and strategies in which the student acquired and repeated said knowledge and procedures. It is not enough anymore. The digital era and the society of knowledge have changed the availability and use of information. It is necessary to think in a creative manner with a productive thinking instead of a reproductive one. This creative thinking produces talent that arises when the necessary conditions are present. It is necessary to create a suitable environment that promotes creativity and free thinking, without fear of mistakes or assessment patterns.

This article offers a teaching proposal in which the student develops their spatial analysis abilities, their area perception and their creative capabilities. The aesthetics designed by Harry Beck shows its consistency and ability in the most diverse applications. The map of the underground maps presents the information through personal experiences and background of the individuals and their area. Each student's mental image goes through screening in the typology of underground maps in order to obtain unique results in the arrangement of the same area. Territorial information is built up on their personal experiences and through the relations between the individuals and their environment. There is a rediscovering of our closest environment, giving space a hierarchy through the design of the network and its stations. The typology of underground maps allows for not only organizing space, but also time as

organization of diachronic contents from dots and lines interconnected through the creativity and individual experiences of each student.

This exercise, in its multiple aspects, wants to use the underground map as a teaching tool encouraging design and creativity through cartographic design. At the same time, it explores the analysis of variable distribution, perceptual in the case of the city underground map, and thematic in the following examples. The exercise gives value to the possibilities that the Geography of Perception and Chorematics give through the structuration of a variable in an area. It is an eminently visual exercise, in which the picture plays an imperative role.

The underground maps in particular, and the subjective cartographies in general, give the student an approach to the understanding of a certain area, quotidian geography and our constant relationship with an area. It presents undeniable advantages:

- Identifies the basic elements of cartographic design.
- Reflects on the possibilities of visual language and a way to prioritize and present information.
- Shows the importance of establishing a hierarchy and arrange information through design and creativity.
- Offers the possibility of teaching geography in a multidisciplinary way.
- Includes human perception as a variable and mediator in the teaching/learning process.
- Customizes learning increasing motivation and positive attitudes towards an active learning of the relations between elements of a certain area.

This type of cartographies has many detractors. Criticism referred to the lack of rigor and excessive generalization is more focused on the cartographic result than in the process itself. In our case, some of such criticism is considered acceptable. Many of the presented maps favour the design and visual aspect of the representation over the functionality and structuration of the contents. This is due, fundamentally, to the fact that it is this, and nothing else, that was the goal of the assignment. Cartography is not an end on itself. It is but a means to allow, in the one hand, to explore the creative capabilities that cartographic design has in its most artistic side, and on the other hand, to analyze, organize and manage information with spatial variability. The knowledge and use of visual language, especially cartographic language, linked to IT (Information Technology) shows a wide variety of interesting possibilities for the humanistic profile of our undergraduates. I cannot but remember these words by Eduardo Galeano, in relation to the importance of the journey and not so much the destination. “Utopia lies in the horizon. I take two steps closer, she moves two steps away and the horizon gets ten steps further away. So what’s the point of utopia? That is the point: to keep walking.” This utopia has served to walk through unimaginable environments that bring impressive results and still has a double reading, both from the form and the background of the task performed. From the form, we get visual results in which design, imagination and creativity of the individual take precedence over assessments and homogenous assignments for all the students. From the background, we can perform an analysis of the Geography of Perception, Chorematics and Graph Theory.

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[5] http://pinterest.com/geografiando/mapos-de-metro/
[6] http://www.youtube.com/playlist?list=PLNYev5GGl3wzwRsdtJv0KHtsN85FRaSEpwww.ine.es
[7] All teaching materials used in class are of free use for the students and everybody that wishes to make use of them through the PLE (Personal Learning Environment) under the name "Geografiando en las nubes ;-)"
[8] Source: Census 2015. INE (Census Bureau)

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"SIGECAH" AS A TOOL FOR THE COLLABORATIVE LEARNING OF SOCIAL SCIENCES IN ANDALUSIAN SECONDARY SCHOOLS

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Abstract

Almost a decade ago, as a result of the initiative promoted by the researcher Laura García Juan, the project SIGECAH (Historical Cadastre Managing System) was born with the aim of improving the analysis of geohistorical sources from cadastral documentation, firstly in Spain, and later taking another geographical scope. Its development and efficiency have diversified it inside the educational and research sector due to its digital platform. In order to make knowledge accessible and to turn students into active agents inside the classrooms of Andalusian Secondary Schools, we present an open didactical proposal for the Social Sciences: Geography and History. Thereby, SIGECAH does not only work as a tool for the treatment of the geohistorical sources and its cartographic transformation thanks to the Geographic Information System, furthermore, because of collaborative learning, teachers and pupils can join the project from their centres of Secondary Education, sharing information and researching about the changes in different places of the Andalusian territory.

Keywords: *SIGECAH, collaborative learning, Geohistorical sources, historical cadastre, Secondary schools.*

1. INTRODUCTION

Since 2007, the research group headed by Concepción Camarero Bullón from the Autonomous University of Madrid, within the framework of two research projects (i) has gathered several researchers, among them Laura García Juan, in a multidisciplinary way to work on the analysis and mapping processes from textual information drawn from different Spanish cadastres throughout the 18th century, mainly, the Cadastre of Ensenada (García Juan et al., 2008).

To respond to some problems that these sources present (lack of related cartography, centralised resources, didactical proposals, dissemination of results, and documental dispersion) and to improve their use in a context where the studies that use cadastral information are booming in the last few years (García Juan, 2015a), SIGECAH (Historical Cadastre Managing System) was born to offer the researchers' community a technical tool to use textual information and create an accurate cartography, thanks to the design of a reconstruction algorithm which provides succesful results (García Juan et al., 2014).

Thereby, developments and refinements of technical characteristics inside the project have allowed the creation of a collaborative website where anyone can participate

(http://sigecahweb.geo.uam.es/ensenada06/), according to their role as user, in the creation and visualization of the contents. Therefore, its didactic capacity increases exponentially in different fields of knowledge. In fact, its pedagogical skills and instructive capacity have been demonstrated both in the university and in other lower educational levels (García Juan, 2015b). Nevertheless, we have not specific studies about the development and application of SIGECAH as a tool for the collaborative learning of Social Sciences in Secondary Schools, taking into consideration the legislative characteristics and curriculum development of specific locations, in this case: Andalusia.

Consequently, this study tries to analyse the possibilities and strengths of the use and implementation of SIGECAH inside the classrooms of Andalusian centres of Secondary Education according to objectives, contents, and evaluation criteria published in the different educational regulations at national and autonomous level.

2. SIGECAH AS TOOL

As we have mentioned above, SIGECAH was born in 2007 with the main target of offering a free tool to transform the textual information gathered in the different historical cadastres, to then generate a precise cartography from the information in the above mentioned sources —which lack of mapping for several reasons— as well as to manage important volumes of information of different types likely to be georeferenced (García Juan et al., 2012).

Thus, we can assume that this system is based on modules and tools for the management and analysis of geohistorical sources. Nevertheless, SIGECAH has numerous virtual elements and for this reason we need to wonder: what does SIGECAH consist of? We are going to approach them from the information published by its creator and current developer, the researcher and teacher of the Autonomous University of Madrid, Laura García Juan (ii).

On the one hand, we find the website in a site hosted and constructed on the CMS (Content Manager System) Joomla. Inside this free software, an interface is divided into three layers*: information access* (where the information is housed thanks to the databases MySQL and PostgreSQL*), business logic* (in charge of connecting the databases with the presentation layer thanks to the engine of the CMS and to the codified Script in PHP to manage the database PostgreSQL) and finally, *presentation* (entrusted to present the information to the user and to interact with the system according to the role assigned to every user). Considering the importance of the role of every user for our study, it is essential to know the permissions that they possess, as well as the different roles: *guests* (users who can only visualize the information offered to the public in general), *researchers* (they have permission to interact with the resident information in the database PostgreSQL that contains the information of historical cadastres -within this profile we have users who can consult the information and others that can also update or eliminate information as well as assign permissions for consultation on information from other researchers-), *administrators* (they can add new functionalities to the system, edit static parts: articles, news… making up the research team in charge of the project), *technical staff* (they control the area of the system which allows adding functionalities to the project, in addition to carrying out its maintenance) (García Juan, 2015a).

In addition to the different roles, it is necessary to emphasize the functionalities inside the web page, which are divided in two profiles: *free* (with general and research profile, where we can find the *didactics module* and the *social networks*), and *with log in* (where access is restricted and leads to the *management module* and to the *cartographic viewfinder).*

On the other hand, we find the relational database organized at present on two components: *Ensenada* and *GIS*. Thanks to the first one, we can identify different aspects (*cadastre individual, goods, geolocation*), through a few relational models and through the application of management that let us know the reality of the period thanks to one of the most important national geohistorical sources for the middle of the 18th century (Camarero Bullón, 2002a). On the other hand, the component *GIS* is fed mainly with property information and secondly with historical cartography. It is here where the information is likely to be georeferenced by means of raster layers and the vectorisation of the elements indicated in the textual source with points (for the location of place names and other elements), lines (for roads, rivers, etc.), and polygons (for plots and blocks) (García Juan, 2015a).

Therefore, and once the most important SIGECAH components have been detached, we will deal with the *didactics module*. At present, it is responsible for promoting and spreading the knowledge of geohistorical sources through resources and modules such as *Kunena*, *EasyBlog*, *Moodle*, as well as the social networks. The above mentioned *module* consists of three content levels: *general profile* (elementary and brief didactic content to reach all users), *didactics in the classroom* (it serves to groups of students of related fields, completed with practical examples and specialised resources), and *researcher* (where, in addition to the previous things, debate and exchange forums are included). However, as it is indicated in the next lines about SIGECAH, its intention is to enable the creation of knowledge to increase the project development and its contents (García Juan, 2015b).

3. COLLABORATIVE LEARNING OPPORTUNITIES AND THE IMPORTANCE OF THE SIG

The technological advance associated to the last decades has completely transformed aspects as education; for this reason, the development of *e-learning* (Curtis & Lawson, 2001) becomes outstanding thanks to the opportunities that it offers to students (active learning, flexibility, cost reduction, etc.), and the increase of the number of followers that it agglutinates every day (Dillenbourg, 2003). Hence, this tool is designed to be used at the network, giving pupils the main role within their learning process not only inside but also out of the classroom (Martínez Sánchez et al., 2001), in addition to didactic resources to understand and comprehend the spatial problems thanks to direct observation, data analysis and cartographic elements (Pagès, 1997).

Along with these progress, the development of the Geographical Information Systems (from now on SIG) and their application as an instrument in numerous fields of knowledge have extremely grown, causing a demand of specialists and being added to the academic curricula (Bosque Sendra, 1992). Thus, some tools used like didactical resources have done better and have been able to transform, thanks to their potential, the models of teaching-learning of the Social Sciences inside the classroom, whether at compulsory or higher education. All these elements lead us to choose collaborative learning as a model for teaching-learning to develop our project in a simultaneous way (in different classrooms and educational centres) thanks to the use of SIGECAH.

This project is included inside a new chapter in the *didactics module* (Figure 1). From here on, we get into an exclusive portal for education centres assigned to the project by means of the system *users/pass* that will allow the access both to students and teachers.

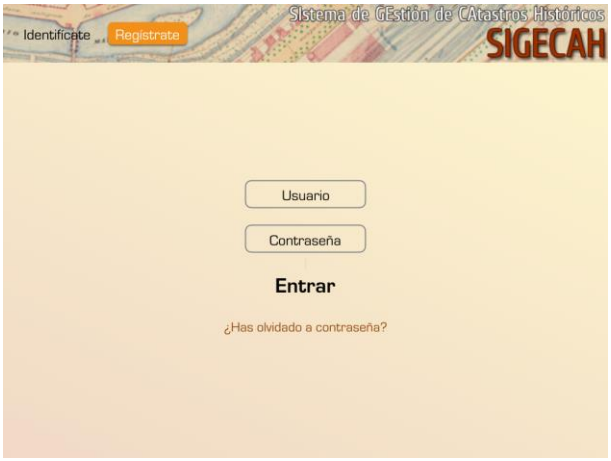

Figure 1. Access interface to the didactics module for the E.S.O pupils.

Considering the previously described roles, and taking into account the above mentioned classification, SIGECAH as a tool inside the classrooms of Obligatory Secondary Education will have several protagonists:

- *Technical staff:* in charge of the development and web maintenance of the platform, as well as interconnectivity with the database and PostgreSQL.
- *Administrators:* provide the material, examine the information sent by the teachers and classify it in a homogeneous way to be visualized by the users.
- *Teachers:* tutor the learning of pupils inside the classroom.
- *Students:* make research with the documents and insert the information to analyse it later in a comparative way.

Once the protagonists have been described, it is time to explain the learning process, but then it is advisable to clearly determine the targets, since the possibilities are numerous and they are going to define significantly the methodological approach to our activity (Figure 2).

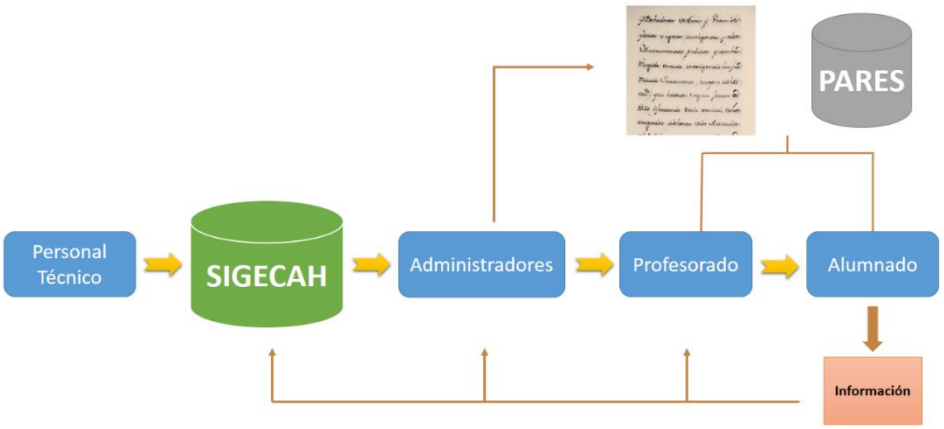

Figure 2. Roles and processes of working out inside SIGECAH.

As we have commented, the project focuses on the documents generated by the inquiry carried out between 1749 and 1756, impelled by the Marquess of Ensenada, key piece of a

deep fiscal reform that did not eventually see the light (iii). It is important to take into consideration that, when speaking about the Cadastre of Ensenada, we are referring to a complex documentary set, with documents at different territorial levels. Therefore, we will only use a part of it, in particular, the answers given to a questionaire with 40 questions, or *Respuestas Generales* (iv), also *Libros de lo Real* (v) and *Libros de los Cabezas de Casa* (vi), both for laypersons and ecclesiastics (Camarero Bullón, 2012).

Thus, we must take into account that every type of documentation requires different treatments and methodologies inside the classroom, depending on diverse factors; for this reason, it is necessary to clarify their features to be able to choose correctly according to the set targets.

3.1 Respuestas Generales

They include the answers to an examination of 40 questions made by the council and experts from each and every town in the cadastre, slightly more than 15,000 (vii). The information they offer, in spite of being declared before experts made a revision on all the statements, brings to light a great deal of information about very different matters: law, farming, cattle, industry, demography, town-planning, geography, etc. This documentation supports a large part of our proposal for several essential reasons: it is digitised and can be consulted through the Portal of Spanish Archives (http://pares.mcu.es/Catastro/); and, on the other hand, it was carried out in the whole territory of the Crown of Castile, that is to say, from Gallicia to Andalusia and from Extremadura to Murcia, meaning that the whole Andalusian territory is cadastred. These motives let us create a collaborative work between all the centres of Secondary Education in Andalusia, in such a way that, through the portal, the results can be compared on different places and learn on diverse questions gathered within the national and autonomic educational legislation, as we will see further on.

Thanks to its results, the students will understand the geographical structure of the Andalusian territories, organized in four administrations: Kingdom of Seville, Kingdom of Granada, Kingdom of Jaen and province of Cordoba; the jurisdictional situation of the different towns in the middle of the 18th century, the royal, municipal and ecclesiastic tax system, the volume of population and its demographic and stratus structure, the economic activity (farming, craftwork, commerce...), the agricultural and stock production, the partition of plots, the price of farming products, the industrial facilities (flour mills, oil mills, gunpowder mills and paper mills...), fulling mills, foundries, etc., the service activities (doctors, pharmacists, bleeders, midwifes, teachers of the first letters and latinity, etc.), the urban real estate patrimony (haystacks, houses, palaces, etc.), the commerce, industries and offices, the number of vessels, the convents and monasteries, hospitals, in addition to the king's and the council's properties in the town, environmental aspects (hills, uncultivated lands, wetlands, etc.).

All this will be carried out through the platform by means of the templates designed for the insertion of the information contributed by *Respuestas Generales*, specifically, one for every question and a preliminary one to include the dates in which the examination was made and the members who were composing the commission that made it (Figure 3). For this purpose, a total of 41 modifiable files have been designed so that students can insert the information needed in every case.

Figure 3. User's interface for the information insertion from Respuestas Generales in the centres of Obligatory Secondary Education (ESO).

Once the property information has been introduced and saved, it directly goes to the SIGECAH database by means of an *SQL* or *shape file* where it remains stored for teachers to analyse, and later, for administrators to review before making it visible to all users (Figure 4).

No limit

	id_pueblo [PK] integer	Nombre del Término o Villa character varying	Fecha de comienzo o reanudación date	Fecha de finalización date	Lugar de reunión o realización character varying	Cargo dentro de la Comisión character varying	Nombre character varying
1	1	Valle de Abdalajis	1751-04-21			Juez Subdelegado	Don Manuel Fau
*							

Figure 4. Information insertion in PostgreSQL from Respuestas Generales.

Then, once the inclusion of all the information has been finished, it is possible to examine and compare it, giving as a result (in most of them), a few theme maps through PostGIS which let us understand the spatial distribution, typology and quantity of the examined factors, as for example, the variety of prices of the different farming products (Figure 5).

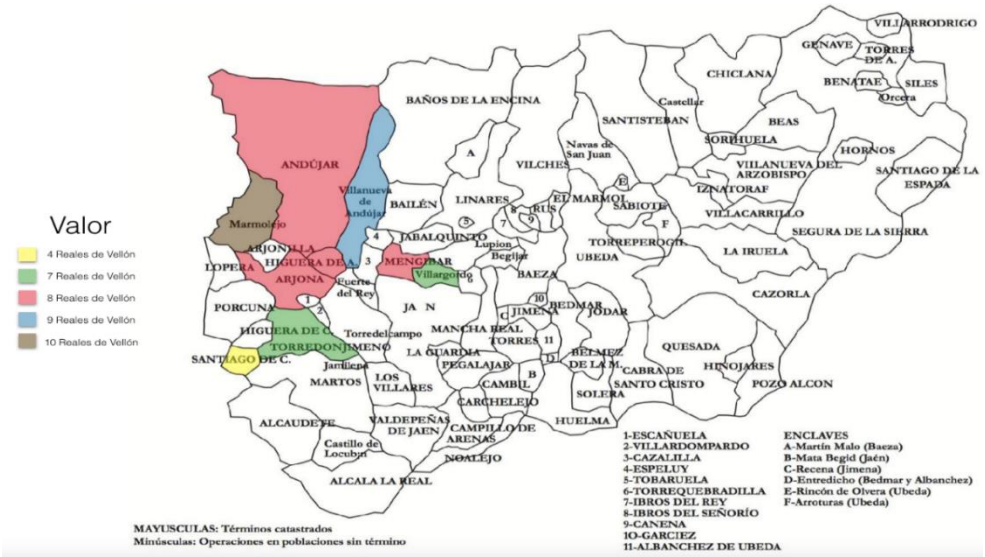

Figure 5. Price of the bushel of alverjones (Lupinus angustifolius) in the Kingdom of Jaen according to Respuestas Generales. Base cartography: Ferrer Rodríguez, A. Nieto Calmaestra J. A., Camarero Bullón, C. (2000:) La organización territorial de la provincia de Jaén, 1750-2000: permanencia y cambio, CT Catastro, 39, pp. 19-50.

It is true that this information only shows general aspects of the town, therefore it is very difficult to work with specific phenomena, like the geographical location of the farm plots or the partitions, for this type of information it is necessary to look at another cadastre document: *Libros de lo Real*.

3.2 Libro de lo Real, Raíz o Maestro

This documentation constitute, as Camarero Bullón states, the authentic cadastre database, as it gathers all the elements subject to fiscal regulation of each of the tax individuals. The above mentioned information is contained in the *Memorials*, once verified and, if it is necessary, corrected. Therefore, the owners' names, the houses, the lands and their shapes and dimensions, the cattle, the revenues and charges, etc. are detailed. All in all, we can check all the properties of each of them and their location, together with their value (average value of the harvest in case of the lands, value in revenue for the houses, etc.), which would be taken to calculate the tax base for the later exaction of the Unique Contribution in the town.

It is here where, with the help of cartographic recreation, we can create the spatial distribution of the territory knowing not only the number of houses, their location and size, but also, the number of plots that they possessed, the area in which they were, their size and margins. For this purpose, we will use PostgreSQL, with its extension PostGIS, with a prior analysis of the element and selection to determine the type of element to insert: *points* (for the place names), *lines* (for paths, streets, rivers, etc.), and *polygons* (for blocks and areas depending on the zone that we are working on) (García Juan et al, 2012).

Thus, we will be able to obtain a much richer local view than with the previous documentation. Nevertheless, unfortunately the loss and documentary destruction have made that numerous Andalusian municipalities are not provided with the copy of the above mentioned documents, for that reason, exploiting these documents in the classroom is more difficult; adding the difficulty of their consultation, because the whole set is not digitised at the disposal of the user in the network. On the whole, the local documentary set that was preserved in the provincial Accounting Offices of Revenue of the Kingdom of Seville (current provinces of Cadiz, Huelva and Seville) and in the province of Malaga has disappeared.

