INSTITUTO NACIONAL DE ESTADISTICA

Pilot study on the disaggregation of water volumes abstracted and used by river basin district

Methodological proposal and first estimates

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1 Introduction

The purpose of the present study is to develop a first methodological proposal for the geostatistical assignment of municipalities in Spain to a given river basin. This statistical exercise is a first step so that statistical information on water disaggregated by Autonomous Community generated by the National Statistics Institute (INE) is broken down by River Basin District.

The National Statistics Institute (INE) carries out two surveys on the environmental variable "water": one on the integral water cycle (*Survey on Water Supply and Treatment* - ESSA by its Spanish acronym) which studies the volumes of water distributed through municipal water supply networks ("tap water") and the volumes of treated wastewater, and another (*Survey on the Use of Water in the Agrarian Sector* - EUASA by its Spanish acronym), which estimates the volumes of water used in irrigated agriculture ("irrigation water").

The statistical treatment that must be given to these two "water products" (*tap/irrigation water*) cannot be unique, since in the first of these surveys, the main design variable is the resident population, due to its strong correlation with water supply, while in the second one, the main design variable is the irrigated area. We are in two very different statistical scenarios, which will require us to propose specific methodologies adapted to each of them.

On the other hand, it should also be pointed out that the two surveys have their own specific characteristics in terms of methodology, which implies that their estimates must be considered in their conceptual context. Given that the approach of the ESSA is based on the hydrological balance of the water supplied to the network, in the case of the EUASA, it is necessary to take into account the agronomic concepts that define the survey variables themselves, in order to characterise the nature of the water volume estimates.

Finally, it should be stressed that this study is not intended to set up scenarios or horizons of water consumption, but to make annual estimates of water volumes effectively collected from the environment and used. Annual data on water volumes should not be interpreted in isolation, but rather within the context of their time series. This remark applies especially to irrigation water, due to the influence of exogenous factors that affect its level and annual variations (irrigated area, rainfall regime, crop water requirements, losses, etc.).

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2 Problems of the spatial disaggregation of statistical information on water

As a preliminary step, it may be appropriate to carry out a mapping description of the complex geographical and administrative division into which the management of water resources in Spain must correspond. This complexity increases due to the applicable legal standards, both national and from the European Union.

2.1 River basins and basin authorities

A river basin is a territory whose surface runoff flows through a series of streams and rivers to the sea, through a single mouth. The geographical boundaries between two contiguous basins is the line of crests and ridges, also called *watersheds*. Rainwater falling on either side of the watershed is collected by the main rivers of the respective basins or slopes. Within the geographical scope of a river basin, sub-basins can be delimited, according to given natural and climatic characteristics.

In terms of purity, a river basin and a hydrological basin differ in that in the former only surface water is considered, while in the latter groundwater (aquifers) is included. Now, as a result of the increasing administrative intervention in the management of groundwater resources, the term "hydrographic" is now being used to encompass the study and management of both surface and groundwater resources. The river basin is the natural area that enables the economic, social and territorial integration of water resources.

River basin authorities with the denomination of *Hydrographic Confederations (HHCC)*, were created in 1926 by a royal decree-law that regulated the administrative management of water resources in each basin. The first ones to be created were those of the Ebro and Segura (1926), of the Duero and Guadalquivir (1927) and of the Eastern Pyrenees (1929), but the process of creation extended over time, particularly in the basins of northern Spain not organised as confederations until 1961. Throughout their history, the HHCC have expanded their administrative competencies in accordance with the economic and social requirements of the time. Thus, Law 29/1985, of 2 August 1985 (*Water Law*), systematised and defined the administrative powers of basin organizations, and Royal Decree 650/1987 of 8 May 1987 established the territorial areas of these organizations.

Subsequently, Royal Legislative Decree 1/2001 of 20 July 2001 approved the Rewritten Text of the Water Law (TRLA by its Spanish acronym), consolidating and adapting all the legal regulations on water. Its object was the regulation of the public domain, the use of water and the exercise of the powers attributed to the State in article 149 of the Spanish Constitution. In the inter-community river basins which are those that exceed the territorial scope of one Autonomous Community, the hydrographic confederations act administratively as public law entities with separate legal personality and attached to the Ministry of the General Administration of the State responsible for water management.

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At present, the inter-community hydrographic confederations are: *Miño-Sil, Cantábrico, Duero, Ebro, Tajo, Guadiana, Júcar, Segura, Guadalquivir, Ceuta, Melilla.*

In the internal or intra-community river basins, that is to say, those which are included entirely within the territorial scope of an Autonomous Community, the functions attributed to the aforementioned basin organizations in inter-community basins are the responsibility of the competent bodies of the Autonomous Community which, in their own territory and by virtue of their autonomy statutes, exercise competencies over the public water domain.

The internal (intra-community) basins are: *Galicia - Costa, Internal Basins of the País Vasco, Internal Basins of Cataluña, Islas Baleares, Mediterranean Basins of Andalucía, Atlantic Basins of Andalucía, Islas Canarias.*

2.2 Mapping of hydrological competence divisions

In order to visualize the division of the Iberian Peninsula and Spain as regards the nature and management of water resources, two maps are presented below. In the first one, the hydrographic confederations (basin organizations) and the internal (intra-community) basins existing until 2004 are presented. The second illustrates the situation in 2017.

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Hydrographic Confederations and internal basins in Spain (until 2004)

Limits of the planning areas of the hydrographic confederations/internal basins and Autonomous Communities

Source: Ministry of Economy, Industry and Competitiveness – Geological and Mining Institute of Spain

Notes:

1. The *Hydrographic Confederation of the Norte* had planning competences in the Sub-Basins Norte I, II and III.

2 In 2007, this confederation was divided into two: *The Hydrographic Confederation of Miño-Limia* with competences over the Sub-basin North I, and the *Hydrographic Confederation of the Norte* (Sub-basins Norte I and II).

3 In the Sub-basin Norte III, the *Internal Basins of the País Vasco* were integrated with management autonomy for drawing up the river basin plan within the territorial scope of these basins.

4 The *Hydrographic Confederation of the Guadiana* had planning competences in the Sub-basins Guadiana I and II.

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Hydrographic Confederations and Internal Basins in Spain (2017)

Source: Ministry of Agriculture and Fisheries, Food and Environment. Hydrographic Confederation of the Guadiana

Notes:

1. In 2005, the competencies of the *Hydrographic Confederation of the Sur,* were transferred to the Autonomous Community of Andalucía, creating the *General Directorate of the Mediterranean Basins of Andalucía*. It was attached administratively to the Andalusian Water Agency, competent administrative body for water issues in that Autonomous Community.