3.3 Libro de los Cabezas de Casas o Libro de Familias

Its denomination changes throughout the cadastred territory, and also the document is not so homogeneous as *Libros de lo Real*, since they did not all gather the demographic information with the same accuracy; for that reason we will find large differences within the Andalusian territory, comparing the ancient Kingdom of Jaen with other places. They are books that contain the demographic information of the town, separating secular from ecclesiastic families. Through them we can make thorough demographic studies that really help to understand the local population structure (Figure 6).

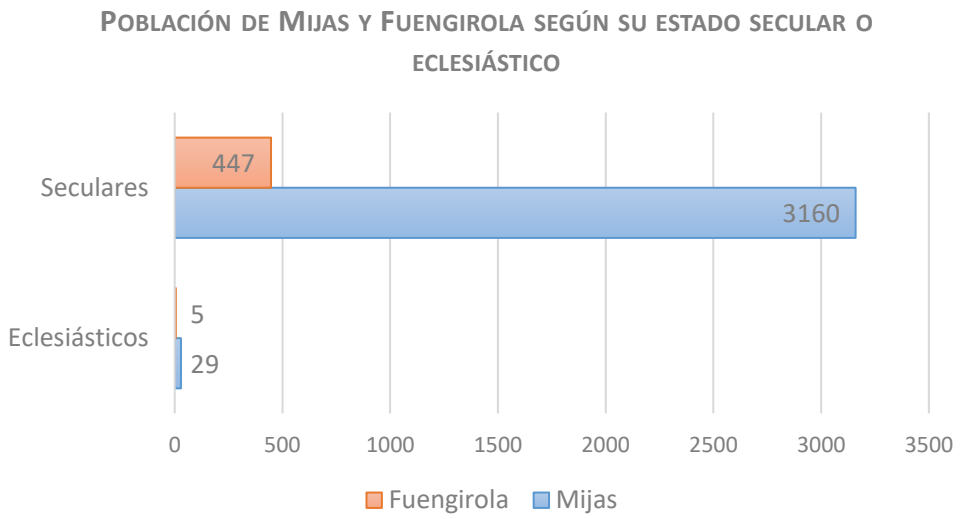

Figure 6. Population of Mijas and Fuengirola according to state: lay or ecclesiastic. Source: Aguilar Cuesta A., I., 2016. Seculares y eclesiásticos a través de los resúmenes del Libro de lo Raíz del Catastro de Ensenada, en VI Jornadas de Historia y Etnografía Villa de Mijas, Mijas.

It will be here where population pyramids will have an outstanding role, when documents give information about age -not always included- the study of the familiar composition, the structure of working population, or the type of settlement (concentrated, disperse, scattered, etc.). There are usually interesting activities here related to the genealogy of the pupils, since the coincidental surnames can be an inspiring element at the time of working inside the classroom.

The working method is very similar to the one employed with *Respuestas Generales*, nevertheless, for each of the neighbours a form will be filled which will include separate information corresponding to them (name, age, marital status, member of the secular or ecclesiastic state, profession, number of children, name, age and profession of them, etc.). This way the forms go on to the database, where they can be corrected by the teachers before being sent to the administrator for checking and publication (Figure 7).

Figure 7. Interface of Libro de los Cabezas de Casa of Cazorla where the information is inserted.

Later, it is possible, by means of the theme maps, to make a composition of the total number of people who were living in the different places, or classified by gender and age range. On the other hand, it is possible to analyse the ageing of the Andalusian population in a certain date and to verify, with other information from the National Institute of Statistics (http://www.ine.es/), the evolution, differences and similarities with the chosen historical time.

4. ONLY GEOGRAPHY? THE TOOL IN THE CURRICULAR ANDALUSIAN CONTEXT

So far we have seen the characteristics and functionality of the tool; nevertheless, we always must take into account the needs for the classroom according to the current legislation. Hence, we cannot forget the educational reality where this is going to be applied, specifically Andalusia.

At present, the Constitutional Law 8/2013, of December 9th, for the Improvement of Educational Quality supports the functioning of the secondary education at national level. Furthermore, Andalusia as an Autonomous Community, also has educational power clearly defined by Aragón Reyes (Aragón Reyes, 2013). This way, it is necessary to confirm the SIGECAH aptitude with the study plans where the curricular arrangement is included, to be more exact, inside the Order of July 14th, 2016, published in the Official Bulletin of Junta de Andalucia number 144 (viii).

One of the typical elements is the intention to offer fundamental components for later inclusion on the labour market or academic career in higher levels to all the students. Specifically, the Andalusian curriculum proposes an interdisciplinar treatment for the development of the basic skills. Nevertheless, educational innovation and research become a priority looking for the collaboration between teachers and new methodological applications, whose recommendations focus on the cross-curricular subjects, the teachers' role as advisers and promoters, the active implication of the students in their own learning, the stimulation of critical thinking and reflection, the research inside the classroom, the methods of compilation and analysis of information, the interactive strategies that allow the construction of knowledge and the use of communication technologies as integrated tools, are offered like methodological recommendations in the classroom. For that reason, SIGECAH stands out as a possible tool to be used thanks to its aptitude to agglutinate inside the classroom, being able to match the pupils' current needs and obeying the current regulation.

If we observe the curricular development of Geography and History as a general subject within the block of main subjects, its importance is remarkable inside the centres of Secondary Education. Out of all the detached targets, sixteen, we can completely or partially reach eleven, since we work with documents at an autonomic level. That is to say:

1. To conceptualize society as a complex system analyzing the interactions between the diverse elements of the human activity (political, economical, social and cultural), assessing through the study of important current difficulties the multifactorial nature of historical facts and how these contribute to the creation of collective and individual identities and to the role that men and women play in them.

2. To place in the space, to know and classify the constitutive elements of the Andalusian, Spanish, European and the world's geographical environment, comprehending the existing connections between these and the humanisation of the landscape and analyzing the political, social, economical, environmental consequences

that it has in the management of resources and making them aware on the need of the conservation of the environment.

3. To know and analyze the ways in which the human society transforms the environment, and in turn how the territory influences the organisation and identity of the above mentioned society, reflecting on the dangers that generates the intervention of man in the environment, giving special emphasis in the case of Andalusia.

4. To understand the geographical and geo-economical diversity of the world, Spain, Europe and Andalusia by means of the analysis, identification and location of their basic resources as well as the most important features of their geographical and human environment.

5. To acquire a global view of the History of Humanity and the place that Andalusia, Spain and Europe take in it, by means of the knowledge of the most important historical facts, social processes and existing interaction mechanisms between the first and the second ones, analyzing the interconnections between past and present and how Andalusia is projected in the present global society supported on its historical heritage.

6. To value and understand the existing cultural diversity in the world and in the historical roots and present of Andalucía, showing respect and tolerance for the diverse cultural events, as well as developing the skill of critical thinking with regard to them, and how these attitudes are a source of well-being and development and also the foundations of democratic citizenship.

8. To appreciate the peculiarities of Andalusian culture and history for the comprehension of the position and relevance of Andalusia within the rest of Spain, Europe and the world and study the ways in which the Andalusian identity, economy and society have developed.

13. To debate and analyze the international projection of Andalucía and its role in the current globalisation process, assessing the most important opportunities and problems of this historical phenomenon for our autonomous community both in its past and in its present.

14. To know and handle the vocabulary and the specific research and analysis techniques for the social sciences, for the development of the problem solving skills and comprehension of the most important difficulties in the current society, giving special attention to the causes of the war conflicts, the signs of social inequality, the discrimination of women, the environmental deterioration and any form of intolerance.

15. To carry out case studies and research works individually or in groups, on current world problems, from the historical evolution of the human social formations and of the most relevant features and challenges of the environment not only in Andalusia but also in the rest of the world, by means of the recopilation of information of diverse nature, verbal, graphical, iconic, estadistic, cartographical proceeding from varied sources, which then has to be organized, editted and presented by means of the use of information and communication technologies and following the basic rules of work and research of the Social Sciences.

16. To take part in debates and spoken presentations on current world problems, from the historical evolution of the human social formations and of the most relevant features and challenges of the environment not only in Andalusia but also in the rest of the world, using information and communication technologies for the recopilation and organisation of the information, respecting the turns to speak and other people's opinions, analysing and valuing the points of view different from yours and expressing your arguments and conclusions in a clear, coherent and suitable way respecting the vocabulary and procedures of the Social Sciences.

Subsequently, the above mentioned targets are attainable by means of a few contents that provide the curricula with the theoretical-practical basis on which to work to reach such requirements, and to develop the basic competences. This way, the current division of the Obligatory Secondary Education in two stages and four courses (ix), determines the division of the contents at Andalusian level. Hence, we find the *first stage* from first course to third course of ESO, where the blocks of contents and their criteria of evaluation are detailed.

Then, we find that during the first course of ESO the content blocks which will be developed are: *Block 1. The physical environment*, and *Block 3. History*. Thanks to SIGECAH we can work on the following chapters: *Andalusian physical environment: relief; hydrography; climate; elements and diversity of landscape; bioclimatic areas; natural environment: areas and specific environmental problems of our autonomous community.*

The evaluation criteria which are completely or partially applied by means of the above mentioned tool are:

1. To analyze and identify the ways of representing our planet: the map, and to locate geographical spaces and places in a map using the information of geographical coordinates. CMCT, CD.

2. To have a global vision of the Spanish, European and world environment, as well as the Andalusian physical environment, and of their general characteristics. CCL, CMCT, CAA, CSC.

3. To describe the peculiarities of this physical environment. CCL, CMCT.

4. To place in the map of Spain, as well as in that of Andalusia, the main units and elements of the peninsular relief as well as the main bioclimatic spots or groups. CMCT, CD.

5. To know and describe the main bioclimatic groups that shape the Spanish and the Andalusian geographical space. CCL, CMCT.

6. To be able to describe the peculiarities of the European and the Andalusian physical environment, indicating their particular features opposite to those of the rest of Spain, Europe and the world. CMCT, CCL, CAA.

8. To know, to compare and describe the main bioclimatic groups that shape the European, Spanish and Andalusian geographical space. CCL, CMCT, CAA.

10. To identify and distinguish the different cartographic representations and their scales. CMCT, CD.

12. To know, describe and value the action of man on the environment and its consequences, by means of the achievement, whether individually or in groups, and taking advantage of the information and communication technologies, for the making and exhibition of an analysis essay on this subject centred on Andalusia, and presenting to the rest of the pupils of the group the main conclusions reached by means of the use of diverse sources, a suitable organization and a technical and correct vocabulary. CSC, CCL, CMCT, CD, CAA, SIEP.

In addition to this, during the second course of ESO, the contents of the *Block 2. The human space* and the *Block 3. The History* are developed. In this case, *SIGECAH* helps us to work completely or partially on the chapters*: Andalusia: the population; the territorial organization; demographic models; migratory movements; the city and the process of urban development. Politics of social inclusion and of gender equality.*

This way, the evaluation criteria and basic skills completely or partially worked on are:

1. To analyze the characteristics of the Spanish population, its distribution, dynamics and evolution, as well as the migratory movements and to compare this with the characteristics of the Andalusian population, its distribution, dynamics and evolution, as well as the peculiarities of the Andalusian migratory movements along history. CSC, CMCT, CCL, CD, CAA.

2. To know the territorial organization of Spain, and to analyze the Andalusian model of territorial organization. CSC, CCL, SIEP.

6. To recognize the characteristics of the Spanish cities and the forms of occupation of the urban space, analysing the Andalusian urban model and the pattern of the territory occupation. CSC, CCL.

10. To comment on the information in maps of the world on the population density and migrations. CSC, CCL, CD, CAA.

17. To indicate in a map the main urban areas and to carry out the comment, valuing the proper characteristics of the Andalusian urban network. CSC, CCL, CD, CAA.

18. To identify the role of main world cities as invigorating elements of the economy of their regions. CSC, CCL, SIEP.

41. To carry out research works, whether individually or collectively, on some of the contents treated in this course and to carry out spoken presentations on some of the contents treated in the course. As for that, the information and communication technologies will be used and rules of organization, presentation and edition of the contents will be followed that should assure their originality, order, clarity and suitability in vocabulary and disposition of the sources with regard to the procedures of research in the Social Sciences. CSC, CCL, CD, CEC, CAA, SIEP.

Along the last course of the first stage of ESO, third course, the contents in which SIGECAH can be used are those of the *Block 2. The human space*. Specifically the

chapters: *The place of Andalusia in the world's productive system. Systems and economic sectors. Structure and dynamics in Andalusia of the primary, secondary and tertiary sectors. Main Andalusian economic areas. Andalusia: main environmental problems and possible solutions. Political and administrative organization of Andalusia, Spain and Europe.*

In this case, the evaluation criteria and the basic skills worked on are:

5. To identify the main Spanish humanized landscapes, identifying them by autonomous regions, specifying the peculiar features of the Andalusian ones. CSC, CMCT, CCL.

13. To locate the farming and natural resources in the world map, emphasizing the ones belonging to the Andalusian autonomous community with special attention to water resources. CSC, CMCT, CD.

22. To describe the main features of the most important political systems, confirming the principles and institutions of the democratic and dictatorial forms of government and comparing the functioning of the main electoral systems, analyzing their positive and negative aspects. CSC, CCL, CAA, SIEP.

23. To explain the political and administrative organization of Andalusia, Spain and the European Union, analysing the functioning of the main Andalusian, Spanish and European Union institutions. CSC, CCL, SIEP.

Finally, during the second stage of ESO, that is to say, in the fourth course, the contents increase up to ten blocks, demonstrating a wider accuracy in the contents, and therefore, thanks to SIGECAH we can work at present (since we work with part of the documents generated from the Cadastre of Ensenada): *Block 1. The 18th century until 1789.*

The criteria and basic skills that are acquired by the above mentioned contents are included in this block, namely:

1. To explain the characteristics of the «Ancient Regime» in its political, social and economic senses. CSC, CCL.

2. To know the advances of the «scientific revolution» from the 17th and 18th centuries. CSC, CMCT, CCL.

3. To know the scope of the Enlightenment as a new cultural and social movement in Europe and in America. CSC, CCL, CEC.

Once such aspects have been detailed, we cannot forget the attention to the diversity inside our tool. Hence, and taking into consideration Chapter VI of the Decree 111/2016, of June 14th (x), several alternatives are proposed to solve the difficulties during the learning process in a flexible way and respecting the different pace of every pupil. Nevertheless, every centre will be in charge of proposing the different adaptations or programs depending on their specific needs.

Thus, bearing in mind the collaborative character of the tool, we propose formulae as the allocation of roles inside the work teams that contributes to the collaboration and integration of the students; this way, the pupils will have to do tasks inside the group that present less difficulty (in case of having a slower learning process), or, of a higher difficulty (if it is a question of highly skilled cases).

In addition to these roles, the documentary transcription or the digitised original texts, can be an element that attends the needs of the students inside the classroom, but whether

using it or not corresponds to the teaching planning inside the classrooms that will tutor it and select the knowledge.

We can see therefore, how the curricular elements that SIGECAH tackles inside the classroom are numerous, without focusing only on Geography, but also incorporating History, Spanish and Literature (due to the toponimical study and its evolution), in addition to some elements of Biology and Geology, thus showing their integration and cross-curricular capacity demanded by the administrations as educational methodologies.

5. CONCLUSIONS AND FUTURE WORK

The current process of normative change in the Spanish education with the entire integration of the Constitutional Law for the Improvement of the Educational Quality (LOMCE), modifies the curriculum of Geography and History along the Obligatory Secondary Education. Nevertheless, one of the fundamental intentions keeps on being the comprehension of the geographical space and its evolution along history. Hence, the technological progress over the last decades in Geographical Information Systems, in addition to the numerous tools and methodological resources, have substantially transformed the learning process inside the classroom towards a collaborative, integrating, technological and cross-curricular system.

Therefore, we have seen that the hard work tackled for almost a decade, has made SIGECAH develop in a multidisciplinary way for specialists of different areas, in order to transform the information of textual character, gathered by the Marquess of Ensenada, into a precise cartography that was never elaborated because of historical events.

Then, an effective pedagogical tool proved in the higher education was created, with which to work geographical aspects (physic and human), historical, economical, socio-political and linguistic in a practical, innovative and collaborative way.

With similar intentions, SIGECAH was developed for the Andalusian classrooms of Obligatory Secondary Education. Thanks to the digitised documents in PARES (*Respuestas Generales*) and the ones preserved inside the local historical archives (*Libro de lo Real y Libro de los Cabezas de Casa*), students can comprehend the evolution of physical space through the didactic module comparing it with the inclusion of information. This information, stored in the database by means of *shape* or *SQL files* constitute the foundations for the development of the later cartographic maps on diverse matters according to the targets planned by the teachers.

Hence, we see how the versatility of our tool is remarked, which also allows, by means of the roles inside the work teams, to attend on the diversity of the students of an inclusive way inside the classroom.

Finally, and as we have announced, we must know that it is potentially a vast pedagogical tool, but it needs the specialists' integration in contemporary matters to the project that will bring the enrichment in the learning process of pupils throughout the 19th-21st century. That is why different forms and files keep on developing to integrate the information of these periods.

NOTES OF CAUTION

(i) There is a pair of competitive research projects SEJ2005-07590-C02-02GEOG and CSO2011-29027-CO2-O2/GEOG, financed by the Ministry of Education and the Ministry of Economy and Competitiveness, respectively.

(ii) The project SIGECAH constitutes the doctoral thesis of Laura García Juan, named: *Sistema informático de gestión integral de fuentes geohistóricas (SIGECAH): Desarrollo e implementación del prototipo inicial a partir del Catastro de Ensenada*, Autonomous University of Madrid, 2015. URL: https://repositorio.uam.es/handle/10486/669607. The different elements of the system have been published in several articles that we gather in the bibliography.

(iii) Although at this point of the project it is a little adventurous, our intention in the medium-term is to incorporate the rest of cadastres and censuses of the 18th and 19th centuries.

(iv) *General Answers* to this questionaire, the same for all cadastred towns in Castile, where a general view of the social and economical features of every town was recorded.

(v) *Book of the Real Things*: it receives different denominations according to the provinces or administrations: *Libro de lo Raíz, de Haciendas, de lo Producible, Maestro, Registro (Book of the Root, Book of Properties, Book of Productions, Master Book, Register Book).* It includes the acknowledged goods, rights, revenues and charges for every neighbour, inhabitant or foreigner with cadastred properties in the town. Like the previous one, it shows separate information for both laypersons and ecclesiastic members.

(vi) *Book of the Heads of the House*, also with several denominations: *Libro de lo Personal, Libro de Vecindario* y *Libro de Familias* (*Book of the personal things, Book of neighbourhhod or Book of families).* It keeps the demographical features for residents, whether neighbours or inhabitants, taken from the *memorials*. Like the previous ones, it makes the difference between laypersons and ecclesiastic members.

(vii) The essential criterion followed by the Administration so that a locality could be cadastred as an independent nucleus was that it conformed an independent tax unit (*alcabalatorio*) (Camarero Bullón, 2003: 116-117).

(viii) Order of July 14th, 2016, which develops the curriculum corresponding to Obligatory Secondary Education in the Autonomous Community of Andalucía, certain aspects of the attention to the diversity are regulated and establishes the regulation of the assessment of the pupils' learning process.

(ix) Royal Decree 1105/2014, of December 26th, which establishes the basic curriculum of the Obligatory Secondary Education and of the Baccalaureate.

(x) Decree 111/2016, of June 14, which establishes the arrangement and the curriculum of the Obligatory Secondary Education in the Autonomous Community of Andalusia.

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MONITORING SOIL EROSION BY RASTER IMAGES: FROM AERIAL PHOTOGRAPHS TO DRONE TAKEN PICTURES

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Abstract

With the aim of understanding the evolution of soil erosion in an ecologically degraded area in southeast Madrid (Spain), an analysis is conducted on a series of aerial photographs, multi-temporal satellite images and high resolution photographs taken from a drone. This natural space has been selected as a pilot project for monitoring soil erosion in recently urbanized areas built on clastic sediments and soils. This characteristic landscape is mainly covered by gullies and is subject to high surface run-off. The evolution of soil erosion varies significantly depending on anthropic influences and vegetation cover. Soils are highly pervious and classified as regosols and arenosols, mixed with luvisols and cambisols where Mediterranean vegetation is present. Recent urbanization has increased the erosion of sandy materials. A better understanding of the soil loss processes will be useful in land use and urban planning.

Keywords: *Aerial photographs, Spot, Landsat, UAV, remote sensing, degradation soils*.

1. INTRODUCTION

The study area is located in the Community of Madrid (Spain), in the Regional Park of the Middle Guadarrama River Basin (*Parque Regional del curso medio del río Guadarrama*), in an area degraded by natural processes and human action. We use field work, aerial photography, and both satellite and UAV (Unmanned Aerial Vehicle) images to analyse degradation processes and changes in recent decades. The development of UAVs makes it possible to do high spatial resolution remote sensing.

The aim of this paper is to analyse a series of historical photographs and satellite images and compare them with current photos taken by a drone equipped with an infrared and visible light camera to study the soil degradation produced by the presence of gullies. Aerial photography and satellite images are important sources of relevant information for studying the dynamics and evolution of soil use processes and for programing initiatives to mitigate the geological risks linked to intensely anthropized areas. It is only by understanding our past and analysing how changes have affected the natural environment that we can avoid its destruction and the risk that this implies for all living beings. Many research projects have used remote sensing to analyse and measure soil degradation, (Dwivedi et al, 1997; Mathieu

et al. 1997 and 2007; Blum, 1998; Haboudane et al. 2002; Wu, 2004; King et al, 2005; Pérez and García, 2005 and 2013; Begueira, 2006; Carpintero et al. 2007; Liberti et al. 2009; García et al. 2014 and 2016; Mokarram et al. 2016; Vishwakarma et al. 2016; Yengoh, 2016, etc.) as this technique uses digital processing to provide multitemporal and multispectral monitoring of erosive processes to enhance the visualization of the results of erosion. This in turn enables implementation of soil protection measures. (Van Camp et al. 2004; Gardi. et al. 2011; Prokop et al. 2011).