2. In 2006, the *Directorate General of the Atlantic Basins of Andalucía* was established, attached to the aforementioned autonomous body, which includes the basins of the Guadalete/Barbate and Tinto/Odiel/Piedras rivers.

3. In 2008, the *Hydrographic Confederation of the Miño-Limia* was renamed *Hydrographic Confederation of the Miño-Sil*.

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2.3 River basin districts

On 23 October 2000, Directive 2000/60/EC of the European Parliament and of the Council was adopted, establishing a framework for Community action in the field of water policy, abbreviated as the *Water Framework Directive*.

The Water Framework Directive (WFD) has brought about a substantial change in European water legislation. Its objectives are to prevent deterioration and improve the status of aquatic ecosystems, to promote sustainable water use by applying the principle of cost recovery of water services management to its users and public participation as an essential element in water resources planning and management processes.

This Directive granted a period of three years (until the end of 2003) for the Member States of the European Union to transpose it into their national legal order. To this end, in Spain, Article 129 of Law 62/2003 of 30 December 2003 on fiscal, administrative and social measures adapted the TRLA to the provisions established by the WFD.

The WFD created the concept of *River Basin District*, which was included in Article 16 bis 1 of the TRLA as "*the land and marine area composed of one or several neighbouring river basins and the transitional waters, groundwater and coastal waters associated with these basins*". For its part, Article 16 bis 5 empowered the Government of Spain to establish by Royal Decree–after hearing the Autonomous Communities–the territorial scope of each River Basin District, which would coincide with that of its hydrological plan.

In application of this legislative mandate, Royal Decree 125/2007 of 2 February 2007 established the territorial scope of the River Basin Districts. Bearing in mind that the structure of river basins in Spain was broadly in line with the organisational structure and division of competence between the State and the Autonomous Communities, it was agreed to maintain, as far as possible, the structure of the existing river basins by means of the corresponding addition of transitional and coastal waters and those of all groundwater located below the boundaries defined by the river basin watersheds of the corresponding River Basin District.

The established River Basin Districts are listed below:

- River Basin District (inter-community basins)
  (River Basin District…..).
  - *of the Miño-Sil*
  - *of the Cantábrico Occidental*
  - *of the Cantábrico Oriental*
  - *of the Duero*
  - *of the Ebro*
  - *of the Tajo*
  - *of the Guadiana*
  - *of the Júcar*
  - *of the Guadalquivir*

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- *of the Segura*
- *of Ceuta*
- *of Melilla*

❖ River Basin District (intra-community basins)
- *of Galicia-Costa*
- *of the Internal Basins of Cataluña*
- *of the Islas Baleares*
- *of the Mediterranean Basins Andaluzas*
- *of the Guadalete y Barbate*
- *of the Tinto, Odiel y Piedras*
- (River Basin Districts) of the *Islas Canarias*
- *La Palma*
- *La Gomera*
- *El Hierro*
- *Tenerife*
- *Gran Canaria*
- *Lanzarote*
- *Fuerteventura*

2.4 River basin management plans

The hydrological planning of water resources at the territorial level of the river basin was, since its creation, an inherent task of the basin organizations. However, this planning was not systematized until Royal Decree 3029/79 was promulgated on 7 December, which ordered that the hydrographic confederations would elaborate so-called "hydrological plans" in accordance with guidelines issued by a so-called National Planning Commission. In application of this legislation, some hydrographic confederations addressed the development of initial hydrological plans in the early 1980s.

The Water Law of 1985 in its Title III (Articles 38 to 44) established the obligation to formulate such plans in inter-community basins within the framework of the National Hydrological Plan, which would be approved by law. This plan would establish the necessary measures for the coordination of the different river basin management plans, which would have to be approved by Royal Decree by the Government of Spain.

On 24 September 1992, by Order of the Ministry of Public Works and Transport, the complementary technical instructions and recommendations for preparing the hydrological plans for inter-community basins were approved, issued in accordance with the provisions of the Regulations on Water Public Administration and Hydrological Planning, approved by Royal Decree 927/1988 of 29 July. The aim of these instructions was to obtain homogeneous and systematic results in the hydrological planning as a whole, based on the intrinsic heterogeneity and the different characteristics of each hydrological plan.

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In line with these instructions and recommendations, the hydrological plans for inter-community basins were drawn up during the 1990s and approved by Royal Decree 1664/1998 of 24 July 1998.

Subsequently, the aforementioned Rewritten Text of the Water Law (TRLA) of 2001 further developed this issue, incorporating in its Title III (Articles 40 to 46) the objectives and criteria of hydrological planning and establishing in its Article 40.3, that the hydrological plan would coincide with the territorial scope of the River Basin District, and should be prepared by the corresponding basin organization (inter-community basins) or by the competent body in the area of water of the Autonomous Community (internal basins).

The River Basin District of the Cantábrico Oriental is of particular importance, since within its scope it includes one area of competence of the State and another corresponding to the AACC of the País Vasco. The elaboration of the part of the plan corresponding to the territorial scope of the Internal Basins of the País Vasco falls within the competence of the Autonomous Community of the País Vasco.

As regards the Islas Canarias, each of its seven islands is constituted as a River Basin District and the Insular Water Council attached to the Island Council is the body responsible for drawing up the plan in each of them.

The River Basin Districts of Ceuta and Melilla belong to the Hydrographic Confederation of the Guadalquivir, which exercises its competence in water administration and, therefore, draws up the corresponding hydrological plans.

The WFD has established a timetable for the preparation of river basin plans in the River Basin Districts of the Member States: (2003 - 2009) and (2009 - 2015) which would constitute the first management cycle of the WFD, and in 2015 the achievement of the WFD objectives must be evaluated. It will follow a second management cycle (2015 - 2021), and a third cycle (2021-2027).

Article 42 of the TRLA established the contents of the river basin management plans, including a general description of the uses and demands existing in the basin and a summary of the economic analysis of water uses. In order to support these analyses from a quantitative point of view, the river basin plans carry out studies and make estimates and projections regarding both the water supplied by public networks and the irrigation water used, as well as the volumes of water abstracted from the environment (gross water demand).