2. STUDY AREA

For this paper, a case study area was selected in central Spain, in the southeast of the Madrid Autonomous Community. The centre of the 837 ha study area is located at N 40º13'56'' latitude and W 3º56'17'' longitude, with an altitude that ranges from 568 m to 635 m. The climate is Mediterranean and is characterized by a four-month summer drought (June to September), an average annual rainfall of 450 mm and an average annual temperature of 14.9º C. The main characteristic of the precipitation is its temporal and spatial irregularity, with monthly rainfall reaching a high of 199.8 mm (November 1997) and a 24-hour maximum of 79.4 mm (24 June 1995). Monthly rainfall varies from 60 mm during the wettest month to 11 mm in the driest, with an average of 16.2 days per year with thunderstorms and 58.8 days annual precipitation ≥ 1mm. The average monthly temperature ranges from 6.0° C in January to 25.6º C in July.

In hydrological terms this area forms part of the middle reach of the Guadarrama River, which flows through tertiary sediments of arkosic sands with some gravel and clay layers. As you move from the river's source in the granitic sierra to its lower reaches, the grain size of the sands diminishes and the amount of clay increases. The river channel is confined within a gently sloping valley flanked by remnants of multiple terraces; gravels predominate in the highest of these, gradually becoming increasingly sandy downstream. In the lower reaches the valley broadens out and becomes flatter, so that the outlines of the terraces are difficult to distinguish. Here the slope contributions and remobilization of material by lateral fans are especially important and are essential for the channel supply during flash floods. The flood plain is not well defined and in the lowest reach has a maximum width of 1 km, (Garzón and Alonso, 1996).

Two features condition the flood risk: in this river the morphological and sedimentological limits between the high water channel and the flood plain are not clearly defined and the sandy banks are very unstable, facilitating remobilization. Another significant effect is the subsurface bank erosion process resulting from the sandy composition of the banks and intercalated sandy material, and also from the elimination of protective vegetation. The result is the formation on the banks of gullies that reach tens of meters in length, where various housing developments have been built, (Sanz et al. 2014).

The soils are mainly regosols and arenosols, (Monturiol and Alcalá, 1990), with the occasional presence of luvisols, anthrosols and cambisols, (Pérez and García, 2016). These soils are highly permeable and have been subjected to increased soil sealing in recent years, because of urban expansion in Madrid.

The study area is one of the few spaces to the south of Madrid which conserves the potential Mediterranean forest vegetation, formed by a dense arboreal stratum of *Quercus* with abundant scrub undergrowth, (*Cistus salvifolius, Cistus alvidus, Retama sphaerocarpa, Phyllirea angustifolia, Thymus Zygis, Thymus mastichina, Rosmarinus officinalis, Daphne guidium, Crataegus monogyna*, etc.), especially where erosion processes (natural degradation by gullying or anthropic degradation from soil sealing) have not occurred. Groups of *Populus*

x canadiensis, Salix fragilis, Salix atrocinerea and Salix purpurea are found in some areas on the banks of the Guadarrama River (Figure 1).

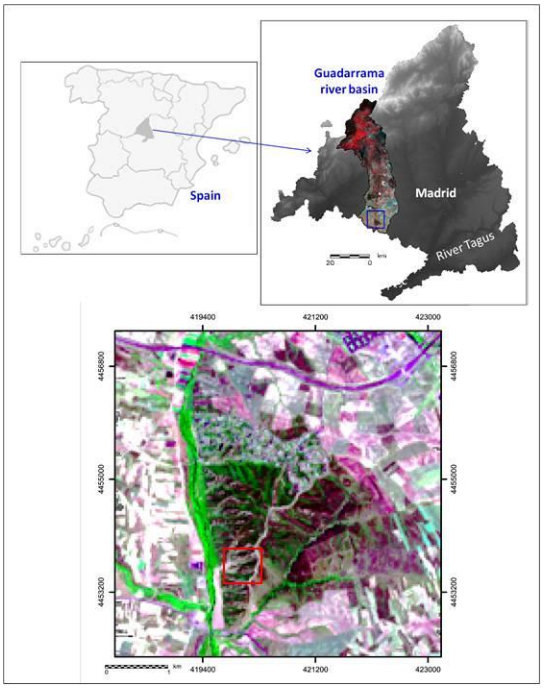


Figure 1. Study area and detail of Landsat 8 image: 7-4-2 (R-G-B), 06-06-2013. The red square marks the largest gully area.

3. MATERIAL AND METHODS

The monitoring and measurement of soil degradation in the southern part of Madrid has been carried out with a range of raster images from the last sixty years. A selection of historic aerial photographs taken on different dates and scales was also used, as well as Landsat and Spot satellite images. In the part of the study area where the most gullies have formed (Figure 2), a drone (Unmanned Aerial Vehicle) was also used to obtain very high spatial resolution images, (0.03 m).

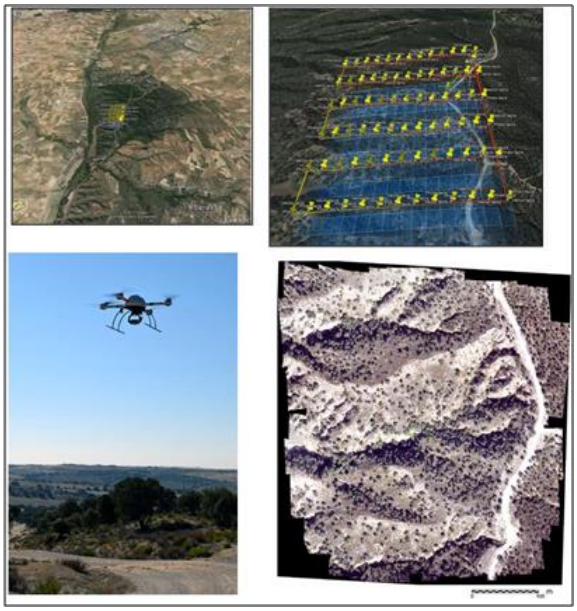


Figure 2. UAV flight plan and image obtained in the visible spectrum.

Table 1 shows the dates and main characteristics of the raster information used. Figure 3 shows the study phases.

Table 1. Raster images selection: aerial photographs, satellite images and UAV image.

Raster images	Date	Spatial resolution/Scale	Spectral resolution
Aerial Photograph	1956	1:25,000	Panchromatic
Aerial Photograph	1961-1967	1:30,000	Panchromatic
Landsat 8 images	06/06/2013	15 m 30 m	Panchromatic Blue, Green, Red, NIR, 2 SWIR
Spot 5 images	08/09/2013	2.5 m 10 m/20 m	Panchromatic Green, Red, NIR/1 SWIR
UAV	12/03/2015	0.03 m	Natural colour (R-G-B) Multispectral (G-R-NIR)

Raster images were geo-referenced to Universal Transverse Mercator UTM coordinates (grid zone 30T) and Datum ETRS89, and all of them were processed with Erdas Imagine-2015 software. Also, the Landsat and Spot images were processed carrying out different spectral enhancements (band combinations, tasseled-cap and principal components), radiometric enhancement (histogram equalization) and spatial enhancements (3x3 convolution filter and resolution merging of panchromatic and multispectral images).

To understand the soil characteristics in the study area, different samples were selected to cover the edaphic range, from the most fertile soils on the river flood plain with the lowest slopes and the greatest vegetation cover, to the most intensely degraded soils. We collected samples of the soil surface horizon and analysed them in the laboratory. The measurements taken were texture (Robinson's pipette international method), pH (paste saturated with water and KCl), organic material (Walkley and Black method), carbonates (Bernard calcimeter) and electrical conductivity (aqueous soil extract and 1:1 soil/water ratio), to define the properties of the soils affected by sealing. Four analyses of each sample were performed to obtain a mean.

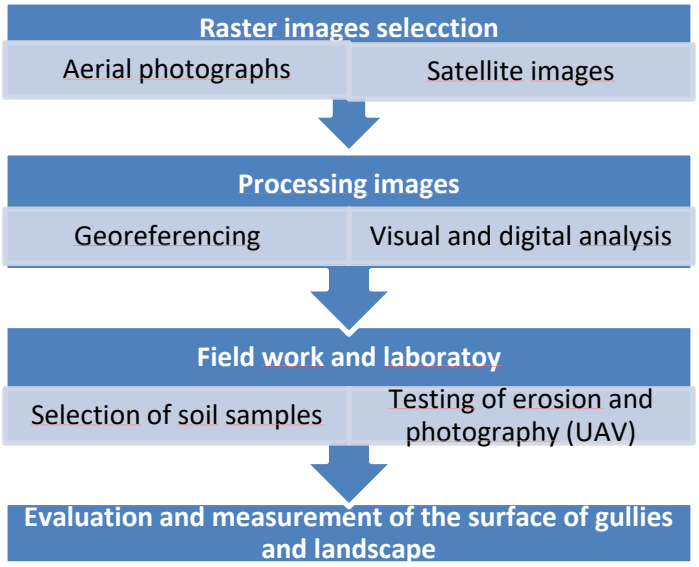


Figure 3. Methodology flow chart.

The raster images were analysed and the information obtained was contrasted with the ground truth. Some images were then trimmed to coincide with the UAV image showing the most extensive surface area of degraded soils. Supervised classifications were then performed using a minimum distance parametric rule. Four categories of state soil conservation or soil occupation were selected: bare soil, forest 1 (woodland), forest 2 (shrubby - herbaceous) and shadows (cast by the trees), although this class was finally included with forest 1.

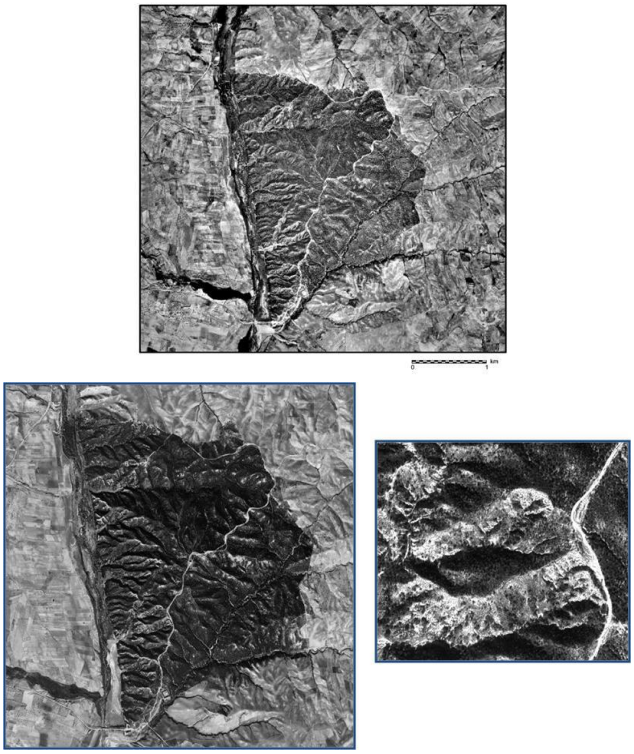
A confusion matrix was used to check the accuracy of the classifications, contrasting the results with the existing maps on both dates and with the ground truth data verified in May 2016. Although the most recent orthophotos of Madrid (Madrid Community, 2011; Scale 1:5000) permit high precision visual interpretation confirming the field data, 50 random sampling points were chosen and their accuracy was checked.

Finally, the classified images from 1956 and 2015 were used to obtain the surface areas of bare soil and the most stable areas with various vegetation strata.

4. RESULTS AND DISCUSSION

The high spatial resolution of conventional aerial photography may seem suitable for analysing soil degradation processes, but the lack of multispectral data and the low temporal resolution make it less important for thematic mapping. However, this type of photography is still essential for geomorphological or small scale vegetation studies and can also be used as a reference source or to validate semi-automatic mapping from the past. This case study uses aerial photographs taken from planes and a UAV for detailed studies, but sun-synchronous orbit satellites were selected as support for smaller scale images. Thus, recent images from Landsat and Spot satellites are analysed here with multiple spectral channels to facilitate the detection and measurement of the erosion processes. It is important to note here that visual identification of the gullied materials is significantly conditioned by the spatial and spectral resolution of the sensor used. The Landsat satellite has higher spectral resolution and the Spot satellite greater spatial resolution and, therefore, both images are used to extract the maximum possible information on the evolution of the terrain.

Panchromatic aerial photos from the 1950s and 1960s provide information on the level of conservation of this natural area in the south of Madrid and the almost complete absence of urban development during those years. In these, a contrast can be observed between the stabilized soil covered by vegetation (dark tones) and the eroded soils with gully formation (light colours). Nevertheless, sectors with high forest density, the largest gullies and drovers' roads can already be identified here. Figure 4 shows a detail of the sector with the most gullies.



Source: www.madrid.org/cartografía.
Figure 4. Aerial photograph 1956 (up) and 1961-67 (down) in the study area.

Although the 2013 30m resolution Landsat-8 image has some limitations, it does have the advantage of providing high spectral resolution, with seven visible and infrared channels that can discriminate between vegetation, sealed soil and gullies after spectral enhancements. With all the processing, the best identification of erosive processes was obtained from spectral enhancement using principal component analysis and tasseled-cap transformation. Principal components analysis is based on summarizing a large number of variables into a smaller group, taking the variance matrix into account, with hardly any loss of information. The variables are the different sensor bands and this analysis is used to obtain a new image, in which the first few components will represent almost the entire range of variability. In Figure 5 the principal components image (left) shows the urban development in individual plots and gardens to the north of the nature area, clearly shown in purple tones, with the gullies in orange.

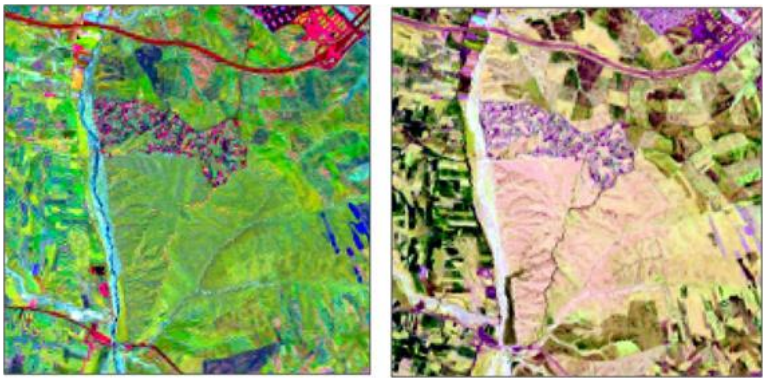


Figure 5. Landsat 8 Image**,** Principal components (left) and tasseled-cap (right).

The tasseled-cap function reduces sensor bands to three new bands representing the brightness or albedo (reflectivity of all bands), green (relationship between visible and near infrared channels) and humidity (considering the mid-infrared). Figure 5 (right) also highlights sealed soils (in purple), and identifies the forest surface area (pink) and gullies in black.

The Spo-5 satellite with higher spatial resolution allows a clearer visual identification of the ground features. It was also processed with a series of spatial enhancements using convolution filtering (3x3 high pass filter) and resolution merge to obtain excellent results. Thus, the resolution merge function improved the level of detail in the final image and the multispectral image was merged with the panchromatic satellite image. This discriminates clearly between urban developments with open building, riverbank vegetation, the densest forest areas, scrubland or open woodland, drovers' roads and the most intensely degraded soils (rills, gullies and ravines with no vegetation cover), Figure 6.

The impact of urban development on the increased soil erosion near large urban nuclei has been studied by many authors (Gover and Poesen, 1986; Poesen and Govers, 1986; Ramos et al. 2000; Zhanga et al. 2003; García and Pérez, 2007 and 2011; Plata et al. 2009; Scalenghe and Ajmone, 2009; Siebelec et al. 2010; Valera et al. 2011 and 2013; Barbero et al., 2013; Xiao et al. 2013).

The image obtained using convolution filtering (3x3 High Pass) facilitates the detection of linear features, (gullies in white, Figure 6).

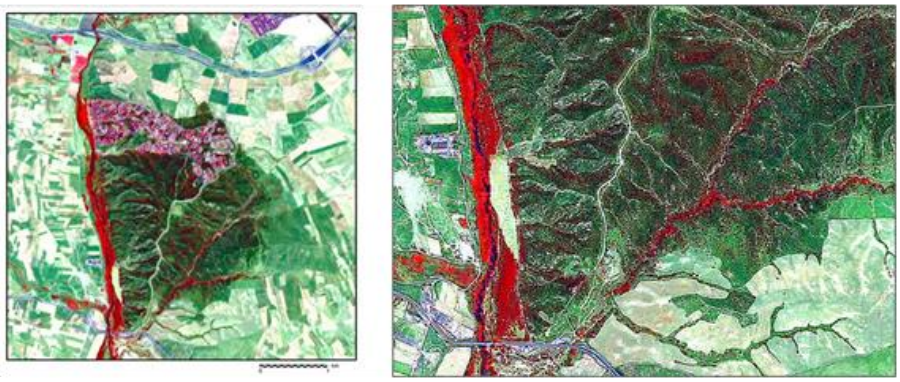


Figure 6. Spot 5 Image, 3-2-1 (R-G-B). 08-09-2013. Resolution merge (left) and 3x3 high pass filter (right).

Once the study area had been analysed, a small sector (17.4 ha, 2.1 % of study area) with the most important erosive processes was selected for a UAV flight to compare the image obtained with the photographs from 1956 and the satellite images. Using the photographs with the highest spatial resolution a classification was made to differentiate eroded areas from areas which present more stable vegetation

The high spatial resolution of the UAV image allows vegetation cover (trees and shrubs) to be identified in detail. It is also possible to map the surface of the badlands and the depth of each ravine. In the future these data will make it possible to measure soil loss more accurately.

Multitemporal analysis of the main gullies highlights the increase in bare soil to the detriment of shrubby and herbaceous vegetation. These bare soils underwent important erosive processes from 1956-2015. In contrast, in those areas where a dense arboreal vegetation of *Quercus ilex* already existed, the stabilization is confirmed or has even increased, with mature, dense, stable forest growth which impedes gully evolution.

The presence of drainage pipes at some gully heads evidences the anthropic cause of the erosion, which is very rapid in sandy sediments. In the nearby housing developments built on these fragile sediments the regular watering of garden areas has facilitated rapid soil loss.

Planting Mediterranean species in these gardens would be much less demanding in terms of water and more viable considering the local climatic conditions, (Figure 7).

In other soils developed on sandy sediments, similar to SW Madrid, changes in the hydrological cycles and increased surface runoff due to soil sealing have led to an increase in gully-formation processes (Assouline and Mualem, 2006; Jacobson, 2011; Jakab et al. 2013).

Figure 7. Photographs showing the erosion of sandy sediments Guadarrama Basin, 04-15-2016.

To see how these erosive processes can affect the soil, four profiles were selected for physical and chemical analysis (Table 2). With these tests the soil was confirmed to be sandy loam. These soils are poor in clay and organic matter and their structure is unstable, favouring erosion processes. They are permeable, neutral or slightly acid, with few carbonates and very few salts. Although these soils are not particularly fertile their loss also implies reduced water infiltration and greater surface run-off. The destruction of the vegetation cover accelerates this erosion.

Table 2. Analytical data and classification soils

Sample	Gravel %	Coarse Sand %	Fine Sand %	Silt %	Clay %	pH (H_2O)	pH (KCl)	O.M. %	Carbonates %	E.C. dS/m	Soils
1	34.78	47.5	28.45	6	18.05	6.23	5.08	1.37	1.03	0.23	**Regosol**
2	34.40	16.7	52.62	10.02	20.65	6.65	5.73	2.69	0.93	0.38	**Fluvisol**
3	16.02	34.2	45.52	6.85	13.43	6.40	5.14	1.32	0.99	0.11	**Cambisol**
4	27.86	31.4	43.67	9	15.93	7.51	6.74	6.56	1.25	0.55	**Anthrosol**

Finally, a supervised classification was carried out using the minimum distance rule with the two images obtained from the 1956 aerial photos and the UAV. The aim was to measure the surface areas with vegetation and with degraded soil and analyse the changes between these two dates, (Figure 8 y Table 3).

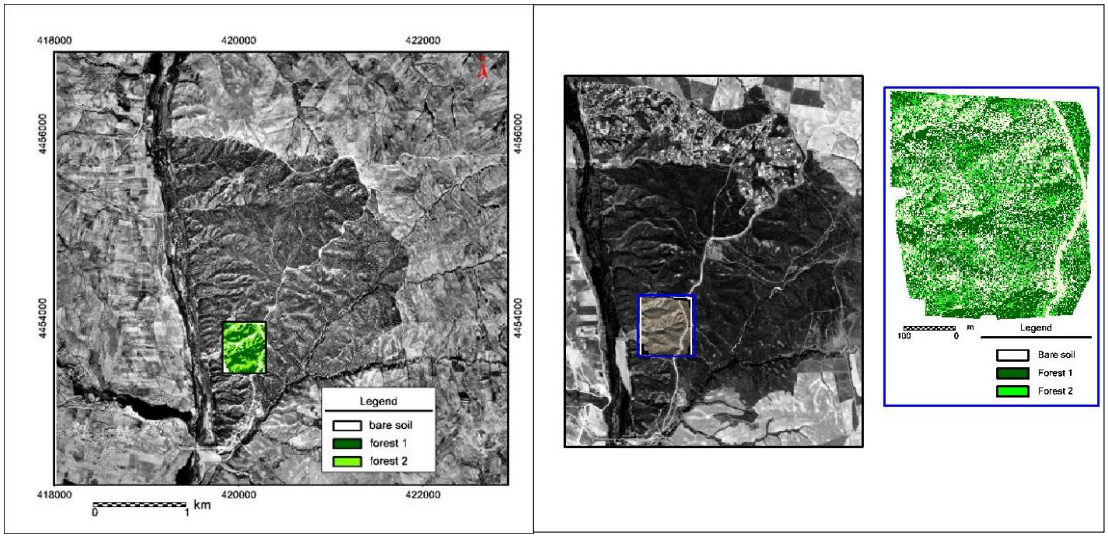


Figure 8. Land cover classification: aerial photograph-1956 (left), and UAV-2013 and localization in Spot image (right).