The quantitative information presented in the river basin plans is very valuable, but even though all the plans present information in the same format for inter-community basins, this information is difficult to compare because the temporal references of population information are not homogeneous. As regards irrigated areas, the estimated figure is based on different time scenarios, which take into account the average of recent years and forecasts on new irrigated land areas.

With respect to irrigation water (abstraction and use) which is correlated with irrigated areas, we can observe the existence of different levels and details of disaggregation of estimates of net and gross demand for crops.

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On the other hand, only some river basin plans describe the methodology that supports estimations of water demands.

As far as the plans for intra-community basins are concerned, it should be noted that the layout of its sections are not always in line with those of the inter-community basins, and the statistical information presented and the methodology used to carry out the estimates is very uneven.

In any case, river basin plans – given their hydrological planning nature – generally present estimates of water demands in different scenarios (first and last year of the period of validity of the plan and/or projections for the next five-year period), but not annual estimates, that is, in each of the years of the planning period.

At this point, it is important to note that the time periodicity of statistical information requirements of EUROSTAT (European Union Statistics Office) for water is the year, which certainly limits to a large degree the usefulness of the information of the hydrological plans for the preparation of annual series of hydrological data on water demands.

Finally, Order ARM/2656/2008, of 10 September 2008 (BOE of 22) of the then Ministry of the Environment, Rural and Marine Affairs, which approved the hydrological planning instructions and replaced those already mentioned from 1992, was also a great step forward in the publication of information on provisions for industrial demand, domestic consumption and admissible net provisions for crop groups in each river basin district.

2.5 Criteria for assigning a municipality to a river basin

In summary, the statistical problem posed is to establish a correspondence between the administrative boundaries of Autonomous Communities and the physical boundaries of river basins, by assigning each municipality to a single basin. In the work carried out at the international level in this field, three main assignment criteria are usually used in cascades:

a) Percentage of municipal area included in the river basin

b) Location of the main nucleus of the municipality in the river basin

c) Percentage of municipal population included in the river basin

a) Percentage of municipal area included in the river basin

The percentage of the municipal area included within the physical boundaries of the river basin is a first assignment criterion, since when it is 100%, the assignment leaves no doubt. In all other cases the decision threshold is usually set at 50%. In such a way that if the municipal area included in a river basin exceeds this percentage, the municipality is assigned to that river basin. The problem posed by the application of this criterion is that a municipality may overlap with more than two river basins, so this criterion may not be conclusive.

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b) Location of the main nucleus of the municipality

Except in some Autonomous Communities with a very scattered population (Galicia, País Vasco and to a lesser extent Asturias), the nucleus where the municipal capital is located has the largest population of it. For this reason, its geographical location within the physical boundaries of the river basin is usually considered a second inclusion criterion of a municipality in a given river basin.

c) Percentage of the municipal population included in the river basin

It may be the case that the municipal area is divided between more than two river basins, and that the population contained in one of the portions–which is not the capital of the municipality–represents the most significant percentage of its total population. In these cases, it can be considered that said population is representative for the socio-economic analysis, assigning the municipality to the River Basin District where this portion is located.

The three criteria mentioned above are able to provide the requirements of the spatial disaggregation that we are trying to establish, although for the purposes of a socio-economic approach, we should take into account others such as–to give just a few examples–rate of urbanization, working population, equivalent tourist population, distribution of irrigated area at municipal level and source of water (surface or underground).

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3 Pilot methodology for the assignment of municipalities in Spain by river basin

In 2008, the INE conducted a study on the feasibility of disaggregating water data by river basin, based on the information traditionally published by Autonomous Community. To this end, and based on a file of records *municipalities - river basin*, containing **10,179** registers provided by the Ministry of the Environment (currently called Ministry of Agriculture and Fisheries, Food and Environment - MAPAMA by its Spanish acronym), the bases for the mentioned study were established.

The number of municipalities existing in Spain according to the INE municipal gazetteer at 1/1/2007 was **8,111**, and the resident population according to the Municipal Register of inhabitants of Spain at the same date, amounted to **45,200,737** inhabitants.

In a first stage, a file cleaning was performed, crossing it with the information from the gazetteer at 1/1/2007, which contains the resident population in each municipality. From this cross-checking of information, **938** duplicate municipalities were identified within the same river basin, and **90** registers in the MAPAMA file did not have the administrative category of municipality because they were population entities, associations, etc., and thus they were deleted. Therefore, after this first cleaning, the number of records to be considered in the base file to make the breakdown by river basins was **9,151**.

On the other hand, **24** municipalities were found in the gazetteer that did not appear in the MAPAMA file. The convention was adopted that at the end of the study, the population of these 24 municipalities would be added to the basin to which each of them was assigned. Therefore, after discounting the 24 municipalities that were not included in the MAPAMA file from the 8,111 in the gazetteer, a total of **8,087** "INE municipalities" were obtained, which were analysed for their assignment to a single river basin.

The distribution by river basin of the **9,151** municipality/river basin registers was as follows:

- Inter-community river basins
  - *Miño - Sil (Miño - Limia)*: 230
  - *Cantábrico*: 402
  - *Duero*: 2,109
  - *Ebro*: 1,775
  - *Tajo*: 1,141
  - *Guadiana*: 472
  - *Júcar*: 800
  - *Guadalquivir*: 542
  - *Segura*: 137
  - *Ceuta*: 1
  - *Melilla*: 1

  TOTAL **7,610**

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- Intra-community basins
  - Galicia- Costa: 182
  - Basins I of the País Vasco: 139
  - Basins I of Cataluña: 668
  - Islas Baleares: 67
  - M. Basins of Andalucía: 280
  - A. Basins of Andalucía: 118
  - Canarias: 87

  TOTAL **1,541**

With regard to the assignment of the **8,087** INE municipalities, according to the number of river basins that overlap with their municipal area, the situation was as follows:

- **7,090** in **one** single river basin
- **956** in **two** river basins
- **40** in **three** river basins
- **One** in **four** river basins (Alcaraz in the province of Albacete)

In order to have a vision of the population weights that make up each of the four previous strata, we have studied the municipalities contained in them, depending on whether their population is lower or higher than 5,000 inhabitants, understanding that this is a reference population in terms of the size of the municipality.

- **7,090** municipalities: **1,103** (with more than 5,000 inhab.) and **5,987** (with less than 5,000 inhab.)
- **956** municipalities: **154** (with more than 5,000 inhab.) and **802** (with less than 5,000 inhab.)
- **40** municipalities: **6** (with more than 5,000 inhab.) and **34** (with less than 5,000 inhab.)
- **1** municipality: (with less than 5,000 inhab.)