Three classes were established: bare soil, dense woodland, and scattered woodland and/or scrubland. A fourth preliminary class, corresponding to the shaded area, was combined with the forest area from the information contributed by the UAV multispectral image. This multitemporal analysis confirms that the percentage of bare soil increased considerably over those sixty years, to the detriment of the areas with more scattered or less developed vegetation. However, areas with dense or highly developed vegetation remained stable.

The presence of dense Mediterranean vegetation woodland thus halts the degradation processes which would otherwise been greater in areas where hydric erosion, anthropic action and the presence of highly permeable soils lead to the formation of deep gullies causing rapid soil loss.

Table 3. Supervised classification

Classes	Aerial Photograph 1956	UAV images 2015
Bare soil (%)	12.00	28.87
Forest 1 (%)	52.35	50.63
Forest 2 (%)	35.65	20.50
Total (%)	*100*	*100*

The landscape of this area is characteristically eroded by gullies, which evolve in different ways depending on anthropic activity. The area known as "*Las Cárcavas*", on the left bank of the river at the southern edge of the Community and protected within the area of the regional Park (*Parque Regional del curso medio del río Guadarrama),* has remained almost unchanged over the last 60 years and has sectors where vegetation density is even greater, which contributes to river bank stability. Conversely, in areas where intensive soil sealing has occurred as a result of urban development, the erosive process has intensified. Earth moving required to construct the road network and buildings, in addition to increased surface water from irrigation have produced significant degradation of Mediterranean woodland and sediment loss. An example of this can be seen in the *Cotorredondo* housing development, where building started in the 1970s on poorly compacted sandy material and which now presents very important erosion problems, (Sanz et al., 2014).

5. CONCLUSIONS

The study area in general shows that arboreal vegetation has recovered between the 1950s and 2015, although at specific points there are problems of erosion affecting the stability of the Neogene materials, vegetation mass and soils. This erosion has been heightened by urban development on sandy materials and by increased surface runoff originating from irrigation or artificial drainage with above-ground outlets.

Remote sensing is extremely useful for measuring degraded soils. A comparison of images from different dates enables the intensity and evolution of the process to be analysed. Furthermore, merging images with different spectral and spatial resolutions gives good results.

The availability of raster images with increasingly higher spatial resolutions allows territorial processes to be analysed from scales that range from the medium level (30 meters for the Landsat images and 10/5 meters for Spot images) down to the highly detailed (3 cm of the UAV images).

The Landsat and Spot images with several infrared channels provide valuable ground information that cannot be obtained with high spatial resolution images that only capture visible channels.

The images analysed between the 1960s and 2015 show a general recovery of the vegetation in certain places. However in areas that have been subject to sealing or badland processes, soil erosion has increased, both in built-up areas and ravines.

These land-monitoring techniques should be incorporated into the tools used by the relevant local authorities.

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ACTIVE SPORT TOURISM IN POLAND: ENVIRONMENTAL CONDITIONS AND MOTIVATIONAL ASPECTS

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Abstract

Active sport tourism has been identified, along with event sport tourism and nostalgia sport tourism, as a category of sport tourism. Active sport tourists travel to participate in sport – being physically active is the main purpose of their travels. Each decision regarding a holiday, weekend or one-day trip is driven by several types of motivation of different intensity and is related to the choice of a destination with desirable environmental conditions. The aim of the study was to analyze the influence of the natural geographical environment variables and motivational forces on the phenomenon of active sport tourism in Poland. The investigations on motivation to participate in active sport tourism were carried out with different fractions of the population of tourists. The analysis of the environmental determinants of active tourism in Poland, such as terrain, climate, air quality and a hydrographic network allow to conclude that the conditions are conducive to different types of active tourism, especially hiking (both lowland and mountain) biking, inland waterway sailing and canoeing. The need to be physically active was the predominant motivation to participate in active sport tourism while ambition was the least important of all motivational dispositions.

Keywords: *Poland, tourist attractions, motivation.*

1. INTRODUCTION

Active sport tourism (AST) has been identified, along with event sport tourism and nostalgia sport tourism, as a category of sport tourism. Active sport tourists travel to participate in sport – being physically active is the main purpose of their travels. While defining this type of tourism, several authors emphasize that active sport tourists are individuals who participate in

sport activities while on holiday (De Knop, 1990; Gibson, 1998; Hinch, Higham, 2011). Active sport tourism involves travelling in order to participate in different sports; its primary aim is to become engaged in physical activity (Gibson, 1998). We posit that the term 'active sport tourism' relates to two-day or multi-day trips, in which the main goal is physical activity – practising the various forms of movement recreation. The difference between active sport tourism and physical recreation lies in a need of leaving a place of residence and in interaction with the natural environment and its special values. The most popular forms of AST are: hiking, climbing, skiing, cycling, horsemanship, canoeing, sailing, windsurfing, kitesurfing, diving.

Poland is the biggest country in the Central Europe, the ninth largest country in Europe, with total land area 312,7 km^2 and population over 38 million people. Poland is a member state of NATO (since 1999), the European Union (since the 1st of May 2004) and a part of Schengen zone. The variety of geographical regions in Poland is of the most importance for different forms of active sport tourism. Poland is situated between the Baltic Sea in the north and two mountain ranges (the Sudetes and Carpathian Mountains Chains) in the south. Poland's territory extends across several geographical regions:

- the Baltic seacoast with coastal lakes and dunes;
- the hilly districts of moraines and moraine-dammed lakes: the Pomeranian Lake District, the Greater Polish Lake District, the Kashubian Lake District, and the Masurian Lake District;
- the regions of Lusatia, Silesia and Masovia, which are located in the broad river valleys;
- the heterogeneous mountain region, including the Sudetes, the Polish Jurassic Highland, the Holy Cross Mountains, and the Carpathian Mountains with the Beskids and the Tatra Mountains, the highest part of the Carpathians.

The study was based on a bibliography referring to geography of Poland, own experiences and the results of empirical research on motivation to active sport tourism. The aim of the study was to analyze the influence of the natural geographical environment variables and the motivational forces on a phenomenon of active sport tourism in Poland. The main questions were:

1. How do the natural geographical features in Poland (landform, a sea, rivers, lakes, climate, the richness of nature) affect the different forms of active sport tourism?
2. Which recreation-related motivational forces are predominant while making the decisions to participate in active sport tourism?

2. THE ENVIRONMENTAL CONDITIONS OF ACTIVE SPORT TOURISM

Tourist attractions are of the most importance for active sport tourism as for all other kinds of tourism. The development of cultural tourism would be difficult without the monuments and the museums; attributes and quality of the natural environment are of similar importance for active sport tourism. Attributes of the natural environment, such as weather and climate, landform, hydrosphere, vegetation and animals, allow for realization of the plans relating to active recreation. The features of the natural environment are particularly important, especially those which allow to practice the various forms of active tourism. The various studies of the suitability for tourism of the natural environment in Poland, which have been carried out for the tens of years, confirm that they are moderately good or even very good. This study was related to the suitability for the different forms of tourism, including leisure tourism, both passive and active (Mileska, 1963; Wyrzykowski, 1986; Kożuchowski, 2005).

The assessments of the tourist attractiveness were made (Wyrzykowski, 1991) and the most useful areas for the specific forms of tourism were indicated (e.g. Doroz-Tomasik, 2016).

The usefulness of the specific features and elements of the natural environment for active sport tourism has been often evaluated (e.g. Mazurek et al., 1984; Sieńko-Awierianów, 2011; Miszuk et al., 2012; Koźmiński, 2012; Błażejczyk, 2004; Pelech, 2012). Favorable and unfavorable features of the natural environment, affecting the development of such and other forms of tourism (Duda-Seifert et al., 2012, Cetner, Dyguś, 2011; Krąż, Balon 2012; Bernat 2010; Warda, Stamirowska-Krzaczek, 2009), were established. Various researches about the local conditions were also carried out, usually in order to determine the possibilities of tourism development in micro- and mesoregions or administrative units (Obrębska-Starklowa et al., 1991; Rinke, 1984; Brzezińska-Wójcik, Świeca, 2010). Researchers have wondered what conditions are necessary for development of the specific forms of active tourism (Józefczyk, 2014; Marek, Lewandowski, 2011).

The studies, various publications and discussions at scientific conferences enable us to describe the environmental conditions of active tourism in Poland in more detail.

Terrain of Poland is distinctive; the term 'zonality' is often used to describe it. The north and the central terrains include lowlands. Farther south a belt of the uplands and the foothills extends until the Sudetes and the Carpathian Mountains Chains. Poland's highest point is the north-western summit of Rysy in the High Tatras (2499 meters ASL). Overall, the difference in height is of about 2500 m, while for the majority of Polish territory relative height does not exceed 200 meters. The predominantly lowland character and flat landscape can be found only in central Poland. Lowlands in the northern part of Poland are cut by bands of the moraine hills, high even for 300 meters above sea level (Wieżyca 329 meters ASL, the Dylewska Mountain 312 meters ASL, the Szeska Mountain 309 meters ASL). Thus, each region exhibits a varied and picturesque scenery, which is even emphasized in their names, such as the Kashubian Switzerland or the ‘Hunchbacked’ Masuria (Mazury Garbate). Further in the south, the landscape gets even more varied, like in the area of the highlands (the Polish Jurassic Highland, the Holy Cross Mountains, the Roztocze range) or in the mountains (the Tatra Mountains, the Pieniny Mountains, the Bieszczady Mountains, the Table Mountains, the Giant Mountains, the Śnieżnik Massif, etc.). Specificity of the terrain in the southern Poland is defined by diversity of the origins of the mountain formations. The Holy Cross Mountains, one of the oldest mountain ranges in Europe, is heavily eroded in contrast with the young Tatra Mountains. Peaks are built mainly from limestone (the Pieniny Mountains), sandstone (the Table Mountains), the Carpathian flysch (the Beskids) and granite in the Eastern Tatras. The locally occurring rocks, particularly in the Polish Jurassic Highland, the Sudetes and the Carpathians, create good conditions for climbing tourism. Natural caves offer additional opportunities for practicing the activity; they are available in three regions: in the Tatra Mountains, the Sudetes and the Polish Jurassic Highland. However, none of the known Polish caves exceed 900 meters in depths (Figure 1).

Source. http://naszregion-nysa.blogspot.com/2016/01/konkurs-mapa-europy-i-polski-etap-v.html?view=mosaic

Figure 1. Map of Poland

The diversity of Polish terrain – dominated by plains – provides perfect conditions for many forms of active tourism. Both mountain and lowland hiking are possible throughout the country, and both have been popular in Poland for over 100 years. The activity is mainly available in the south part of the country, where different levels of difficulty and diverse landscapes (the Carpathians, the Sudetes) are offered. Prevailing plains create the ideal conditions for cycling tourism. A dense network of cycling trails was created, including the six pieces of the international EuroVelo routes or the Greenways trails. A huge project called the Eastern Trail Bicycle Green Velo was carried out in recent years in eastern Poland. There are also, in upland or mountain areas, conditions for more extreme uses of a bicycle, including mountain biking and downhill mountain biking. The most of the terrain in Poland are suitable for the horseback active tourism which developed significantly over the past two decades (Jankowski 2008). New horse riding trails were formed in the Polish Jurassic Highland, the Holy Cross Mountains, the Sudetes, the Beskids and the Bieszczady Mountains and, finally, in the central part of Poland – the Łódź Horse Trail, touted as the longest in Europe (2100 km). Landform in Poland is suitable for skiing tourism, both downhill and cross country skiing. Skiing is limited to winter months and depends on snow precipitation.

The climate in Poland is mostly temperate throughout the country. The climate is oceanic in the north and west and becomes gradually more continental towards the south and east. Poland is in the temperate latitudes, where maritime air from the North Atlantic and continental air from the east converge, causing frequent day-to-day and year-to-year variability in the weather patterns. The average annual temperature in Poland is about 8°C

and varies for the regions of Poland depending on height above sea level and distance from the Baltic Sea. In the summer, for instance, temperatures are lower in northern Poland because of the Baltic Sea. Temperatures are the lowest in the mountains and the highest in western and central Poland. Summers are warm, with average temperatures between 15-21°C depending on a region. Winters are cold, with average temperatures between 3°C in the northwest and -6 °C in the northeast. Average annual precipitation for the whole country is 600 millimeters, but isolated mountain locations receive as much as 1,300 millimeters per year. The total is slightly higher in the southern uplands than in the central plains. The highest precipitation is in the mountains and uplands and the lowest occurs in the central, lowland areas of Poland. On the average, precipitation in summer is twice that in winter. Spring arrives slowly in April, bringing mainly sunny days after a period of alternating winter and spring-like conditions. In the summer months of June, July and August, showers alternate with dry, sunny weather and the temperature averages about 18°C; the maximum summer temperature is 40°C. Early autumn is generally sunny and warm before a period of rainy, colder weather in November begins the transition into winter. Winter, which may last one to three months, is cold and cloudy and brings frequent snowstorms but relatively low total precipitation. The average temperature in January is about -4°C but it can fall as low as -35°C.

Clean air is very important for tourism activity. The quality of air in Poland is good or very good and continues to improve along with changes in the Polish industry. The best conditions are in the north-east Poland and this area is called "the green lungs of Poland".

Poland has a dense hydrographic network, including lakes, artificial lakes, ponds, swamps and rivers, almost all belonging to the Baltic Sea catchment area. The purity of the waters has definitely been improving in recent years but remains unsatisfactory. Although the three largest rivers in Poland (the Vistula, the Oder, the Warta) and the coastal waters of the Baltic Sea are locally polluted, one of the most famous regions, Masuria in northern Poland, is known for its 2,000 lakes of pure water. Masuria and the Masurian Lake District are known in Poland as "land of a thousand lakes". The terrain is rather hilly, with connected lakes, rivers and streams. Forests account for about 30% of the area. The northern part of Masuria is covered mostly by the broadleaved forest, while the southern part is dominated by pine and mixed forests. Conditions for diving in Poland are not the best because of the impurity and temperature of water, as well as the size and the depth of the water reservoirs. The lake with the greatest depth of more than 100 meters is Lake Hańcza in the east part of Masuria. Diving usually takes place in some lakes (e.g. Lake Hańcza, Lake Drawsko, Lake Powidzkie, Lake Miedwie, Lake Mamry), in the flooded mines and quarries, and selected places on the shores of the Baltic Sea (e.g. around the Hel Peninsula and Łeba). Windsurfing and kitesurfing are very popular forms of active sport tourism in Poland because of splendid conditions on the numerous lakes and the coastal waters of the Baltic Sea, especially on the Hel Peninsula. Conditions for canoeing and kayaking are excellent in Poland because of a large number of lakes, particularly in the aforementioned lake districts. The dense river network, including the large rivers (the Vistula, the Oder, the Warta, the Bug, the Noteć, the Narew) and a huge number of smaller tributaries is also very important for canoeing. Smaller rivers, combined with picturesque natural landscape, create the highest grade conditions for canoeing, rarely found in Europe. Small rivers are wild, unregulated, with the natural vegetation on the banks. The unique hydro-technical facilities, such as the Augustów Canal, the Elbląg Canal (the height difference reaching over 100 meters), the Gliwice Channel, the Bydgoszcz Canal and others, make the travel by canoe more attractive. Besides canoeing, local conditions are conducive to rafting. Some stretches of major rivers, some larger lakes, both natural and artificial, the coastal waters of the Baltic, including the Pomeranian Bay, Gulf of Gdansk, the Vistula Lagoon and the Szczecin Lagoon, create good conditions for yachting. The lakes

most popular amongst the sailors include: Lake Jeziorak, Lake Iławskie (Czarnecki, Lewandowska-Czarnecka, 2008), Lake Solina, Lake Otmuchowskie, Lake Nyskie, Lake Turawskie, the Great Masurian Lakes and the Reservoir Rybnicki, which never freezes. All these bays and lakes allow various water based activities like windsurfing, kitesurfing and waterskiing. The sailing season in Poland is quite short; it lasts only 5-6 months.

Conclusion: The analysis of the environmental determinants of active sport tourism in Poland, such as terrain, climate, a hydrographic network and the air quality, allowed to conclude that the conditions are conducive to different types of active sport tourism, especially hiking (both lowland and mountain), biking, the inland waterway sailing and canoeing.

3. SOCIAL CONDITIONS OF ACTIVE SPORT TOURISM

Each decision regarding holiday, weekend or one-day tour is associated with several motives of different intensity; it is the interaction between individual motivations that generates behaviours (Bowen, Clarke, 2009). Motivation is defined as a process of stimulating people to act, the inner drive or pressure to take action in order to accomplish some goals (Mullen, Johnson, 1990).

According to Winiarski (1991), active recreation behaviour is driven by seven motivational forces including: activity, catharsis, health, emotion, society, ambition, knowledge. Another frequently cited theory regarding leisure and travel motivation is Iso-Ahola's Social Psychological Model of Tourism Motivation (SPMTM) (Iso-Ahola, 1982). It is based on the concept of 'push and pull' factors, leading people to travel (Dann 1977, Crompton 1979). The 'push' factors are the internal forces (intrinsic motivation) which predispose to travel, while the 'pull' factors are the external forces which attract to chosen destinations. Iso-Ahola suggests that motivation is an internal force, which modifies the behaviour of an individual similarly to 'pull' factors. People participate in tourism to reach satisfaction through striving for something or through avoiding something. Four motivational categories are defined: seeking personal rewards; seeking interpersonal rewards; escaping interpersonal environments; escaping personal environments (Wolfe, Hsu, 2004).

In the present study a questionnaire was used. The sample selection was purposeful. Participation in the study was voluntary and anonymous. The surveys were carried out in Poland in 2014-2015 among:

- 375 tourists on the mountain trails (hikers) in the summer who stayed in the five mountain hostels in the Beskids (Silesian and Żywiec),
- 177 participants of the summer windsurfing camps (windsurfers) in Jastarnia on the Hel Peninsula at the Polish seaside,
- 126 participants of the summer sailing camps (sailors) at the Masurian Lake District,
- 193 downhill skiers (skiers) in the winter weekends on the ski slopes in the Beskids (Silesian and Żywiec).

Statistical analysis included 871 correctly completed questionnaires. The examined sample was not representative, so conclusions can only be drawn regarding this particular study population.

The investigations were carried out in the form of a diagnostic survey. The research tool was a questionnaire consisting of 49 statements concerning the motives for participation in active sport tourism. The respondents evaluated each item of the questionnaire using the 5-point Likert scale, selecting the best comment representing their views among the following: "absolutely yes" (5 points in statistical calculations),"rather yes" (4 points), "I don't know" (3

points), “rather not” (2 points) and “absolutely not” (1 point).

Based on the comments, descriptive statistics like arithmetic means ($\bar{x}$) and standard deviations (*SD*) were calculated for each of the seven forces of motivation, according to the concept of Winiarski (1991). Each of the seven motivational forces were studied basing on the seven questionnaire statements.

The internal consistency (the reliability) of the questionnaire was positively assessed. Cronbach’s alpha coefficient of the reliability was 0.76. A repeated measures ANOVA and post-hoc tests were used to determine significance of the differences between the means of the seven motivational forces for the participation in active sport tourism. The assumed significance level was $\alpha < 0.05$.

The study is a trial to determine the importance of motivational forces underlying the decisions to participate in active sport tourism. The analysis revealed some differentiation with respect to motivational dispositions affecting the decision to participate in tourism. 'Activity' seems to be the main force behind the decision connected with tourism because of the highest mean in almost all groups of the respondents, except sailors (mean values: total 3.49, skiers 3.72, hikers 3.65, windsurfers 3.63). Sailors recognized ‘society’ (the highest mean 3.61) and ‘catharsis’ (the second in order mean value 3.57) as the most important motivational forces. The post-hoc tests revealed that these differences are statistically non-significant ($p > 0.05$). The mean values for ‘ambition’ were the only significantly different in the all groups of respondents ($p < 0.05$). ‘Ambition’ proved the least important with the lowest mean (total 3.00, skiers 2.95, hikers 2.99, sailors 3.01, windsurfers 3.12) among all other motivational forces, irrespective of the type of leisure activity (Table 1).

Table 1. Motivational forces – mean, standard deviation and *p*-value

Motivational force	Total (n=871)		Hikers (n=375)		Windsurfers (n=177)		Sailors (n=126)		Skiers (n=193)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Activity	3.64	0.47	3.65	0.55	3.63	0.51	3.49	0.48	3.72	0.55
Catharsis	3.33	0.80	3.32	0.53	3.30	0.83	3.57	0.65	3.36	0.48
Health	3.50	0.54	3.50	0.96	3.56	0.90	3.46	0.64	3.48	0.44
Society	3.52	0.41	3.48	1.20	3.50	0.81	3.61	0.72	3.49	0.51
Emotions	3.52	0.64	3.50	0.87	3.49	0.86	3.51	0.55	3.55	0.40
Ambition	3.00*	0.39	2.99*	0.79	3.12*	0.63	3.01*	0.54	2.95*	0.49
Knowledge	3.33	0.50	3.30	0.85	3.27	0.77	3.49	0.58	3.31	0.56
Index variability	F=8.473 p<0.011*		F=12.905 p<0.001*		F=6.490 p<0.001*		F=9.130 p<0.001*		F=14.021 p=0.032*	

* statistically significant

Knowledge on motivation which influence decisions concerning holiday trips might enhance the effectiveness of marketing campaigns promoting both tourist products and tourist values of places of destinations. If we would like to shape, intensify and satisfy the needs, they should be determined and investigated first. Motivation, which stimulates and gives direction to human actions results from unsatisfied needs which are strong motivators. Products related with active sport tourism, might constitute an offer both for the inhabitants of a particular region (especially its urban areas) interested in one-day or weekend trips and for those from out of the region.

Health prophylactics is strong motivation to practise sport as a form of leisure activity. Dynamic development of active sport tourism should be promoted and supported, as it is a health-related form of movement recreation. Motivational force 'health' was also one of the

most important for our questionnaire respondents.