The assignment of the municipality to the river basin was made following the second of the assignment criteria (location of the main nucleus of the municipality in the river basin) with the help, in problematic cases, of the crossing of the maps of municipal boundaries and River Basin Districts geographic borders (*Spatial Data Infrastructure - IDEs* of MAPAMA). All municipalities with a population greater than 5,000 inhabitants have been studied in terms of their assignment to a single river basin.

However, there have been cases of municipalities with more than 5,000 inhabitants in which the above-mentioned assignment criterion is not conclusive, which has made it necessary to adopt a series of conventions that will be explained below.

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The final result after carrying out the work described above (including the 24 municipalities missing in the MAPAMA file) was as follows:

- **7,785** municipalities in **one river** basin
- **318** municipalities in **two river** basins
- **8** municipalities in **three river** basins
- **No** municipality in **four river** basins (*Alcaraz is assigned to the Júcar Basin*)

This makes a total of 8,111 municipalities.

This stratification according to the number of basins to which the municipality is attached, has the following population correlation:

- One river basin: **7,785** municipalities with a population of **44,398,138** inhabitants. Of which:
  - 1,252 with more than 5,000 inhab. (population: 38,603,045 inhab.)
  - 6,533 with less than 5,000 inhab. (population: 5,795,093 inhab.)
- Two river basins: **318** municipalities with a population of **795,839** inhabitants. Of which:
  - 12 with more than 5,000 inhab. (Population 565,396 inhab.)
  - 306 with less than 5,000 inhab. (Population 230,443 inhab.)
- Three river basins 8 municipalities (all with less than 5,000 inhab.) (population: **6,760** inhab.)
- No municipality in four river basins

TOTAL POPULATON: 44,398,138 + 795,839 + 6,760 = **45,200,737** (register at 1/1/2007)

Of the twelve municipalities with more than 5,000 inhabitants that have been assigned to two basins, three are located in the AACC of Galicia and the remaining nine in the AACC of the País Vasco. In the first one, the four municipalities that can be considered naturally attached to the river basins of the Cantabrico and of the Miño-Sil, are: Ribadeo, Da Guarda (La Guardia) and O Rosal.

Of the nine located in the AACC of the País Vasco, the municipality of Abadiño (Abadiato) is attached to the river basins of the Cantábrico and of the Ebro, and the problem of the remaining eight is caused by the question of transfers which we will address next.

For the 314 municipalities with a population of less than 5,000 inhabitants assigned to more than one basin (306 to two and 8 to three) and whose assignment to a basin was difficult, in order to reduce the workload and not overestimate the population assigned to the *municipality-basin* record, the convention was adopted to divide by two or three its population and assign each of the population fractions to each of the river basins. This distribution affected some 237,000 inhabitants who represent 0.5% of the total population of Spain, so the bias that may have been incurred is not considered significant.

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With regard to the AACC of the País Vasco, the situation is special, since the River Basin of the Ebro has water transfers to municipalities located in the territorial scope of the Internal Basins of the País Vasco. Thus, the transfers of Cerneja - Ordunte and Zadorra - Arratia provide water for the supply of the Gran Bilbao region and that of the Alzania - Oria to some municipalities of Vizcaya.

The municipalities supplied in part by the Zadorra system and by the River Basin of the Cantábrico are 15, eight with more than 5,000 inhab. and 7 with less:

- Abanto, Barakaldo, Galdakao, Bilbao, Mungía (*Munguía*), Muskiz, Valle de Trápaga-Trapagaran, Ortuella (more than 5,000 inhab.)
- Arrankudiaga, Larabetzu, Laukiz, Ugao-Mirabelles, Lezama, Zaratamo, Ziérbana (with less than 5,000)

On the other hand, 19 municipalities of the AACC of the País Vasco, mainly supplied by the Zadorra system, were assigned to the River Basin of the Ebro.

- Arrigorriaga, Basauri, Berango, Darío, Errando, Etxebarri, Getxo, Gorliz, Leioa, Portugalete, Santurzi, Sestao, Sopelana (with more than 5,000 inhab.)
- Barika, Loyo, Plentzia, Sondika, Urduliz, Zamudio (less than 5,000 inhab.)

As regards basin assignments of other municipalities in Spain located in one basin but which receive transfers from another, the convention has been adopted to assign them (along with their population) to the basin where they are physically located. This situation occurs in the following cases:

- Transfers *Ebro - Pas - Besaya and Cerneja - Alto de Tornos* that improve water availability in the municipalities of the Cantabria, including Torrelavega and Santander: the municipalities have been assigned to the River Basin of the Cantábrico.
- The transfer *Araviana - Ólvega*, which through the Araviana river supplies water from the Basin of the Duero to the municipality of Ólvega in Soria, located in the geographical area of the Basin of the Ebro. This municipality has been assigned to the Basin of the Ebro .
- The transfer *Ciruana - Ruidecañas*, located in the Tarragona region and brings water to the Reus region.
- Transfer to the *Campo de Tarragona*, which drains water directly from the Ebro.

The municipalities of the AACC of Cataluña that receive water from these two transfers have been assigned to the Internal Basins of Cataluña.

The final results are:

- Inter-community river basins
  - *Miño - Sil (Miño - Limia)* : 825,316
  - *Cantábrico*: 2,152,063
  - *Duero*: 2,217,892
  - *Ebro*: 3,122,831
  - *Tajo*: 7,353,839

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- *Guadiana*: 1,735,635
- *Júcar*: 4,956,589
- *Guadalquivir*: 4,138,432
- *Segura*: 1,885,245
- *Ceuta*: 76,603
- *Melilla*: 69,440

  TOTAL **28,533,885**

➢ Intra-community river basins

- Galicia- Costa: 2,049,660
- Basins II of the País Vasco: 1,380,545
- Basins II of Cataluña: 6,600,169
- Islas Baleares: 1,030,650
- Basins MM of Andalucía: 2,343,445
- Basins AA of Andalucía: 1,236,432
- Canarias: 2,025,951

  TOTAL **16,666,852**

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4 Geostatistics of river basin districts

4.1 Resident population as conversion auxiliary variable

In 2014, Spain had to provide EUROSTAT with information requirements on water data (years 2011 and 2012). Given the time elapsed since the study was carried out with reference to 2007, population data was updated, taking as a reference the resident population of the Municipal Register of inhabitants at 1/1/2011, which amounted to 47,190,496 inhabitants. There was an increase in the population of approximately two million inhabitants compared to 1/1/2007, with a special impact on the Autonomous Communities of Madrid, Cataluña, Comunidad Valenciana, Baleares and Canarias. With respect to the first four Autonomous Communities, this population increase is reflected in the population increase attached to the River Basin Districts of the Tajo, I.B. of Cataluña, the Mediterranean Basins Andaluzas, Guadalete/Barbate and Tinto/Odiel/Piedras.