4. CONCLUSION

The need to be physically active ('activity') was the predominant motive to participate in active sport tourism while the 'ambition' was the least important for the respondents from all motivational dispositions, but was the only one that reached the assumed level of significance.

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SPATIAL ANALYSIS OF TOURIST ACTIVITIES AND SERVICES IN THE HISTORIC CITY: THE CASES OF MALAGA AND PLYMOUTH

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Abstract

The main objective of the research is to analyse the geographical distribution of tourist attractions and services in the historic city in order to understand the tourist system spatially and functionally. Two medium size port cities have been selected as study cases: Plymouth (UK) and Malaga (Spain). The methodology consisted firstly of field work to identify the location of different elements of both tourist systems, secondly elements were classified into groups, thirdly information was uploaded using an open-source tool called Meipi, which allowed to disseminate information and to make comments in real time. Finally, information was presented in maps, divided into mobility, built heritage, sightseeing, leisure attractions, water-related activities and events, arts and culture, historic references, accomodation, eating and drinking, shopping, and tourist information and services. Conclusions show which areas are consolidated or in progress in terms of tourist use and which of them could be adapted to tourist activities.

Keywords: *Urban tourism, cultural tourism, heritage, coastal cities, tourist-historic city.*

1. INTRODUCTION: THE GROWING PHENOMENON OF URBAN TOURISM

Urban tourism is a growing phenomenon worldwide. In Europe, it represents 33.8% of all kinds of tourism (Eurostat, 2016) and it has become a priority in European tourist policy since the first Tourism Action Plan (European Commission, 1999). There are many reasons for the steady growth of urban tourism in Europe. The first one is the increasing role of leisure in people's life. The greatest demand is for activities that can be fulfilled in a day trip and since most of people live in cities, urban systems themselves were turned into destinations for leisure activities (Burtenshaw, Bateman and Ashworth, 1991). Harvey (1989), Richards (2005) and Urry (1990) support the idea that the shift from modernity to postmodernity relates to the blur of distinction among culture, economy and tourism. Pine and Gilmore (1999) explain this transition as the change from an economy based on the production of goods and services to other one rooted in the production of experiences. Willey (1998) points out the substitution of the division of work and leisure by other society dominated by information and communication, where the exchange of symbols play a key

role. In this context, the city is not anymore seen only as a place of production or power, but also as a place of play and leisure (Urry, 1990). This way, cities are transformed into places for consumption where the urban environment itself becomes a commodity to be sold to individual consumers and investors (Meethan, 1996). This vision might imply that all places become potential tourist destinations.

Thanks to its adaptability, urban tourism is seen as the solution to many problems, such as deindustrialisation and decay of coastal resorts. In this context, culture is achieving a growing interest as a tourist attraction (Mínguez, 2012; Drazic et. al., 2014; Paul, 2013). In addition, urban tourism is less seasonal than other segments, although it presents strong differences between working days, weekends and bank holidays. In particular, the growing interest of city centres as tourist destinations is a response to urban decay caused by the loss of traditional urban activities. Moreover, there have been changes in the way of travelling that make cities more competitive than other destinations. In particular, long holidays have given way to short holidays spread over the year (Andalusian Ministry of Tourism and Commerce, 2012). Cities are especially interested in short term holidays because they are mainly taken in weekends, thus serving as a complement to business trips which tend to be on weekdays (Law, 1996).

Urban tourism is related to the visit to cities, covering a wide range of motivations such as culture, events, conferences, services of different kinds, business, shopping, health, among others. Exceltur (2013) considers the following segments in urban tourism: culture, leisure, shopping, visiting friends and relatives, major events, gastronomy, learning languages, cruise tourism and sun and beach.

One of the difficulties to define urban tourism is the ambiguous distinction between visitors and locals, since both groups stay in the same places and use the same services. According to Ashworth and Page (2011) and Maitland (2010), the residents' behaviour in their free time is quite similar to the one of tourists, sharing shops, restaurants, leisure attractions, activities and means of transport. As a result, sometimes it is not useful to identify tourists from the classical point of view of distance and time, instead it would be more useful to think of diverse groups of users with different needs and behaviours, which are reflected in in their different purchasing power and urban preferences. As a result, tourists often carry out activities that traditionally involve local people (Ataberk, 2014), although their original motivation was another, while residents often behave like tourists in their free time. The World Tourism Organization and the European Commission (2005) state that the most popular activity developed by urban tourists is visiting attractions such as monuments and museums, followed by sightseeing, eating and drinking, and shopping.

Focusing on the profile of urban tourists, Law (1996) considers the following classification in relation to motivation and length of stay: business activities, conferences and exhibitions, short term holidays, short trips, visiting family and relatives, attendees to festivals and visitors using the city as a gate of a tourist region. On the other hand, Jansen-Verbeke and Lievois (1999) consider that main motivations of urban tourists are culture, shopping, sightseeing, events, leisure and sports. Apart from them, other secondary elements are crucial in the success of an urban tourism destination, such as accomodation, commercial offer, gastronomy, nightlife, events and transportation (Ota, 2014). The urban landscape needs to be of great quality as well, which includes built heritage, views, urban design and architecture (SECTUR, 2009).

2. SPATIAL CONCENTRATION OF TOURIST ACTIVITIES AND SERVICES

Urban tourists tend to concentrate in a small area of the city. In European cities the area visited by tourists is usually only a part of the historic centre, called the tourist-historic city (Ashworth and Tunbridge, 2000). The main elements of this area are the monuments, museums and other attractions, which conform nodes surrounded by the historic atmosphere that tourists expect. Visitors walk along the streets that connect the nodes and are perceived as "historic". In these streets there are other secondary attractions that have not an appeal by themselves and whose main interest is their location between nodes. The spatial concentration of tourists is caused by city's features and by visitors' characteristics (García Hernández, 2003). The city's features are orography, urban fabric, existence of physical or psychological barriers and the presence of milestones. Focusing on visitors, their behaviour is affected by their motivations, previous knowledge of the destination, expectations and previous experiences.

Concentration of tourists has also a practical interest. It makes possible to exceed a minimum threshold to make profitable those businesses dependent on tourism, such as hotels, shops and restaurants. In addition, concentration of attractions makes it possible to walk from one point of interest to another, reducing the need of car parking and public transportation. The short stay of tourists is also a reason for the concentration of tourist activities in a very limited space. In many cases people only spend a few hours in a city and in some occasions the city belongs to a route or is ancillary to other destination or attraction that is the main reason for visiting the region. Since many tourists only visit cities quickly, in some occasions the commercial and gastronomic offer achieve a more prominent role than accomodation or tourist attractions themselves (Ayala Castro, 2007).

The concentration of tourist activities and services makes it possible to clearly distinguish a highly monofunctional tourist area around the most relevant monuments or museums. This area is surrounded by a buffer zone where tourist activities are mixed with other urban activities. The third area covers the rest of the city, where the tourist activity has not been developed (Jansen-Verbeke, 1998).

The tourist-historic city refers to an area that became redundant in many cases due to its difficult access and restrictions to mobility. Thus, accessibility is fundamental when studying functionality of these areas. Van den Berg, Van der Borg and Van der Meer (1995) differentiate between external and internal accessibility. External accessibility covers all the means of transport that allow tourists arrive to the city. Internal accessibility refers to the means of transport that permit the movement of tourists inside the city.

The study of tourist activities and services in the city has the difficulty of trying to separate tourist activities from those that are not, taking into account that tourists not only use services addressed to them. A restrictive selection would exclude from example the great majority of shops, restaurants and means of transport, which are essential for tourists but where residents represent the greatest part of users and clients (Lievois, 2007).

3. THE TOURIST SYSTEM

In order to analyse the concentration of tourist activities and services it is common to refer to the tourist system, which has been addressed by authors such as Burtenshaw, Bateman and Ashworth (1991), De la Calle Vaquero (2006), García Hernández (2003), Law (1996), Romero Moragas (2001), and Van den Berg, Van der Borg and Van der Meer (1995). Resources are divided into primary and ancillary. Primary resources attract tourists to the city and they include museums, monuments, urban landscape, the weather, attractions of all kind,

gastronomy, events, conferences, exhibitions, etc. Ancillary resources add appeal and offer complementary services such as shops, restaurants, hotels, means of transport, cleaning services, signage, etc. Nevertheless, there is not a clear limit between primary and ancillary resources, which are closely related to the diversity of motivations.

The main objective of the research is to analyse the geograhical distribution of tourist attractions and services in the historic city of two selected cities: Plymouth (UK) and Malaga (Spain), both of them are medium size port cities that have made an effort in recent years to regenerate their city centres and waterfronts in order to attract a larger amount of tourists and make this activity central in their economy.

In order to analyse the characteristics of the tourism system in both cities we have taken as a starting point the studies conducted by Vera, López Palomeque, Marchena and Antón Clavé, EURICUR, Jansen-Verbeke, Troitiño Vinuesa and Troitiño Torralba, and De la Calle Vaquero. The latter states that, in the operational level, the systemic approach is a fruitful perspective in the analysis of relations between tourism and historic cities since this phenomenon is characterized by complexity and change: the complexity of the city as product, destination and tourist space, and the dynamics of change inherent to the urban and tourist phenomena (De la Calle Vaquero, 2006).

Vera, López Palomeque, Marchena and Antón Clavé (1997) recognise four basic elements in the tourist system: visitors, actors, transportation systems and tourist destination. Visitors are people who decide to travel to a destination based on a motivation and a socio-demographic profile. Public and private actors influence the design of tourism products, which has traditionally been limited to hotels, restaurants and travel services. Transportation systems connect origin and destination and move tourists inside the city. The tourist destination consists of the attractions, local society, complementary activities, infrastructure and equipment.

To EURICUR (Russo and Van der Borg, 2002) the concept of tourist system relates to the set of factors that determine the appeal of a city, distinguishing between primary and complementary products, accessibility and the destination's image. Primary products are the attractions that trigger the arrival of most visitors, in historic cities they are normally heritage and culture. Complementary products consist of hotels, restaurants, shops, exhibition centres, conference centres and any kind of tourist services. These factors strengthen or weaken the appeal of the city and visitors' perception. Accessibility is divided into external and internal. External accessibility refers to connectivity of the city with potential markets of visitors, it affects directly the cost of travel. Internal accessibility reflects the movement within the city, it affects the quality of stay. Finally, the image of a city is determined largely by its level of overall development, for this reason all the measures taken by local governments to improve urban quality affect the image of the city and its tourist appeal.

Jansen-Verbeke (2001) applies the concept of tourist system to the relationship between the city centre, visitors and actors promoting tourist activities. In relation to the city centre, the author makes a classification into primary, secondary and conditional elements. Primary elements are monuments, museums, theatres, exhibition centres, events, the characteristics of the environment and urban morphology, lifestyle and traditions. Complementary elements are responsible to meet the tourists' demands, mainly accomodation, shopping, and eating and drinking facilities. Conditional elements refer to services mainly used by tourists, such as specific means of transport or information offices. Regarding visitors, the author considers the following features: motivations, number of people, distribution of time and sociodemographic characteristics. Finally, local actors adapt and improve tourist products thorugh the construction of a tourist image and its dissemination.

Meanwhile, Troitiño Vinuesa and Troitiño Torralba (2009) analysed the distribution of accommodation, shopping, and eating and drinking facilities in the historic city of Toledo. Accommodation is classified according to category in 4, 3, 2 and 1 stars hotels on one side, and 2 and 1 star pensions on the other side. Eating and drinking facilities are divided into restaurants, cafes and mixed. Shopping includes crafts, traditional food and souvenirs.

De la Calle Vaquero (2006) took into account the following elements for the study of the tourist system in Spain's World Heritage cities: accommodation, shopping, eating and drinking facilities, and transportation. Accommodation is classified according to its location in the city centre, the periphery, in historic buildings or in the vicinity of transport stations. Regarding shopping, the author highlights the sale of handicrafts and tourist souvenirs. Eating and drinking facilities is divided into restaurants on one side and bars, pubs, cafes and the like on the other. Finally, means of transport are divided into conventional means used sometimes by tourists and means of transport frequented almost exclusively by these users.

4. METHODOLOGY

Based on the approaches mentioned above, a work process was performed to reflect the distribution of tourist activities and services in the historic centres of Plymouth and Malaga. These cities have been chosen because both of them are medium-sized in their own context, peripheral in relation to metropolises, coastal cities wth a relevant protected heritage and both of them have made an effort in recent years to increase their number of visitors focusing on urban tourism, especially taking into account cultural assets. The work phases were as follows:

First phase. A first classification of elements was made in accommodation, shopping, eating and drinking, urban scene, image and visitors. The study area in both cities covers the historic city, defined as the neighbourhoods protected by heritage-related urban plans or other urban policies. A map of both study areas was elaborated to show plot limits, outline of buildings, representative public spaces and place names. In both cities the work area was divided into 19 sectors.

Second phase. We went through all the streets and public spaces of the study area to collect the data. The visits took place at first in Plymouth in September 2011, June 2013 and August 2016. In Malaga data collection was made in June 2010, April 2013 and August 2016. From each item its location and name were marked, some references were noted and photographs were taken.

At this stage the classification of elements was expanded with the activities developed by visitors that can be represented in a map, following the methodology developed by Donaire Benito and Galí Espelt (2008) to approach the movement of tourists. A distinction was made for activities inserted in buildings having heritage protection in accordance with the methodology developed by Troitiño Vinuesa and Troitiño Torralba (2009).

Third phase. Information was processed using an open source app called Meipi (2016a; 2016b) (Figure 1).

Source: Meipi, 2016a.

Figure 1. Meipi developed for Malaga's case study.

This type of tools have been used by various authors, including Salerno, Casonato and Villa (2011) and Olukole and Balogun (2011) to capture tangible and intangible aspects of the city normally not represented in conventional cartography. The procedure involved the creation of four categories, coinciding with the initial classification of elements. Each element led to an entry, which are the components of the categories. Each entry is located at a spatial point, this gives a first glimpse of the concentration of elements. Entries work like files according to the following structure (Figure 2):

- Name of the element.
- Category. It is the basic classification of elements.
- Tag. It serves to establish subgroups and common characteristics to elements belonging to different categories.
- Photography from the street.
- Short description.
- Figure of urban protection. It is indicated if the plot belongs to a Conservation Area in the case of Plymouth or to the Special Protection Plan in the case of Malaga.
- Buffer zone. It is mentioned if the plot belongs to this figure for protection of monuments' surroundings in the case of Malaga.
- Architectural protection. It refers to the type and degree of protection of the building, if it belongs to the English Heritage List in the case of Plymouth or to the Andalusian Heritage List or the Special Protection Plan List in the case of Malaga.
- Other comments. It shows other relevant features such as state of conservation, last intervention, etc.

Source: Meipi, 2016a.

Figure 2. Structure of an entry.

In total 378 entries were created for Plymouth and 404 were created for Malaga.

Fourth phase. Information was presented in maps showing the elements that represent more clearly the tourist use of the historic city. Maps were classified into mobility, built heritage, sightseeing, leisure attractions, water-related activities and events, arts and culture, historic references, accomodation, eating and drinking, shopping, and tourist information and services. Finally, a synthesis map was made in both cases.

5. ANALYSIS

In many cities, there are a few main assets which justify their visit, for example a relevant monument, a particular event or specialist shops. The current trend in urban tourism is to diversify the offer as people's interests are becoming more and more specialised. The difference between main tourist attractions and ancillary resources depends on the source taken into account. Furthermore, the difference between visitors and locals are becoming shorter as the former are interested in going deeper into the local culture and the latter behave like tourists in some occasions, for example when visiting monuments or for special events. This difference is even weaker in Plymouth as most visitors are national and have in general terms the same cultural background and interests as locals. In the case of Malaga it is easier to distinguish visitors from locals since most of them come from abroad, they speak a foreign language and have different habits, for example at the time of having lunch or dinner they eat earlier than Spaniards, choose different food, go to certain museums, dress in a different way, use other means of transport and buy particular souvenirs that locals usually do not purchase.

Below, the main conclusions of the analysis are presented, divided into the following topics: mobility, built heritage, sightseeing, leisure attractions, water-related activities and events, arts and culture, historic references, accomodation, eating and drinking, shopping, and tourist information and services. Finally, a synthesis map has been made in both cases.

1. Mobility. As it has been explained above, internal means of transport have an impact on the global image of the tourist destination and are one of the most valued assets in urban destinations. In Plymouth, the following ones have been considered: yachting, ferries, taxis, buses, cycling and pedestrian areas. Plymouth has a rich offer of marinas and moorings. Among them, the more relevant ones for tourists are Sutton Harbour, located at the heart of the tourist-historic city, and Royal William Yard, which is integrated in a renovated area of great heritage value. There are several ferry and water taxi services in the study area. Taxi ranks are mostly located in the Barbican, Hoe, City Centre and their periphery. A tourist bus

runs around the Barbican and the Hoe, operated by Plymouth Discovery Tours. Regarding local buses, most of them begin or finish in the City Centre. Regarding cycling, the City Council recommends some advisory and signed cycle routes but many of them are shared with buses or cars. Finally, there are a number of pedestrian areas in the historic city. In Malaga, the following means of transport have been considered: yachting, tourist boats, buses, horse-drawn carriages, cycling, pedicab, segway, taxis and pedestrian areas. Arriving to the historic centre by yacht is now possible after the regeneration of the port for tourist purposes. This regeneration also made possible to consolidate an offer of tourist boats around the bay. The tourist bus makes a round trip stopping at the main monuments and attractions. Vistors also use local buses, since most of them stop at the Alameda, the gate to the historic centre. Horse-drawn carriages make a fix itinerary between the port and the Cathedral. In the last years new cycling routes have been opened and some companies have started offering guided tours. Pedicabs and segways operate in different areas of the historic centre, while pedicabs move around the Cathedral and Alcazaba, segways make larger guided tours up to Gibralfaro and along the sea promenade. Taxi stands can be seen in access routes to the historic centre, while most of the inner core has been pedestrianised and access is only permitted for residents and hotel guests (Figures 3 and 4).

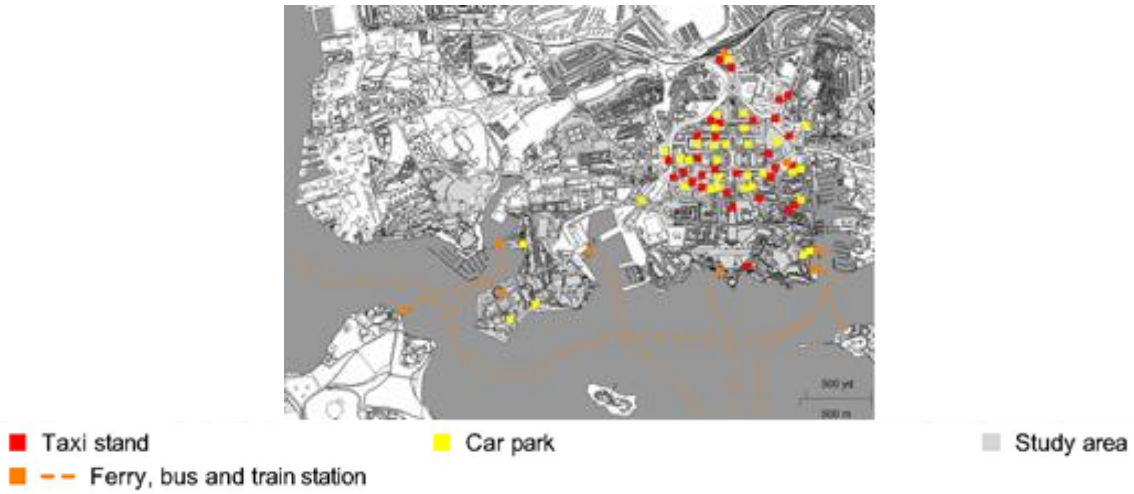

Figure 3. Means of transport within Plymouth's historic city and close surroundings.

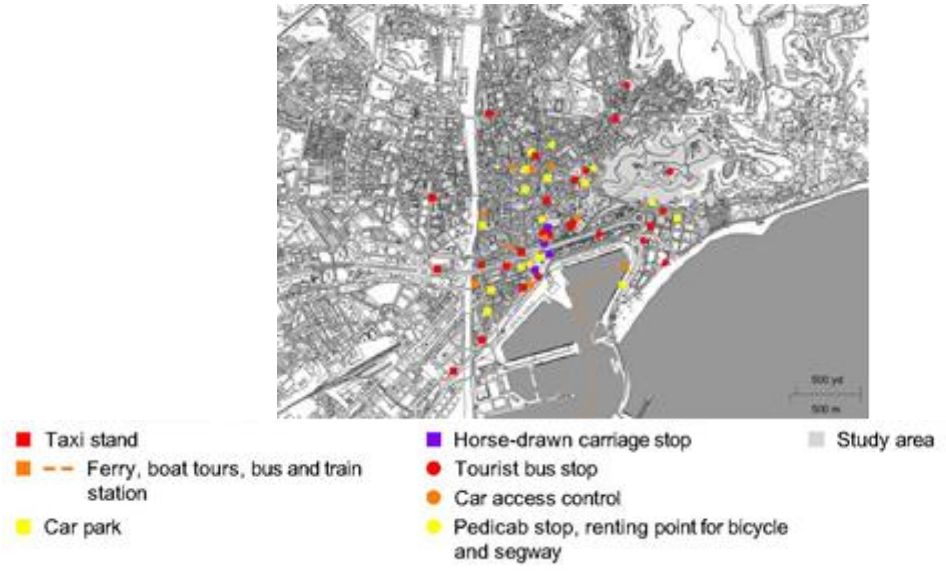

Figure 4. Means of transport within Malaga's historic city and close surroundings.

2. Built heritage. In Plymouth, it can be concluded that there are three heritage areas, each of them with a very different relative weight, namely Mount Wise, Royal William Yard and the central areas covering the Hoe, Barbican and parts of the City Centre. Regarding particular buildings, there are three clusters, the first one is in the City Centre south of Royal Parade, the second one is in the Barbican and the third one is on the Hoe. In Malaga, it can be concluded that the most attractive heritage assets for tourists are the Condes de Buenavista Palace (Picasso Museum), Alcazaba, Picasso's Birthplace, Gibralfaro Castle, Roman Theatre and Cathedral. At a second level are Atarazanas Market, Town Hall, Episcopal Palace and Old Wholesalers Market (Contemporary Art Centre) (Figures 5 and 6).