The assignment of municipalities to River Basin Districts is identical to that established in the study by basins carried out with reference to 2007. However, the new division by River Basin Districts – with respect to the previous one by rive basin – introduces modifications that should be mentioned. In fact, the River Basins of the Miño-Sil and of the Cantábrico were already included in the work file, but not the municipalities assigned to the River Basin Districts of the Cantábrico Oriental and Occidental. Similarly, the River Basin Districts of Guadalete/Barbate and Tinto/Odiel/Piedras, new planning areas in the Atlantic Basins of Andalucía, were also not included in the file.

In the first case, an approximate distribution of municipalities has been carried out, taking into account the geographical line that divides into two parts the basin of the Cantábrico to give origin to the two River Basin Districts. On the other hand, in the case of the River Basin District of the Cantábrico Oriental, all the municipalities assigned to the Internal Basins of the País Vasco have been assigned to it.

Finally, with regard to the River Basin Districts of Guadalete/Barbate and Tinto/Odiel/Piedras, all the municipalities in the province of Huelva attached to the Atlantic Basins of Andalucía have been assigned to this latter River Basin District.

4.2 The irrigated area as conversion auxiliary variable

In the previously mentioned statistical work carried out by basins in 2007, the breakdown of irrigated areas by river basins was not addressed.

The conversion of irrigated area information by Autonomous Community into data by River Basin District presents methodological specificities. In fact, an important issue that must be emphasised is that it is practically impossible to know exactly, at the level of River Basin Districts, the areas actually irrigated in a given year.

This data is always difficult to estimate and very much depends on the methodology applied in its study and the convention adopted to define what is meant by irrigated area, whether it is the area that is irrigated in each season (April

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- September) or the area that is entitled to the use of water granted by a concession for irrigation (irrigation area). It should be taken into account that the area actually irrigated in an agricultural season and in full production regime, within the hydraulic area dominated by the irrigation system, may differ from the the irrigation area surface.

Therefore, for the purposes of the hydrological planning, what is relevant is the irrigated area which really describes the situation (understood as an average of the last representative years), being this the area generally offered in the river basin management plans, although some of them provide estimates on the irrigated area in a *"dry","wet" or "normal*year.

For the statistical study under consideration, and for similar purposes of the use of the Municipal Register of inhabitants with regard to the "temporary harmonisation" of population figures for all the river basins and river basins districts, the 2011 *Survey on Crop Areas and Yields (ESYRCE by its Spanish acronym)*, which is prepared annually by the MAPAMA to estimate the irrigated area by Autonomous Community, has been chosen. The ESYRCE is a field research during the months of May to August, in which information is taken directly on the plot of land in a geo-referenced sample of the national territory. The results obtained complement other statistical information from the MAPAMA for official data collection, which are subsequently published in its Statistical Yearbook, broken down by crop and irrigation techniques at the provincial and Autonomous Community level, but not by river basin or river basin district.

The use of this survey for estimating the irrigated area in this study makes it possible to homogenize the estimates with annual periodicity, but it can introduce a bias regarding the comparability of the volumetric estimates of the model with those resulting from the river basin plans. In hydrological plans, the representative spatial unit to characterize the irrigated land in the River Basin District is the Agrarian Demand Unit (ADU), which is an irrigation area that shares common characteristics according to the main criterion of constituting a differentiable management unit, either because of the origin of its resources, administrative conditions, type of irrigation, hydrological similarity or strictly territorial considerations.

For the breakdown of irrigated areas by River Basin District, the *municipality-river basin district* assignment previously established has been used, assigning to each municipality the irrigated area estimated by the Agrarian Census 2009 carried out by the INE. As there are differences between the estimates of the Agrarian Census and the ESYRCE at Autonomous Community level, the results of the census have been calibrated to this survey, applying the coefficient calculated to the irrigated areas of all municipalities. The results of the ESYRCE broken down by province have also been used as an external source of comparison.

It should be noted that the information for evaluating irrigated areas in each ADU is not unique. In fact, it can come from the information of the basin organisation itself on irrigated areas with concessionary right, the inventories of irrigated lands carried out in an Autonomous Community, the INE Agrarian Census, the irrigated areas registered in the Rural Cadastre with the cataloguing of such areas, or a

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combination of all the above mentioned sources for the estimation of an average annual irrigated agricultural area.

In each irrigation season, the irrigated area may be altered by many and varied factors such as rainfall regime, crop typology, the transformation of rainfed areas into irrigated land, or the abandonment of marginal irrigation lands–in which diverse causes are juxtaposed, such as the low assurance of supply, the poor profitability of farms or the ageing of the population–where irrigation is sporadic or non-existent.

Another difficulty added to the estimation of the irrigated area in a given River Basin District is that, while the areas of public irrigated land (i. e. subject to administrative concession by the basin organisation because agricultural holdings using the concessioned water, assigned to an irrigation entity) are administratively registered in the Water Commission of the basin authority, private irrigated areas serving holdings that collect water from the environment by their own means (self-supply) – usually groundwater – are generally not, and therefore their irrigated area is more difficult to estimate quantitatively.

Finally, it should be noted that, conceptually, irrigated area should be understood to mean the area irrigated with a maximum of one hydrological year. This so-called "net irrigated area" is the demanding area of the water resource and the calculation area for the estimation of irrigation water demand. This net area is calculated from the (gross) area that comprises the ADU, excluding the unproductive area and taking into account crop rotation and fallow land areas, since the total irrigable area of the ADU cannot be effectively irrigated each year.

4.3 Mapping of river basin districts

The following is a general mapping of the river basin districts (terrestrial) in Spain.

In the annex, the maps of each of the river basin districts are included, which have been designed by the INE from the Infrastructure of Spatial Data of Spain (IDEE by its Spanish acronym) of the Ministry of Agriculture and Fisheries, Food and Environment (MAPAMA). Two series of maps have been drawn up: a physical series containing the main waterways that run through the territorial area of the river basin district, and another series showing the correspondence of the territorial boundaries of the river basin districts with the administrative boundaries of the provinces. In order to simplify the planimetry, the layer of the Autonomous Communities has not been superimposed on that of river basin districts, even though the *river basin district-province* correspondence can be used to automatically derive the *River Basin District- Autonomous Community* mapping. The River Basin Districts of Baleares, those of the seven islands of Canarias and Ceuta and Melilla are not included in the map series, since the cartography of the aforementioned River Basin Districts does not add additional information as the territorial areas of these River Basin Districts coincide respectively with those of the Autonomous Community, of each island and of the corresponding Autonomous City.

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River Basin Districts in Spain (2017)

Source: INE's own elaboration based on the Infrastructure of Spatial Data of Spain (IDEE) of the MAPAMA.

Notes:

1. For the purposes of the Water Framework Directive application, the Basin of the Cantábrico is divided into two River Basin Districts: *River Basin District of the Cantábrico Occidental* and *River Basin District of the Cantábrico Oriental.*

2. In the *River Basin District of the Cantábrico Oriental*, the Autonomous Community of the País Vasco has the planning competences in the territory of the *Internal Basins of the País Vasco*.

3. Each of the seven islands of the Islas Canarias conforms a River Basin District.

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5 General methodology for estimating water volumes by river basin district

5.1 EUROSTAT and OECD requirements for statistics on water resources

Since the late 1990s, EUROSTAT has been requesting from its member countries statistical information on the data of the integral water cycle (precipitations, collection, use, population served by the sanitation networks and wastewater treatment plants, wastewater discharges and pollution load, etc.). For its part, the Organisation for Economic Cooperation and Development (OECD) has also been collecting data of a similar nature from its member countries.

In line with the growing importance of water data and in order to reduce the response burden for respondents, EUROSTAT and OECD agreed to establish a joint data collection with the so-called *Joint Questionnaire - Inland Waters (JQ - IW)*. Thus, the JQ-2006 questionnaire was created and sent at the beginning of the fourth quarter of 2006 to the member countries of both international organizations, in order to update the information for 2003 and 2004. Subsequently, and with the said time reference, Spain completed the JQ-2008 questionnaire. It should be noted that the hydrological information requested in the JQ questionnaire is at the national level, without any geographical or spatial disaggregation.

In order to adapt to the new approach of the Community water policy established by the WFD, a new "regional" questionnaire (REQ - IW) was implemented in the 2010 data collection, requesting the breakdown of the data contained in the JQ both at Autonomous Community level (NUTS II) and by River Basin District (RBD).

To provide these new international requirements, the INE reactivated the work aimed at establishing a methodology for converting data by Autonomous Community to River Basin District, taking advantage of the study carried out with reference to the year 2007. To this end, the information on the resident population was updated from 2007 to 2011, and it was carried out ex-novo an *Autonomous Community/River Basin District* conversion for the variable *irrigation surface area*.

All this made it possible for the INE to send EUROSTAT with reference to the year 2011, in the REQ - IW 2014 questionnaire, preliminary data of water collection and use volumes (supply and irrigation networks) broken down by river basin district.

The INE is the focal point in Spain for the completion of the JQ/ REQ- IW questionnaires, and is responsible for coordinating with the MAPAMA for the data under the competence of this Ministry.

Finally, as regards volumetric water estimates, the seven River Basin Districts of the Islas Canarias (one for each island) have been grouped into a single aggregate, which would therefore correspond to the territorial scope of the River Basin of the Islas Canarias.

5.2 Methodological conventions and determination of model parameters

Once the correspondence between Autonomous Communities and River Basin Districts has been established, based on the variables *resident population* and

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irrigated areas, conversion coefficients should be applied to the volumes of water supplied by public (municipal) supply networks and to the volumes of irrigation water used in irrigated agriculture. As already indicated, the sources of information will be respectively the *Survey on Water Supply and Treatment* (ESSA) and the *Survey on the Use of Water in the Agrarian Sector* (EUASA), the results of which are published, broken down by Autonomous Community on the INE website.

The volumes of water collected and used are estimated based on the tables of conversion coefficients for Autonomous Community - River Basin District, which are applied to the volumetric data of water broken down by Autonomous Community.

As regards water in public supply networks, the breakdown of the results of the Survey on Water Supply and Treatment published on the INE website is: households / economic sectors / municipal consumption. In the questionnaire of this survey, a more detailed breakdown is requested *(households / industry / services / tourist and recreational uses / municipal consumption / other)* which does not correspond to the pricing formats invoiced to users for water services. This obliges the reporting units to make approximate estimates, in particular as regards tourist and recreational services and uses.

This information complements that obtained in the modules on the use of water in manufacturing and service industries, which are included in the *Survey on Waste Generation in Industry* and in the *Survey on Waste Generation in Services*, respectively.

For irrigation water, some precision is required since the methodology for its calculation applied in the EUASA and in the river basin plans differs in its conceptual premises. In the river basin management plans, the methodology for calculating the volumes of net water demand (use) and gross water demand (abstraction) is as follows.

Based on the climatic series in the period under consideration, a net amount per hectare and year is established for each crop, expressed in cubic meters. The net amount for a crop indicates the volume of water per net irrigated area that must be contributed in the root of the crop plant to reach an optimum production level, thereby satisfying its water requirements and taking into account the values of precipitation and evapotranspiration of each crop. The net demand is obtained by multiplying the net amount for each crop by the net crop area. Calculations for estimating the total net demand can be made within each ADU, subsequently adding the net demands of all of them, or directly at the level of the entire river basin district.

For the calculation of gross demand, that is, the volume of water that needs to be collected from the environment (surface water or groundwater) to ensure the net demand for crops in a given territorial area, the so-called "overall irrigation efficiency" (E_p) is calculated. Gross water demand is expressed as the quotient between the net demand (crop water needs) and E_p. The difference between gross

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and net demand represents the volumes of returns of irrigation water and of overall losses of the irrigation system.

The E_p also expresses the relationship between the volume of water supplied from the intake point in the water public domain and that finally used in the crops benefiting from irrigation before irrigation of the plot. It is a synthetic indicator composed of three efficiencies:

Efficiency in transport networks, also known as "*conveyance*" (E_c), which are those that bring water to the reservoirs, ponds of the irrigation entity or the agricultural holding itself in the case of private irrigation systems with self-supplying water.