Figure 5. Main heritage assets within Plymouth's historic city and close surroundings.

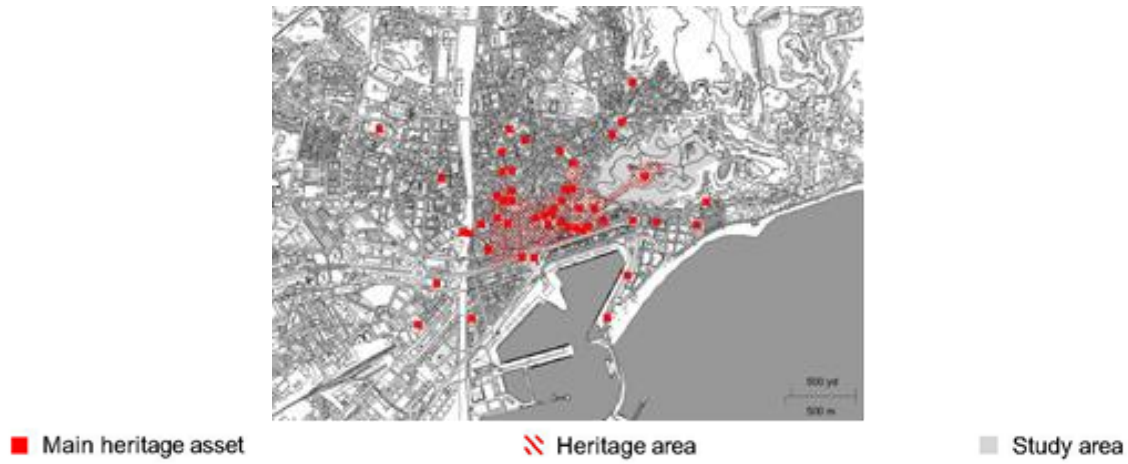

Figure 6. Main heritage assets within Malaga's historic city and close surroundings.

3. Sightseeing. In Plymouth, it is possible to distinguish four areas or topics. One is the waterfront in general with its views to the Sound, these views can be enjoyed from the upper part of the Hoe, the Citadel, Hoe Road, Stonehouse Peninsula and Mount Wise. The Hoe offers open views to the city, the waterfront and landmarks like Smeaton Tower and the Naval War Memorial. The Barbican is a neighborhood characterised by its narrow streets and an old city atmosphere. Finally, Armada Way offers a shopping atmosphere, open-air cafes and many street events around the Big Screen. In Malaga, four types of spaces can be distinguished. Open views to the city and the sea can be enjoyed from Mount Gibralfaro, the port and the sea promenade. Secondly, there are parks and gardens like Paseo del Parque, Puerta Oscura and Pedro Luis Alonso. A third type of spaces is represented by the historic

centre's narrow streets, which offer urban atmosphere and intense commercial activity. Finally, the port is characterized by its function as an open air shopping centre (Figures 7 and 8).

Figure 7. Areas recommended to do sightseeing and enjoy views within Plymouth's historic city and close surroundings.

Figure 8. Areas recommended to do sightseeing and enjoy views within Malaga's historic city and close surroundings.

4. Leisure attractions. In Plymouth, leisure attractions concentrate in two areas and some of them are dispersed. In the Barbican or around are located the National Marine Aquarium, Gin Distillery, Mayflower Exhibition Centre and Clay Art. On the Hoe there are a number of bathing facilities, where Tinside Lido stands out. There are other bathing facilities in Stonehouse Peninsula and Mount Wise. Finally, the Big Screen gathers large groups of people for special events and the Pavillions offer a diversity of leisure activities. In Malaga, the most attended leisure attractions and areas are the theatres, beaches, bars and nightclubs. The most popular beach for tourists is the Malagueta, which is also the most accessible one from the historic centre (Figures 9 and 10).

Figure 9. Main leisure attractions within Plymouth's historic city and close surroundings.

Figure 10. Main leisure attractions within Malaga's historic city and close surroundings.

5. Water-related activities and events. Plymouth offers a variety of events related to the sea all year round, it has also a number of facilities where it is possible to develop water-related activities. Around the Barbican there is a particular cluster of marinas and yacht clubs. Among the most relevant competitions the Tall Ships Race stands out. Malaga has not organised recently sport events or other activities related to the sea that might attract a significant number of visitors. In the vicinity of the historic city there is only one yacht club. After the renovation of the port, yachts can also dock in the pier close to the historic centre (Figures 11 and 12).

Figure 11. Yacht clubs and marinas within Plymouth's historic city and close surroundings.

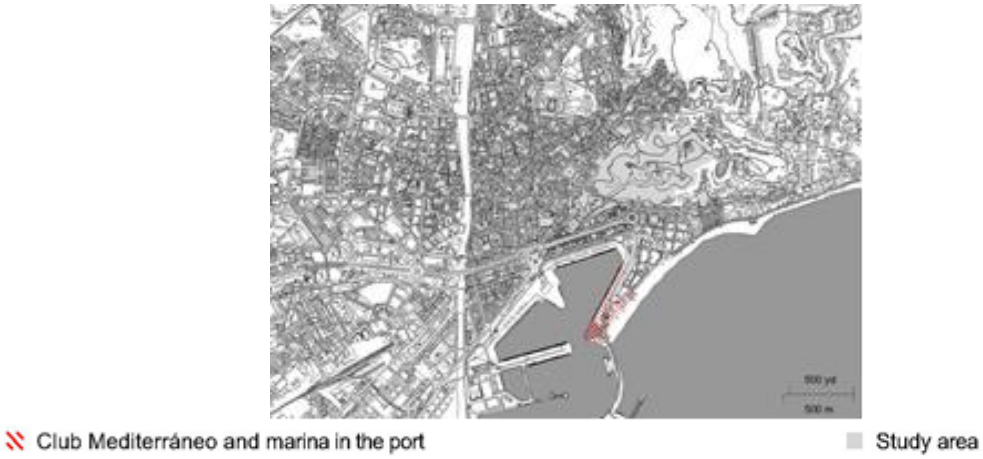

Figure 12. Yacht clubs and marinas within Malaga's historic city and close surroundings.

6. Arts and culture. In Plymouth, arts and culture venues are dispersed around the Barbican and the City Centre. Sutton Harbour allocates the Barbican Theatre and Plymouth Arts Centre. The Theatre Royal and Reel Cinema are in Derry's Cross. Finally, the University offers a variety of arts and culture-related events and the City Museum and Art Gallery are located just in front of the campus. Resources related to art and culture have a major role in the mass tourist diffusion. In Malaga, museums play the main role since the city focused its tourism development in recent years on this topic. The most relevant ones in terms of number of visitors are the Archaeological Museum in the Alcazaba, Cathedral Museum, Picasso Museum, Casa Natal de Picasso, Carmen Thyssen Museum, Pompidou Centre and Contemporary Art Centre. Museums present certain concentration around the triangle formed by the Old Customs, La Merced Square and La Constitución Square (Figures 13 and 14).

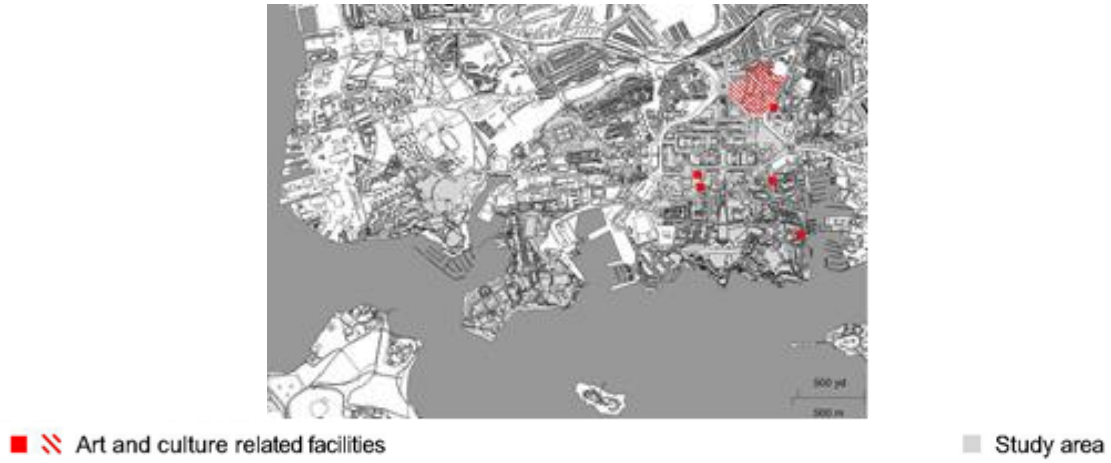

Figure 13. Arts and culture related facilities within Plymouth's historic city and close surroundings.

Figure 14. Arts and culture related facilities within Malaga's historic city and close surroundings.

7. Historic references. In urban destinations, another common aspect in tourist information sources is the link of a city with certain historic characters, artists or events. In the case of Plymouth, these references mainly focus on its military history and its link with some of the most relevant discovery voyages. These references appear in plaques, explanations, memorials and street names. They have been divided into four categories: seafarers, war, Royal Navy and marine and maritime references. References to seafarers can be found in the whole city in diverse forms, proof of the identification of Plymouth with these renowned historic characters. References to wars are also quite extended, in particular the concentration of memorials on the Hoe stands out. References to the Royal Navy are located on the Hoe, in Stonehouse including the Royal Marine Barracks and the former Royal Naval Hospital, and in Devonport including the Dockyards. Finally, more general naval references can be found in all neighbourhoods of Plymouth. In Malaga, the interest in recent years has been focused on promoting the references to Picasso, taking into account that Malaga was his birthplace. References to historical characters are located mostly within the former walled city and the park, and references to Picasso show a clear concentration around the two main resources related to the painter: the Picasso Museum and his birthplace (Figures 15 and 16).

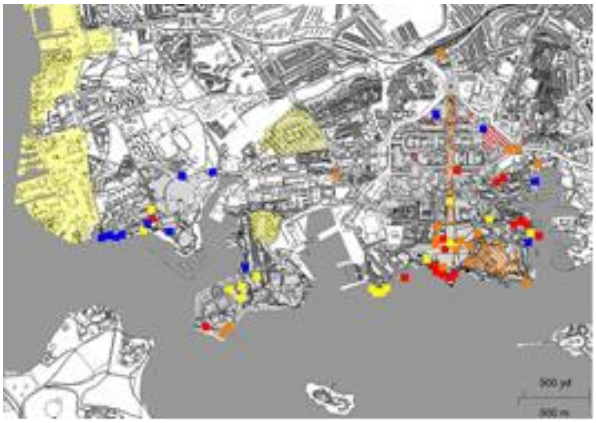

Figure 15. Historic references within Plymouth's historic city and close surroundings.

Figure 16. Historic references within Malaga's historic city and close surroundings.

8. Accomodation. A good offer in accomodation is essential for attracting staying visitors. In Plymouth, three categories were distinguished, namely hotels, guest houses and remains of former hotels. These categories are subject to interpretation and are more related to the size of the premises than to other aspects such as, for example, how each establishment describes itself. Thus, hotels refer to the largest businesses, they usually belong to international companies and offer services like full board, parking places or conference rooms. Guest houses are the traditional small accomodation facilities, normally run by families or early retired couples who live there, they usually only offer breakfast. This category includes bed and breakfasts and hostels. These establishments are charming but they do not fit the increasing needs of many international visitors, for that reason there are current plans to upgrade them and create more hotels of a higher standard. Finally, remains of former hotels give an idea of previous tourist areas that have lost this activity nowadays. Location of large hotels do not respond to clusters, they are in the surroundings of the central areas where there is a good accessibility. Guest houses gather in two areas. The largest concentration is on West Hoe, there is another group of this kind of smaller establishments between the Hoe and the Barbican. Finally, there are a few remains of former hotels in areas which had a significant tourist activity in the past like the Crown Hotel in Devonport, Durnford Hotel in Stonehouse Peninsula and the Grand Hotel on the Hoe, now converted into luxury residences.

Accomodation in Malaga was classified into three groups: hotels, guesthouses and hostels. The third group consists of accommodation for backpackers, whose characteristics do not match previous models. 42 establishments were taken into account in total in the study area. It is possible to observe a specialisation in five sectors. Along the River Guadalmedina there is a concentration of recently opened hotels, they are from the middle and upper categories. The area around Martinez Street - Alameda - Heredia is one of the traditional areas of concentration of small establishments of lower category. Around Larios Street - Granada Street - Cathedral new hotels have opened recently, they are of medium capacity and upper category. In Carretería Street and its surrounding new establishments have opened in the last few years, they are mostly backpacker hostels. La Caleta is a traditional area of hotels in the historic city, linked to the eastern bourgeois expansion and they are above average capacity (Figures 17 and 18).

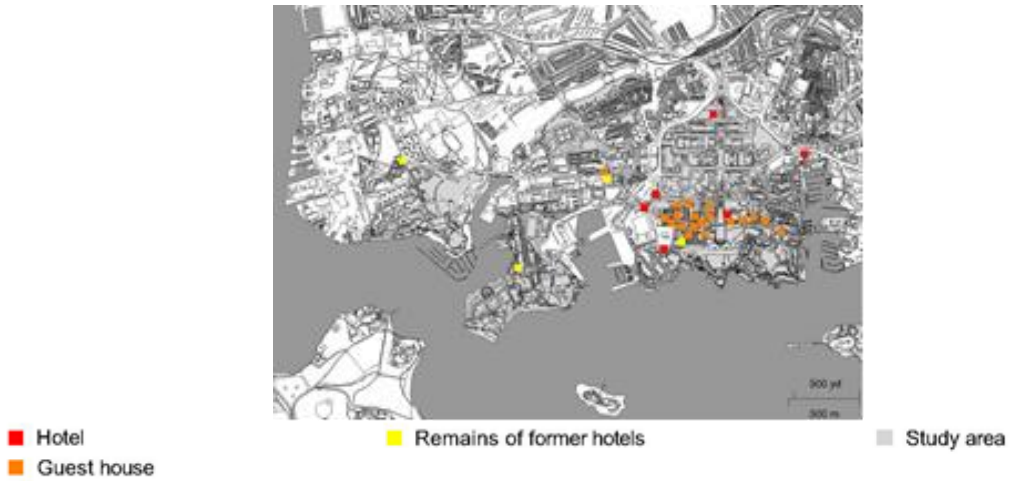

Figure 17. Accomodation facilities within Plymouth's historic city and close surroundings.

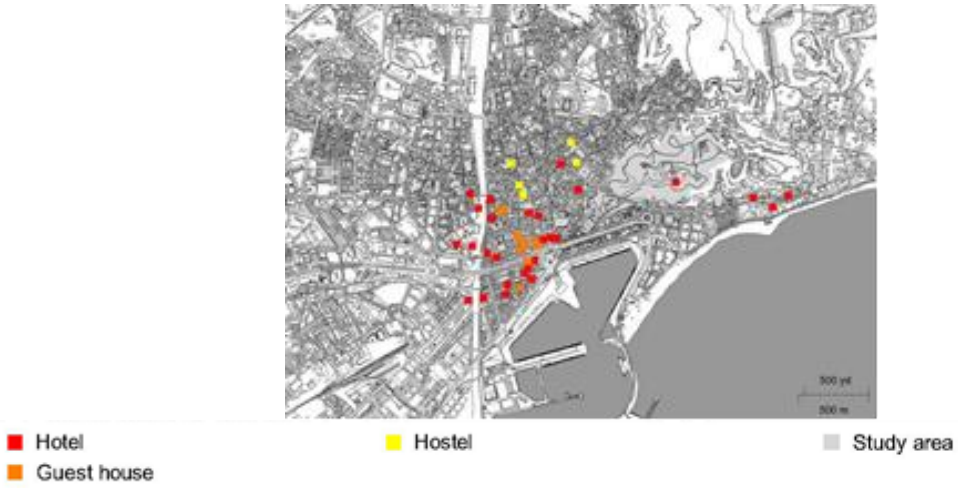

Figure 18. Accomodation facilities within Malaga's historic city and close surroundings.

9. Eating and drinking. Gastronomy is another aspect which Plymouth is keen on promoting. The city offers some traditional specialities from Devon and Cornwall. Four categories were distinguished, namely cafes, restaurants, parlours and kiosks, and pubs and night clubs. Parlours and kiosks include all premises offering food to eat in the street such as fast food, sweets, fudge, bakeries, ice creams and the like. Only establishments in areas with a high presence of visitors or where the number of people increases dramatically in bank

holidays and major events have been considered. It does not mean that tourists do not visit premises in other areas, especially in the City Centre, which offers a wide range of restaurants and cafes, but in this area the demand is constant all week long. It can be concluded that the Barbican concentrates in a very limited area most of the cafes, restaurants, parlours and pubs advertised for visitors. Outlets serving traditional specialities are also concentrated in the Barbican. The Hoe, and especially its waterfront, offers a number of establishments as well, more dispersed than in the Barbican. In Malaga, bars, cafes, restaurants, outlets selling directly to the street, pubs and clubs contribute to the attraction of the city. Eating and drinking premises are located in the most visited area of the historic city, which in turn leads to an increase in the appeal of those spaces. These premises tend to concentrate in particular urban areas more intensely than other tourist activities. They are grouped around axes and nodes and make entire sectors monofunctionality. 81 establishments were considered in total, organised in cafes, restaurants, parlours, and pubs and clubs. Ten concentration areas can be distinguished: Puerta del Mar – Larios Street, Larios Street – Cathedral, Las Flores Square, Chinitas Passage, Uncibay Square, La Merced Square, Madre de Dios Street, Alcazabilla Street, La Caleta and the port (Figures 19 and 20).

Figure 19. Eating and drinking facilities within Plymouth's historic city and close surroundings.

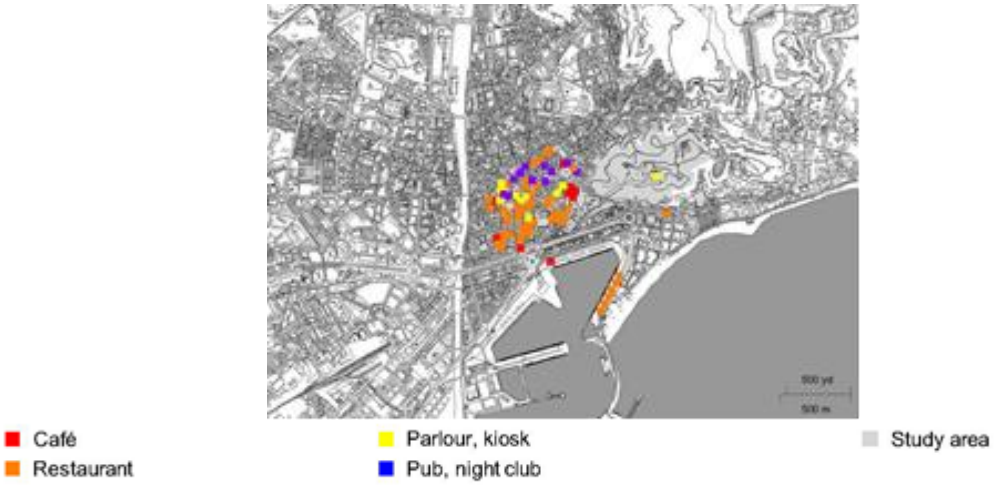

Figure 20. Eating and drinking facilities within Malaga's historic city and close surroundings.

10. Shopping. Four categories were distinguished in the case of Plymouth, namely art galleries, craft and specialist shops, souvenirs shops and finally the City Centre shopping

area. Art galleries help to identify the Barbican as a distinct "art quarter", some of them have occupied old warehouses. Crafts and specialist shops concentrate in the Barbican as well, they fit with the promotion of the Barbican as a historic neighbourhood and offer good quality products in locally run shops. Standard souvenirs are not as extended as in other cities, probably thanks to the existence of alternative shops of better quality, there are some examples of these in the Barbican too. Finally, the City Centre shopping area as a whole is one of the main reasons for visitors from the surrounding region to come to the city. In Malaga, 42 establishments were considered, organised into three groups: art galleries, specialty shops, and craft and souvenir shops. In relation to souvenir shops, only those with a high presence of foreigners were considered. The location of the souvenir shops in particular gives an idea of the areas of maximum concentration of visitors, since these businesses are not frequented by locals. Seven areas can be clearly distinguished: Alameda, Martyrs Square, Tomás de Cózar Street - Granada Street, Císter Street, Larios Street and the port (Figures 21 and 22).

Figure 21. Main shopping facilities used by tourists within Plymouth's historic city area and close surroundings.

Figure 22. Main shopping facilities used by tourists within Malaga's historic city area and close surroundings.

11. Tourist information and services. This group covers all means of showing visitors what to visit or where to look at. It includes explanations, plaques, plans, visitor centres, street

signage and advertisements. In this group, we have also taken into account public toilets, which are a useful service for pedestrians, and townscape initiatives, which are concentrated in certain areas. In Plymouth, explanations and plaques showing information about particular items or events are widespread in the city. Public toilets are regularly distributed as well and some of them are located in the busiest areas of the Barbican, Armada Way or the Hoe. In last years, a number of townscape initiatives have been developed. The Barbican has conserved its cobblestones and its harbour floorcape and it has added artistic furniture, lighting, public art and open-air cafes. Public art has been extended around Royal Parade and Bretonside. Armada Way and some of its adjacent streets have street cafes, landscaping and a varied floorscape. The area around the City Market has been recently regenerated too. Plans and street signage concentrate in major routes such as Armada Way, Barbican approaches and around the railway station. Advertisement clusters for pedestrians are located in the Barbican, around Southside Street and New Street. In Malaga, explanations, signage and plaques are distributed throughout the former walled city, River Guadalmedina, and Alameda Park. Nevertheless, there is a clear concentration around the consolidated tourist areas, especially the attractions linked to the figure of Picasso achieve a relevant prominence in tourist information elements (Figures 23 and 24).

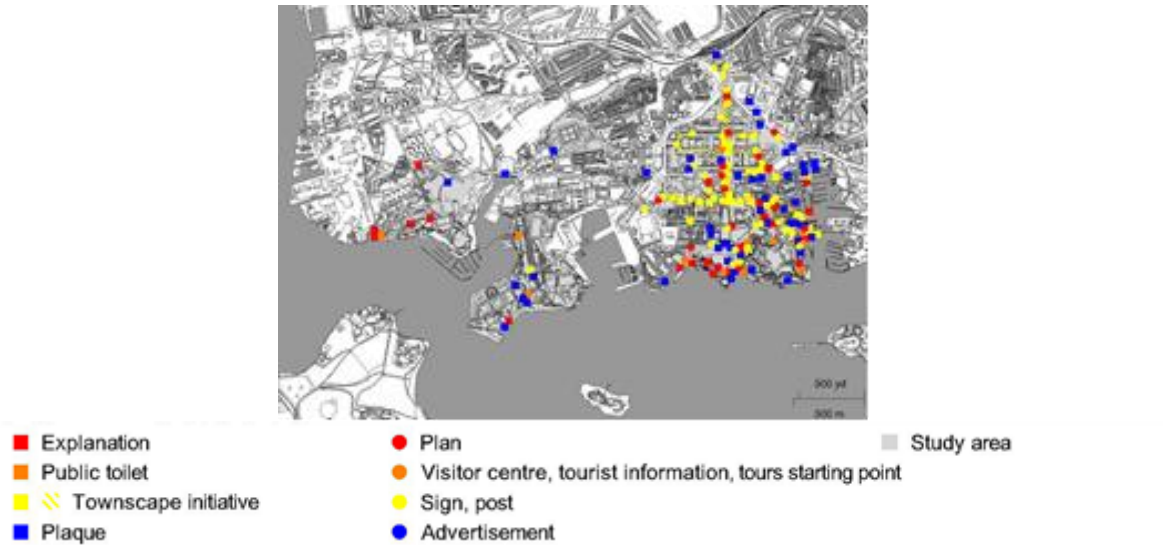

Figure 23. Tourist information and services within Plymouth's historic city and close surroundings.

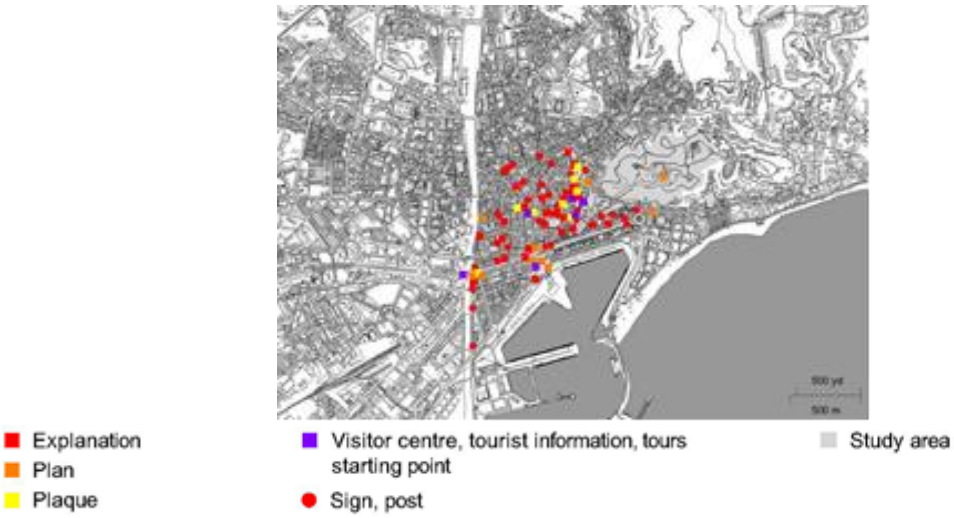

Figure 24. Tourist information and services within Malaga's historic city and close surroundings.

6. CONCLUSIONS

Taking everything into account, the consolidated tourist area in Plymouth covers the Barbican, the Hoe with its waterfront and the area around the Guildhall. Other significant assets are the marinas, ferries, National Marine Aquarium, Plymouth Pavilions and Theatre Royal. Areas where tourist activity is growing thanks to regeneration and marketing projects are the City Centre, Royal William Yard and Millbay, considering that the cruise terminal is finally developed as expected. Potential areas are South Yard, Mount Wise and Ker Street monuments in Devonport, the Sound including Mount Edgcumbe, the Cremyll Ferry, Drake's Island, Mount Batten, Stonehouse's waterfront, the main military areas of Royal Marine Barracks, Royal Naval Hospital and the Royal Citadel, the eastern and northern area of Sutton Harbour, the train and bus stations which need upgrading, the City Museum and Art Gallery, the Palace Theatre and Charles Church (Figure 25).

The consolidated tourist area in Malaga covers the main monuments, museums, shopping areas, public spaces and stations: Alcazaba, Gibralfaro Castle, Roman Theatre, Cathedral, Picasso's Birthplace, Picasso Museum, Carmen Thyssen Museum, Centre for Contemporary Art, Larios Street, Chinitas Passage, Granada Street, La Merced Square and the port. Areas where tourism can be consolidated in the future thanks to urban renewal operations and marketing are the first stretch of Reding Promenade with the Bullring and the Municipal Heritage Museum, the Alameda and Heredia neighbourhood. Potential areas to accommodate a greater number of tourist activities are the second stretch of Reding Promenade with the Miramar Palace and the English Cemetery, the north and west of the former walled city with its churches, Mercado Atarazanas and the Convent of Santo Domingo. In fact, new small hotels and apartment buildings have started to be promoted recently in these areas by investors that have perceived their potential. Finally, some resources have tourist potential but are located in an environment outside of tourist flows. Among them are the churches of La Victoria and San Felipe Neri, María Cristina Conservatory, Wine Museum and the Convent of La Trinidad (Figure 26).

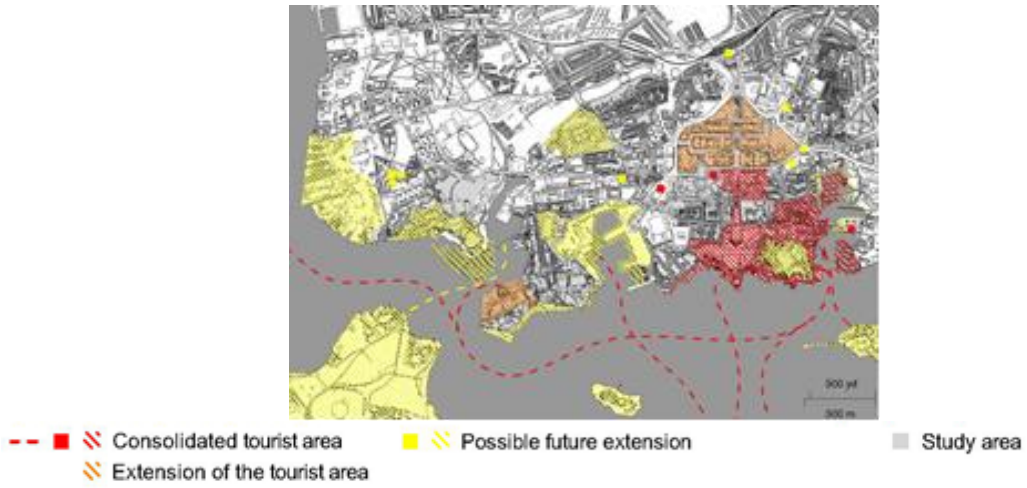

Figure 25. Consolidated tourist area within Plymouth's historic city and possible extension.

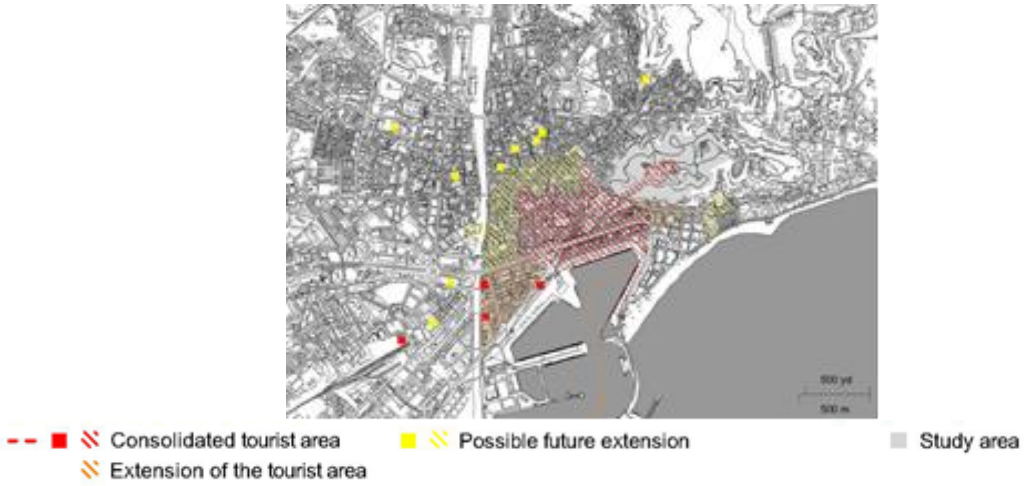

Figure 26. Consolidated tourist area within Malaga's historic city and possible extension.

The analysis of the tourist system applied to the cases of Plymouth and Malaga has proved useful to identify consolidated tourist areas in historic areas and surrounding neighborhoods that could be better promoted. Many of these areas already have a strong potential especially thanks to their heritage values and physical connections to tourist services. This methodology could be applied to other cities that have adapted their historic centres to tourist-related activities and services.

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THE CITY FROM COMPLEX SYSTEM THEORIES. AN APPROACH TO THE STUDY OF MALAGA URBAN AREA

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Abstract

For almost 100 years ago, many authors have understood that cities are the most complex artifacts built by humans. The very idea of the city is coeval at the beginning of sedentary life and agriculture, in the early Neolithic period about 10,000 years ago. Although it is as old this type of human organization, continues to present a paradoxical problem as possibly all humans have the ability to recognize a city, just as we recognize a forest, even if we are unable to explicitly express our appreciation. In this article, we will try to make an approach to the state of the town of Malaga from the perspective of the theory of complex systems.

Keywords: *City, neighborhoods, complexity, theoretical model, diversity.*

1. INTRODUCTION

Sedentary lifestyle, a way of life for human beings, is fairly recent, in relative terms (approximately 10,000 years ago), when compared with the emergence of the genus Homo, around 2.5 million years ago in Africa, Wong, K. (2015).

This, along with agriculture, was the hallmark of the Neolithic revolution. The first settlements developed in the area of the Near East (actually West Bank) and possibly at the same time in the region of Anatolia (now Turkey). Later in the Tigris-Euphrates Valley (5,300 BC) giving rise to the Sumerian civilization; and in the Indus Valley in the territory of present Pakistan Mohenjodaro flourished in A.C. 3000

Just a little over 100 years ago, some authors and authors have begun to reflect on what it means to live in a city for humans beings. In the words of Park, R. (1925), cities are "the most prodigious and complex human artifacts and at the same time, the 'natural' habitat of civilized man." Because of its complexity, both forests and cities are difficult to define succinctly. In fact, the multiplicity of definitions that have been made about it being a city, "the urban" gives an idea of its very complexity. As Capel, H. (1975, p. 256) expresses "One of the most interesting problems of urban geography is undoubtedly that of the very definition of "urban", the definition of the city".

It is a paradoxical problem as possibly all humans have the ability to recognize a city, just as we recognize a forest, even if we are unable to explicitly express our appreciation. Currently a shift in focus where it matters least try to define the city closed form is observed, the main objective is to understand "that" makes it as is.

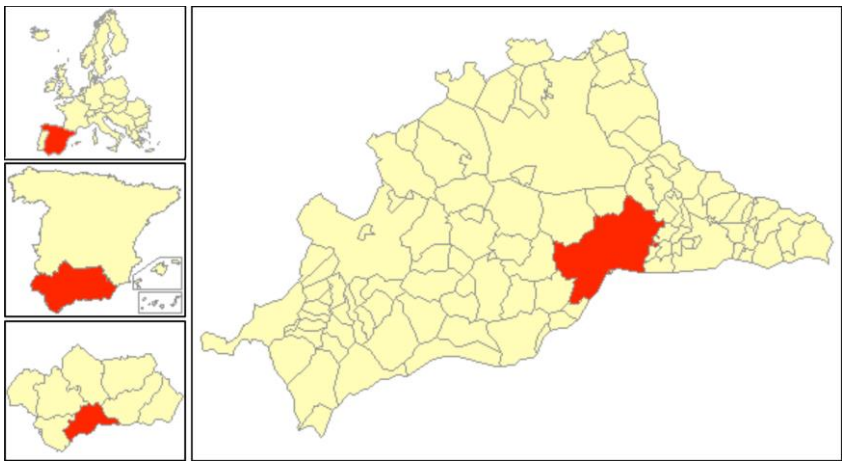
This new view has its origin in the proposals of the "General Systems Theory" of Bertalanffy, L.V. (1992), and currently, in the field of what are termed as "Complex Systems

Theory." The analysis of the effects of scale in urban systems and its temporal evolution, from the perspective of Complexity Theory is the basis of studies GAVAIX, X. (1999); Batty, M. (2001, 2003); Batty, M. and N. Shiode (2003).

It is from this perspective that this communication is based on results and unpublished data from my own doctoral thesis, Escudero, C.A. (2012) is articulated and which is expected to contribute to the knowledge of the urban phenomenon.

2. FIELD OF STUDY, DATABASES AND GENERAL METHODS

This study was conducted for the city of Malaga, defined as the urban fabric that presents a clear solution of continuity. That is why the goals were out of a number of neighborhoods and districts, that although administratively belong to the municipality of Málaga, has no structural or building continuity with the main urban core. (Figure 1)



Source: Instituto de Estadística y Cartografía. Junta de Andalucía.

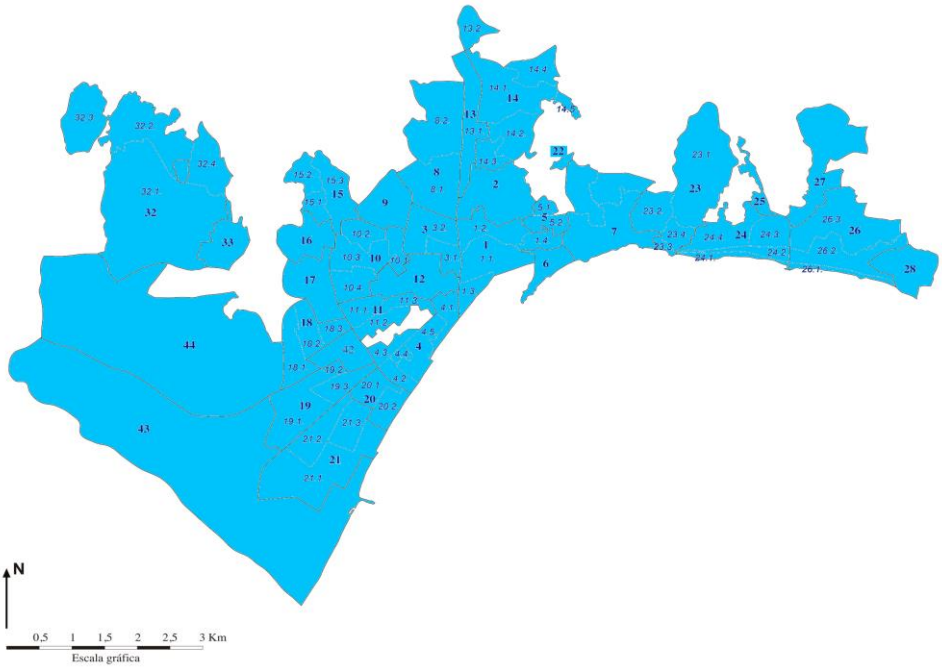
Figure 1: Situation maps and location of the area of study.

The main sources of information were used in this study were: From the territorial point of view, the revision of land-use planning Malaga 1983, a division of the municipality proposed in neighborhoods Lopez Cano, D. (1984).

The neighborhood is a territorial unit built, which is defined primarily social. That is, are the social aspects of its inhabitants and their interrelations, the "neighborhood life", which gives it character, but certainly the type of built space will also contribute to their identity. The division was also used in Districts and Census Tracts, which is used by the National Institute of Statistics, as many of the data provided are referred to in this way.

Demographic and socio-economic data (total population, sex, education level, professional stratum) for neighborhoods, were obtained by aggregating data for census apples Population Census of March 1, 1981 corrected with updates Padron, of high and low municipal, as of December 31, 1981, which were used in the revision of land-use planning Malaga 1983. Another important source of information was the Census of Buildings and Commercial INE It is also necessary to indicate that in that same time, two important studies published city of Malaga, which favors the completeness of the information bases. "Socio demographics of neighborhoods malagueños" Lopez Cano, D. (1984) Figure 2 and the "Social Atlas of the city of Malaga" Ocaña, C. (1984).

For calculations of surfaces a graphical method was designed using Adobe Photoshop and is based on technical analysis of the "Monte Carlo Methods" Sobol, I. (1976) and exhaustively tested its suitability in a study on the mulched in Malaga, Escudero, C. (1994).



CODIGO	BARRIOS
1	CENTRO
	1.1. Centro Histórico
	1.2. Carretería
	1.3. Muelle Heredia
	1.4. Gibralfaro
2	CAPUCHINOS
3	TRINIDAD
	3.1. Trinidad - Perchel
	3.2. Trinidad - Ensanche
4	HUELIN-PERCHEL
	4.1. Perchel - Bulto
	4.2. Huelin
	4.3. La Isla
	4.4. Jardín de la Abadía
	4.5. Ayala
5	CAMINO NUEVO
	5.1. Haza Victoria
	5.2. Barcenillas
6	MALAGUETA
7	CALETA - LIMONAR
8	LA PALMA - MARTIRICOS
	8.1. Martiricos
	8.2. La Palma
9	SUAREZ
10	ARROYO DEL CUARTO
	10.1. Castillejos
	10.2. Haza Cueva - Campillos
	10.3. Martínez Maldonado
	10.4. Carranque

CODIGO	BARRIOS
11	CRUZ DE HUMILLADEROS
	11.1. Santa Julia
	11.2. La Unión
	11.3. Paseo de los Tilos
12	POLÍGONO DE LA ALAMEDA
13	CIUDAD JARDIN
	13.1. Ciudad Jardín
	13.2. San José
14	MANGAS VERDES
	14.1. Cortijo Bazán
	14.2. Mangas Verdes
	14.3. Parque del Sur
	14.4. Jardines de Málaga
	14.5. Peinado Grande
15	CARLINDA-SUAREZ
	15.1. Granja Suarez
	15.2. San Alberto
	15.3. Carlinda - Florysol
16	CAMINO DE ANTEQUERA
17	CARRETERA DE CARTAMA
18	CAMINO DE SAN RAFAEL
	18.1. Cortijo Torres
	18.2. Tiro de Pichón
	18.3. San Rafael
19	SAN ANDRÉS
	19.1. San Andrés - La Luz
	19.2. Dos Hermanas
	19.3. El Torcal

CODIGO	BARRIOS
20	TABACALERA
	20.1. Girón
	20.2. Tabacalera
21	PARQUE DEL OESTE
	21.1. Los Guindos
	21.2. Parque Mediterráneo
	21.3. La Misericordia
22	SIERRA BLANQUILLA
23	EL MORLACO
	23.1. Cerrado de Calderón
	23.2. El Morlaco
	23.3. El Rocio
	23.4. Parque Clavero
24	PEDREGALEJO
	24.1. Pedregalejos playa
	24.2. Las Acacias
	24.3. Valle de los Galanes
	24.4. Pedregalejos Alto
25	LA MOSCA
26	PALO
	26.1. El Palo - Playa
	26.2. El Palo (núcleo)
	26.3. Miraflores del Palo
27	PINARES DE S. ANTÓN
28	EL CANDADO

CODIGO	BARRIOS
32	PUERTO DE LA TORRE
	32.1. El Tomillar
	32.2. Puerto de la Torre (núcleo)
	32.3. Puertosol
	32.4. El Atabal
33	COLONIA DE STA. INÉS
42	POL. IND. RONDA EXTERIOR
43	ZONA IND. AZUCARERA
44	POL. IND. EL VISO

Source: Lopez Cano, D. (1984): Sociodemografía de los barrios malagueños.

Figure 2: Division into neighborhoods and slums, of the urban nucleus of Malaga.

It was also used as a source of information databases power consumption. As a source of information listings electricity consumption, expressed in kilowatt / hour per year, registered for 1055 low voltage transformers, the town of Malaga were used. These energy consumption data are referred to the year 1982 and were supplied by the company Sevillana de Electricidad, which acted as sole operator on those dates in Andalusia. If from a systemic point of view, this is an important input variable, its equivalent from the point of view of output variable would be the Production of Municipal Solid Waste (R.S.U.).

As database listings daily weighing of refuse collection service of the City of Malaga in 1982. These lists were used were made from the weighing of trucks responsible for garbage collection, made at the end of service, go to download at the municipal landfill. These data are reported daily, along with incidents suffered by the truck responsible for collecting, so the factors that could affect data collection, such as strikes, breakdowns and other incidents were promptly appropriated. Obviously it had to adapt the surface collection R.S.U. sectors, by calculation, to the surface of the neighborhoods.

From the point of view of Melaine, M. and Koelian, G. (2001), analysis of urban metabolism involves characterizing the flows of matter and energy related demand for products and services of urban populations as well as the processes and activities that occur in urban space. The study of matter and energy balances, the intensity of the flows involved, as well as distribution and spatial and temporal variation is the basis of metabolic analysis of cities. As an indicator of the internal functional structure of the city Pielou E.C. (1975) Diversity Index, which is a modification of the Gini, C. (1912) index, was used.

$$D = \sum p_i p_j \Big/ \sum p_i^2$$

This index compares the probability of choosing randomly two elements (business premises) of the system (neighborhood or city) are species (activities) other than with respect to the likelihood that these are of the same species (activity). That is compared diversity (Σ pipj) against specialization (which was expressing the Gini index: Σ pi2). This use of diversity indices in the study of cities, was presented by the author at the First World Congress of Health and Urban Environment in Madrid. Escudero, C. and Guevara, J.M. (1998).