The efficiency of distribution channels from these water sources to the plot of crops (E_d),

The efficiency of the irrigation technique applied for plot irrigation (E_a).

The efficiency of the transport network depends both on its age and state of conservation, on the conveyance structure (pipeline, lined or unlined channel), on the material and, in the case of surface water from reservoirs or marshlands that are far removed from irrigation areas, on the length of the transport pipes. In the case of private irrigation lands supplied with groundwater, due to the proximity of the water source to the irrigated plot, losses in the conveyance networks can generally be considered non-significant.

With regard to the distribution network, irrigation ditches, pipes or sprinkler of the irrigation community or of the agricultural holding, their efficiency also depends on their age, condition and construction materials (land, cement, etc.).

The application efficiency is determined by the degree of water use made by the plant according to the irrigation technology used in the plot (drip - localised / sprinkler / gravity).

The overall efficiency would be obtained as the product of the three above-mentioned efficiencies:

$$E_p = E_a * E_d * E_c$$

The estimation of these efficiencies is not simple, given the wide diversity of circumstances of the ADUs that make up a basin/river basin district. These estimations are usually made globally for the whole basin/River Basin District, proposing generally accepted orders of magnitude and evaluating the losses in the conveyance networks according to their condition (*good/regular/bad*) and the material from which they are made (earth, cement, etc...) and their construction characteristics (pipe, uncovered, etc.).

In the case of the water use estimates of the EUASA, the irrigation entity is requested to provide volumes of water used for crop irrigation and water distributed to agricultural holdings according to irrigation technique. As data collection for this latter variable is more robust, the estimation of the volume of

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water used by crop types is calibrated to the total volume of water used by irrigation techniques.

Therefore, the estimation that the above mentioned survey makes on the volumes of water used by type of crop cannot be conceptually assimilated to the net demand of them. This would be "*water used on the plot*" (gross demand after losses in the conveyance/transport and distribution systems have been discounted) without taking into account the inefficiencies of irrigation techniques and possible water requirements for washing the salts deposited on the land.

On the other hand, water returns (leakage of irrigation water or surpluses/discharges) are accounted for the purposes of hydrological planning–in a given hydrographic domain–as a percentage of gross demand, for the purposes of calculating the volumes of water released to meet the net or theoretical demands of crops. Given that these water returns are reused, since the theoretical design of the INE survey, the estimation made by the EUASA on the volume of water used in plot by agricultural holdings takes into account these water inputs.

This would be the case for public irrigation, whose irrigation water is managed by the irrigation entities/communities which are the reporting units of the EUASA and which represent approximately two thirds of the irrigated area in Spain. However, in the case of "private irrigated lands" managed by agricultural holdings not attached to irrigation entities and which obtain water resources through self-supply (usually groundwater), returns and losses are usually minor, so estimates from the survey on the volume of water used could be slightly overestimated.

Likewise, the figure on water use, estimated in the EUASA cannot be considered as an estimation of water consumption (consumptive use) in a given hydrographic territory, since for this purpose it would be necessary to count as water inputs, returns and a part of the water losses in the water transport and distribution systems.

With regard to gross water demand or collection from the environment, the EUASA does not estimate this magnitude but the "*volume of water actually available*" for irrigation in the reference year of the survey. This variable is defined as the volume of water available to the irrigation entity to supply its distribution networks, that is, once the losses in the transport networks have been deducted from the concessioned water. Water (surface and underground) not subject to administrative concession is also included in these volumes.

The estimation of these volumes is complex, because the groundwater used for private irrigated lands is not sufficiently catalogued by regulation, and also because of the use of groundwater in dry season as support irrigation in areas of public concession. On the other hand, estimations of primary data on conveyance network losses collected by the EUASA are subject to significant non-sampling errors caused by the lack of responses.

5.3 Statistical breakdown of data

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5.3.1 VOLUMES OF WATER ABSTRACTED

The information will be divided into three blocks:

- Irrigation water abstraction by irrigation communities and self-supply of agricultural holdings.
- Water abstraction for distribution by public supply networks (these are municipal networks, without prejudice to the institution or legal entity that assumes the management of the service).
- Direct abstraction from the environment by economic sectors.

The product under consideration will be raw water, that is, untreated (non-potable). The volume of water directly collected by households is considered not to be significant.

As regards the source of water abstracted, the groundwater/surface breakdown will be applied. It can also be considered a heading of "other sources" that would include desalinated water, regenerated water from wastewater treatment plants (WWTP's), etc.

Surface waters (inland, i. e. not marine, nor transitional water) are waters with a surface current or those that are retained on the surface of a land depression, that is to say, dammed. Among surface running waters there are natural waterways (rivers, streams, torrents, etc.) and artificial waterways (irrigation canal systems, industry and navigation, drainage systems, ponds, artificial dams, etc.).

Groundwater is water abstracted, as a general rule, from an aquifer by boring or drilling. This category includes inland water in the water table and in geological depressions. Water abstracted from springs is also included. Surface waters do not include those that are collected for the refrigeration of thermal or nuclear power plants and those from leaks, the latter being included under the heading of surface waters.

As regards the gross demand for irrigation water, an upward correction should be made to the magnitudes of the variable "*volume of water actually available*" estimated by the EUASA. This has been carried out on the basis of a comparison of the structure of the gross demands of all the river basin districts contained in the river basin plans with the structure of the variable of the EUASA mentioned above, with corrections being made on the basis of information on transport losses provided by the said survey. The annual reports of the hydrographic confederations have also been used to the extent of their availability.

The ESSA provides an estimate of water abstracted from the environment (gross demand) for the supply of water to public networks.

Estimation of the volumes of water abstracted will not include those used for electric power generation and cooling of thermal and nuclear power plants, since

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water consumption in these economic activities (understanding this as the difference between water input and output) is not significant.

5.3.2 VOLUMES OF WATER USED

The water use data estimated by the ESSA and published on the INE website are broken down into three sections: *households / economic sectors / municipal consumption*, with "households" defined as the population resident in main or secondary dwellings such as chalets, holiday dwellings, etc.

As previously indicated, the ESSA uses the hydrological balance approach to estimate the volumes of water supplied to the network and users. Thus, water used by users is understood to mean water recorded/measured in the users' meters, both at the community and individual level. Now, for the purposes of this work, apparent losses of water (non-physical) will also be considered as volumes of water used. These are due to inaccurate meters (sub-metering), unmeasured authorized consumption (gaugings, watering of public parks, fountains, purges, cleaning or overflow of deposits, etc.) and unauthorized consumption (fraud).