Using these variables and indices, which is what is symbolized schematically by the use of a flow diagram in Figure 3, he gave some very interesting results. Over the next section you will see its main features and what they mean in the whole city of Malaga, and by extension, in other urban centers with similar characteristics.

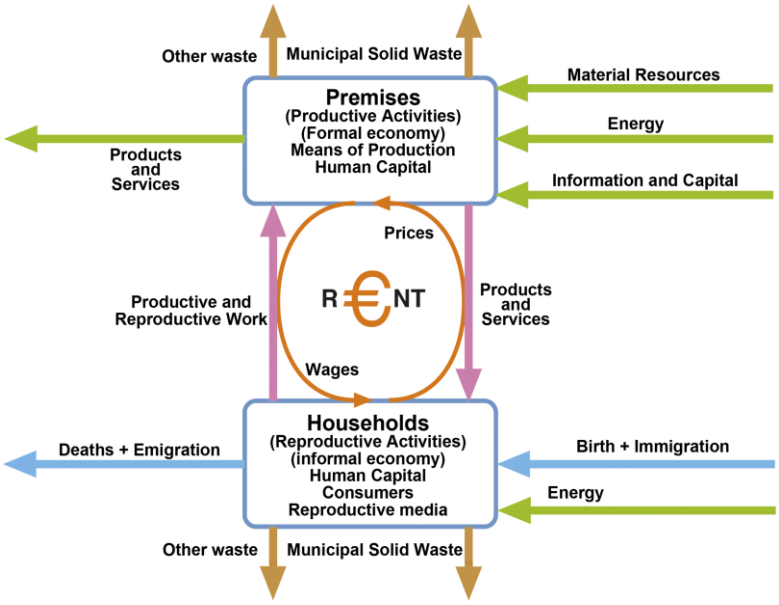
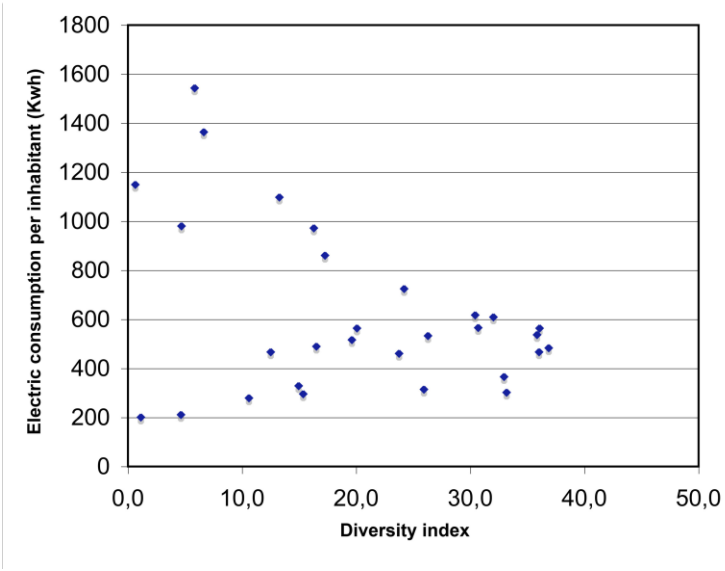


Figure 3. Simplified schematic flow of matter and energy in cities.

3. RESULTS

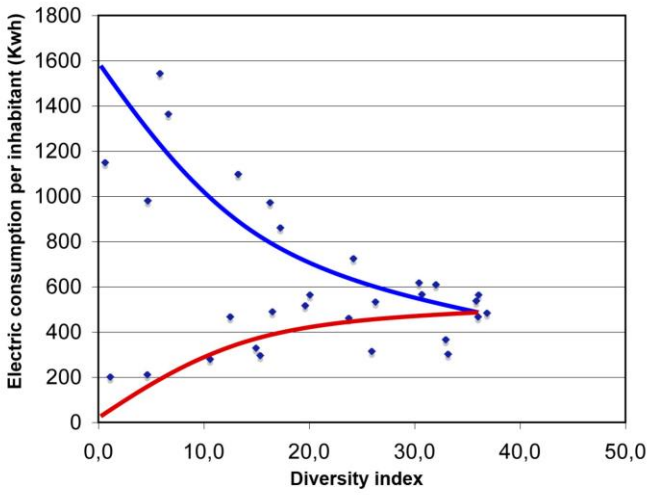
To verify that relationship is established between the structural complexity of the neighborhoods, expressed from Diversity Index Pielou, and power consumption is necessary to take into account the size of the neighborhood factor, and therefore express the energy expenditure in the form of annual consumption per habitant. (Figure 4).



Souce: Sevillana de Electricidad.

Figure 4: Cloud points generated between the values of diversity and power consumption per inhabitant in the neighborhoods of the city of Malaga.

Apparently there seems to be no clear trend in that cloud of points. It would seem that has two branches, one upper and lower decreasing trend of growing trend. That was the first surprise, since it could be thought "a priori" that high levels of diversity should be associated with high levels of energy consumption. (Figure 5)



Source: Sevillana de Electricidad.

Figure 5. Sketch of the two trends detected in the relationship between the Diversity Index and Power Consumption. In the downward trend blue, red upward trend.

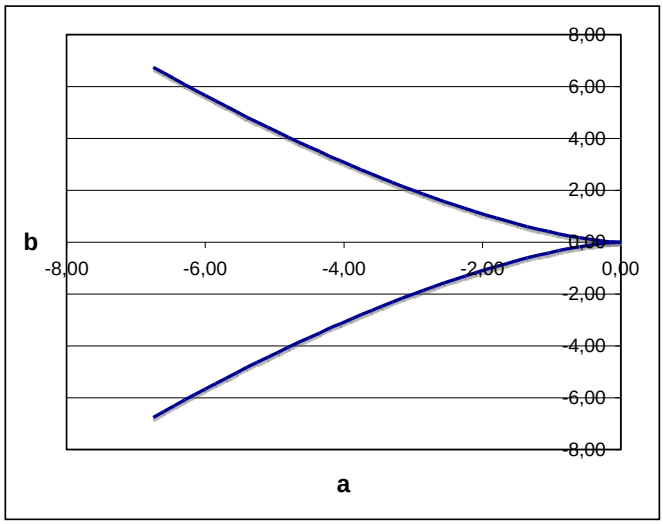
The second surprise holds the graph is that the maximum values of diversity are always associated with intermediate values of power consumption "per capita" values that are between 400-600 Kwh.

At first you might think that there is no way to set a function to the point cloud, as for the values of X the values of f(X) are not unique. However, during the work of analysis of the data some pretty amazing evidence, which gave an unexpected turn to the interpretation of the results obtained.

First it was found that there was a plot quite faithfully reflected the trends observed in the point cloud. This graph corresponded to the solutions of the semi-parabolic equation:

$$4a^3 + 27b^2 = 0$$

This equation, whose solutions to the interval [0 to 6.75] are shown in Figure 6, is quoted by Rene Thom (1985) in the exhibition of his Catastrophe Theory, as a representation of "control plane" of the "Catastrophe Elemental in Cúspide".



Source: Made from René Thom (1985) "Parábolas y catástrofes".

Figure 6. Graphical representation of the solutions to the equation 4a3 + 27b2 = 0. It is remarkable similarity of this graph with trends reflected in the above.

The "Catastrophe Theory" was proposed by Rene Thom in 1972 in his book "Stabilité structurelle et morphogénése" as a mathematical theoretical explanation to the problem of "discontinuities" in the behavior of systems. Is the appearance of " jumps" in the variation of the variables that define them. Perhaps the term "catastrophe" that popularized the theory, not too lucky because it implies a negative character changes when this theory really just trying to systematize the motives of the "abrupt changes".

The theoretical framework of the "Catastrophe Theory" and its counterpart "Chaos Theory" has been used by some authors to explain the evolution of urban centers. Popolizio, E. and Schneider, V. (2001) applied these concepts to analyze changes in the urban dynamics of the city of Resistencia (Argentina), finding that urban migration and consequent growth of the city, was the main agent generator instabilities that helped dramatically change the structure of the city and its dynamics.

Ilya Prigogine (1983), (Nobel Prize in Chemistry in 1977 and author of the "theory of dissipative structures" and "dynamic systems far from equilibrium") applies the concepts of "order fluctuations" and "bifurcations of the system", a configuration analysis and temporal evolution of hierarchies of interconnected urban centers, as a result of the emergence of new economic functions and actions of communications and transport.

Usually these abrupt changes are associated with bifurcation points, i.e. to situations in which the system chooses between two or more solutions stability. One way to visualize this concept is to imagine a glass with a marble in the background. If we push the marble, it will rise and fall a little by the walls of the glass to re-stabilize at bottom Figure 7.

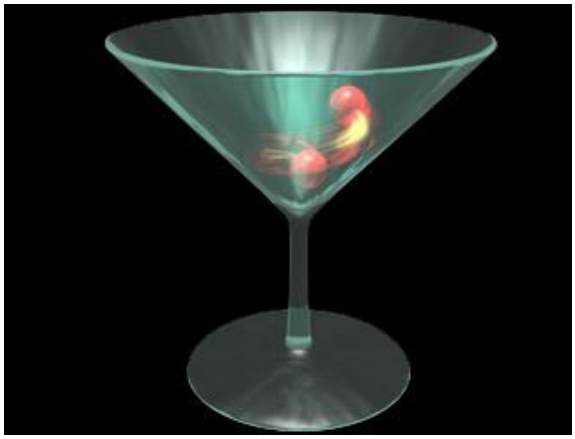


Figure 7. A small disturbance on the marble at the bottom of the cup makes this swing around the point of maximum stability until it recovers its initial state.

If the push is greater, the vagaries of the marble will be broader and persistent Figure 8 before returning to its rest position. That is, the marble system responds with greater fluctuations, continuously, to disturbances that affect them. But it always ends in the same place, at the bottom of the cup.

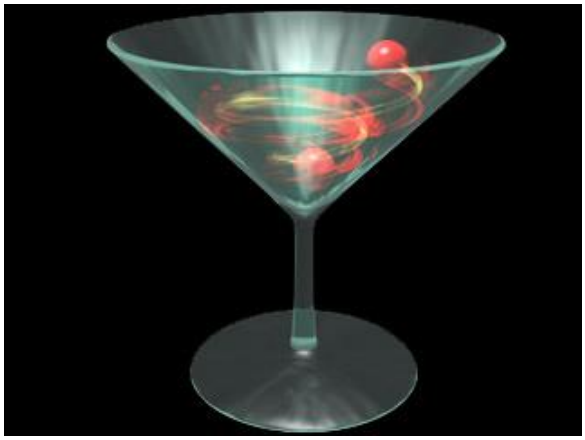


Figure 8. Higher disturbances cause greater fluctuations farther and longer at the marble of its stable state.

Now imagine that the cup is surrounded by other empty glasses, if the push that we give the marble system is strong enough, you can make your trip ends in the bottom of a different from the original own cup. In this case the system has "jumped" to a new state of stability, Figure 9. It has come to a fork: the edge of the original glass, and has fallen to a new state: the bottom of the new cup. What has been the catastrophe?: The jump from one cup to the neighbor. Although it also falls within the jump he may have led to the marble to the blackness of CHAOS.

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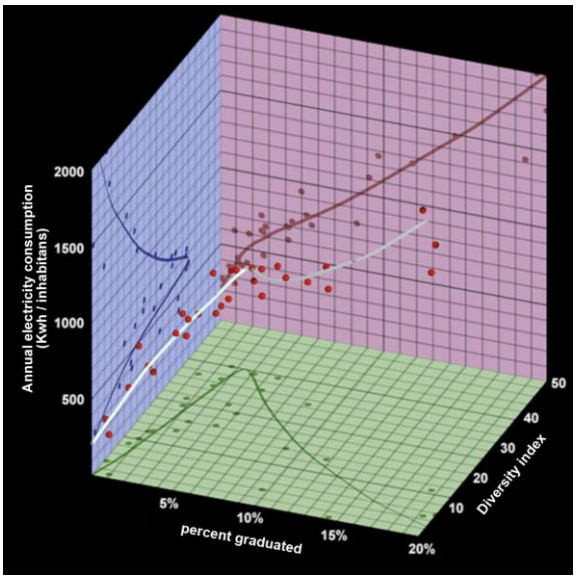
Source: PhD thesis Escudero, C.A. (2012).

Figure 9. If the shock is strong enough, can throw the marble to the edge of the cup, where his career can now lead her to a new, different from the previous stable state. Or send the ball into the abyss of chaos. The edge of the cup defines the boundary of a catastrophe.

In a complex system where multiple factors interact affected by any number of sources of disturbance it is much more difficult to determine the possible paths of evolution of the system. However, in the case presented is feasible to think that have been isolated, or at least recognize, the variables that define the space control.

In Subchapter 3.2. of my thesis was ascertained that the socio-economic status (voiced by level of education) of the inhabitants of neighborhood had a very strong influence on the intensity of energy consumption. When graphed in 3D space (one dimension for each variable) for each neighborhood, their values: percentage of graduates; diversity index and electricity consumption per inhabitant the following result (Figure 10) was obtained.



Source: PhD thesis Escudero, C.A. (2012).

Figure 10. Representation of the values of percentage of graduates; diversity index and per capita electricity consumption for the neighborhoods the urban nucleus of Malaga. It has drawn the trend line on the point cloud.

The graph is observed as with increasing the percentage of graduates in the neighborhoods, electricity consumption increases and from a greater than 5% of graduates, gradually decreases the diversity index.

Rueda, S. (1997, pp. 4) suggests that the ratio of energy consumed and Diversity (E / H) in an urban area, it would be a good indicator of the organization, and therefore robustness and stability. Diversity increased (H) implies an increase of the interconnection between the elements and increased internal regulation circuits. The same author states that: "... On the other hand, the instability generated by the dispersed city, must be offset by a greater contribution of energy and resources as control circuits are to deliberately create, which does not happen in the compact and diverse city since, as already said, the systems composed of heterogeneous parts include more recurring regulating circuits.".

The appearance of control circuits is associated with increased system complexity. As it increases, a greater number and variety of elements interact with each other creating regulatory loops modulating system variation against disturbances. The system increases its resilience to external shocks, internalizing variations (Margalef, R., 1991). This would say that by increasing the complexity of the system acquires a greater number of strategies to cope with the changes without altering its structure.

The systems are very homogeneous have fewer strategies against disturbances. In cultural systems like human societies, can be "purchased" outside in exchange for a high cost, energy and economic strategies, and through extensive use of transportation. A residential complex of high purchasing power, consisting of single-family homes, persists over time because its residents use a lot of energy and economic resources, consumer goods carry their homes and keep them in living conditions.

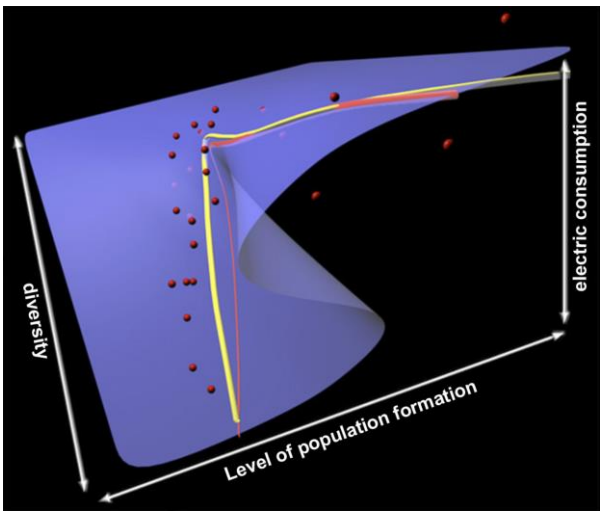
At the opposite extreme are the nuclei of substandard housing self-construction, or other meanings: shanties; favelas; bidonvilles; etc. In most cases, associated with strong temporary immigrant population flows very low purchasing power, or excluded social groups. In all cases are highly vulnerable urban subsystems (Díaz Díaz Muñoz Castillo M.A. and C. 2002, Gonzalez Garcia, I. 2003). The latter author bases his vulnerability assessment based on a number of both socio-economic factors (income level, education level, associations...); as structural (equipment, infrastructure, quality housing...); functional (accessibility, economic activity; public projects...) and environmental. From this perspective Gonzalez Garcia, I. 2003 re / sp1 states: "The vulnerability (of these areas) belongs to a blind spot of social and institutional perception. In a social structure that delegates the resolution of the problems in the various administrative levels, the perception of the vulnerable does not surface, only produce their exclusion from everyday acts, the most marginalized spaces are circumvented, and verbalization of the problem is circumvented next.". Therefore, these spaces remain while they remain excluded from everyday life. If for any reason they hit the network partner - economic city (revaluation of land they occupy, by political interests or social conflicts with the neighboring population) they are simply wiped off the map and displaced people to another marginal area.

Barros, J. and Sobreira, F. (2002) have made an interesting analysis of the dynamics of these marginal human settlements and their clash with the planned city, from the point of view of the Theories of Complexity. Apparently, from this perspective, the spatial and temporal persistence of these subsystems is only possible while holding spaces are not desired by the orderly city, and are able to increase their internal complexity and self organization so that they can successfully defend their own persistence. These situations are seen in many Third World cities.

Between these two extremes of any city neighborhoods are located. Intermediate situations of social, economic and structural nature define the urban fabric. They wanted to visualize what the stability - vulnerability of different neighborhoods of the city of Malaga,

[1] re/sp abbreviations will be used to indicate the source of the quote is an electronic magazine unpaged. In the bibliography accompanying these references with your hyperlink.

superimposing the results of Figure 10 on the space control Catastrophe Type 2 "Cusp" René Thom. (Figure 11).



Source: PhD thesis Escudero, C.A. (2012).

Figure 11: Translation at control space cusp catastrophe, values education level, diversity and power consumption of the neighborhoods of the city of Malaga type. The red dots represent the values for each neighborhood, the yellow line is the adjustment was made to the point cloud, the red line marks the border "jump" batch in control space.

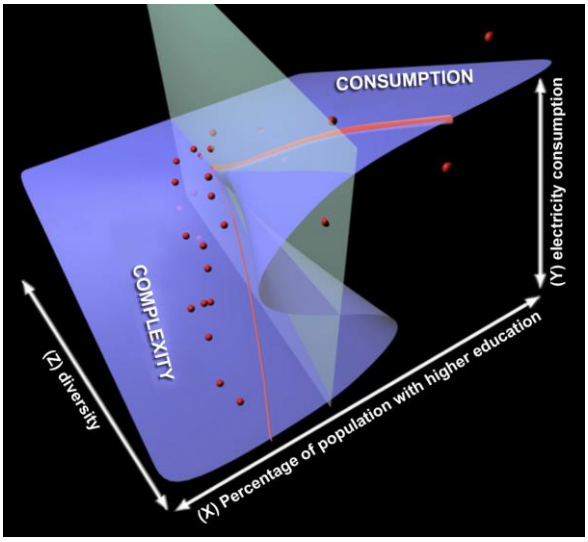
4. DISCUSSION

Increasing activities developed in a neighborhood causes an increase in energy consumption for two reasons. The first is directly due to the energy needs of the activities developed. The second is a result of increased activities in the neighborhood increases the chances of meeting the demands of consumption of the resident population. This may make the neighborhood to potential residents, in a market structure will favor those with sufficient purchasing power (or capable of risking greater economic effort) to change their place of residence more attractive. As discussed earlier, the purchasing power is related to the level of income, and this with the level of instruction. Therefore, the neighborhood tends to gradually increase the proportion of graduates and since these have a higher consumption capacity, will increase the net energy consumption and indirectly encourage the implementation of new activities.

So far the system seems to be developed by fluctuations fueled by positive feedback loops: Population growth increases the number of activities, they attract and increase the proportion of the population with higher purchasing power and both events do increase energy consumption. However a controlled only by positive feedback loops system is unstable because it would be amplified without limit fluctuations.

Really the system is stable because also appear negative feedback loops: As housing neighborhood and local availability decreases, thereby factors built competition for space (and therefore prices) increase deal. This acts as a deterrent to potential occupants.

On the other hand, the increase of activities and population density (both resident and visitor) causes an increase in noise, waste production and pollution, reduced parking spaces, increased neighborhood conflicts, further deterioration infrastructure and street furniture, etc., and therefore a general deterioration in the quality of life in the neighborhood. This will act as a deterrent to those with economic capacity to choose an area that meets your wishes "Quality of Life". (Figure 12)



Source: PhD thesis ESCUDERO, C.A. (2012).

Figure 12: Distribution of Malaga neightborhood between the lower and upper levels of the cusp catastrophe model. It is noted as most of them are located in the area where strategies increased complexity are more relevant than energy consumption.

From this point of view, it is possible to say that urban systems maintain their stability two opposite ways: either by increasing their structural complexity and dynamics; or by the ability to maintain high energy consumption "per capita". You could say that in the lower plane of the cusp catastrophe model strategies increasing complexity are developed, while the higher consumption strategies dominate. Interestingly, like most neighborhoods of the town of Malaga city they were at the lower level, encompassing the increase of energy available with increased organizational complexity.

It is not surprising to find that the neighborhoods that are in the area dominated by high consumption strategy, are the neighborhoods of the city of Malaga more residential component of high socio - economic level: the neighborhood 7 (El Limonar); Neighborhood 23 (El Morlaco); Neighborhood 24 (Pedregalejos); Neighborhood 27 (Pinares de S. Anton); Neighborhood 28 (El Candado).

However, we should not forget that most districts do not follow this strategy. This makes a whole city as a complex system works well structured. The neighborhoods of the strategy remain consumption thanks to the existence of a city where dominate maintenance strategies or increased complexity. Or at least that was what happened in the city of Malaga in the late twentieth century, it might be interesting to see what happens today.

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