In Spain, legislation requires that the water supplied by municipal supply networks be drinkable, that is to say, it has been treated at drinking water treatment plants (DWTP).

Estimates of recorded water volumes and apparent losses are included in the ESSA questionnaire and published on the web. http://www.ine.es/dynt3/inebase/index.htm?type=pcaxis&path=/t26/p067/p01/serie&file=pcaxis&L=1

These apparent losses are, from the point of view of consumption–not of water balance–volumes of water used. For this reason, they should be added to the volume of water recorded.

However, the percentage structure of the breakdown of apparent losses in these three sections by Autonomous Community is not reliable, since, although progress is being made in the completeness of these variables, at the current stage of the collection of the ESSA information, the reporting units -when they give information on them- limit themselves to establishing orders of magnitude or approximations. This is why, given the robustness of the survey estimates for Spain as a whole, the convention has been adopted to use–for all Autonomous Communities–the breakdown of apparent losses at the national level, in order to distribute them among households, economic sectors and municipal consumption.

The percentage structure of apparent losses at the national level:

- Imprecision of meters 48%
- Unmeasured authorised consumption 39%
- Unauthorised consumption 13%

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"*Unmeasured authorized consumption*" will be considered as municipal consumption and the volumes corresponding to the two remaining variables will be assigned to *households / economic sectors*, according to the weight of each of these users in each Autonomous Community.

In order to avoid misunderstandings in the interpretation of the results, it is advisable to fix the branches of economic activity according to the sections and divisions of the CNAE-2009, which will conform the sections of the breakdown by River Basin District for the collection and use of water. This requires some preliminary considerations.

As indicated above, the ESSA information published by the INE is organised into three blocks *(households / economic sectors / municipal consumption).* This breakdown was, so to speak, imposed both by the importance given to the indicator *water consumption per inhabitant* ("households") and by the absence of external sources to the survey on water use in manufacturing industry and in the services sector, and therefore a breakdown of the heading "economic sectors" was not advisable.

On the other hand, the breakdown of volumetric data by River Basin District according to type of user must have a certain coherence with that established in the river basin plans.

As a general rule, river basin plans establish (without considering irrigation water) two blocks of uses: "*urban use*" which includes household water uses and commercial and other activities of the services sector (including municipal consumption), and "*industrial uses*" of industries connected to the network. The establishment of this breakdown into two blocks is based on the fact that the water use of households, services and municipal consumption is strongly correlated with the population, while the demand for water from industry depends on other factors. In some cases, the uses of households and of the services sector are often covered by the term "*sector doméstico*", in line with the Anglo-Saxon nomenclature used by international organisations ("domestic sector").

For the reasons mentioned above and for the purposes of the present analysis, it would seem advisable to group the uses of households, those of the services sector and municipal consumption under the same heading that we are going to call "domestic sector". This would avoid possible inconsistencies in estimating the water use of the economic activities of the services sector, which take place in dwellings that do not have a commercial water service contract.

Based on all these considerations, the information in three sections that combine the approaches *branch of economic activity / product / user* would be:

- ***Irrigation water:*** Section A *(agriculture and forestry)* (divisions 01 and 02)
- ***Agriculture, livestock and forestry***
  - Included in this section are the volumes of drinking water–distributed through public supply networks–for irrigation of orchards and greenhouses, forest exploitation and water supply to livestock holdings.
- ***Industrial sector and other economic activities*** (divisions 5 to 43):

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- Section C (*manufacturing industry*) ; divisions 10 to 33
- Section D *(Supply of electrical energy, gas, steam and air conditioning);* division 35
- Section E *(waste management and decontamination*); divisions 38 to 39
- Section F *(construction*) ; divisions 41 to 43

➢ ***Domestic sector:***

- ***Households (****population residing in main and secondary residences)*;
- ***Services:*** Sections G to U - divisions 45 to 99 (excluding 84)**;**
- ***Municipal consumption*** (can be assimilated to division 84)

Although the branch of economic activity "*exploitation of irrigation canals*" (irrigation communities) is classified in division 36 (*water collection, treatment and supply*) of the CNAE-2009, the exception should be made for irrigation water. Bearing in mind that the focus of this study is the "use of the product water", this branch will be classified in section A of the mentioned CNAE.

The heading "*municipal consumption*" includes the uses of buildings and offices of the Local Administration, water for cleaning and flushing of streets, cleaning of sewers and tanks in WWTP's, as well as watering of gardens, public sources, fire services, etc. Water used for cleaning filters in drinking water treatment plants (DWTP) is excluded, since this water is not supplied to the network and is therefore not used by users.

In the third block, both industrial uses of water for electricity generation and cooling water used in thermal and nuclear power plants are excluded.

It should be noted that for extractive industries use water, especially with regard to washing and flotation of minerals, transport of concentrates, etc., the balance of water consumption is usually positive, given the contributions of water resulting from drainage and seepage in mining facilities.

5.4 Scope and limitations of the study

In the present study, agronomic, hydrological and statistical approaches have been combined to estimate the volumes of water abstracted and used by river basin district. Throughout the report, methodological difficulties have been identified and the appropriate warnings and cautions have been outlined for a correct interpretation of the results obtained.

One of the limitations encountered in approaching this study has been the fact that river basin plans do not use the same terminology to define the variables and magnitudes that affect water resources and their uses. Likewise, not all of these plans specify the methodology used to calculate gross and net water demand.

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Another difficulty is that annual reports of basin organizations, both for inter-community and internal basins, are not standardized in the same reporting format.

6 Application of the proposed methodology to the calculation of water volumes collected and used by river basin district (2011- 2014)

Following, estimates of water volumes are presented for 2011, applying the established methodology. Estimates for the rest of the time series, years 2011,2012 and 2013, will be calculated according to the same criteria and conventions applied for the 2011 estimates.

6.1 Volumes of water abstracted

6.1.1 GROSS IRRIGATION WATER DEMAND

As already mentioned, the estimation of values for this variable presents both methodological and statistical difficulties. Estimates reflected in river basin plans based on net and gross demand for crops for different temporal "scenarios" or "horizons" are subject to significant variations due to changes in crops, climatic conditions as well as the irrigated area itself.

For losses of irrigation water in the distribution, that is, from the intake point to its arrival in the reservoirs or ponds of the irrigation entities, average estimates by River Basin District have been made–based on the EUASA sample data–with the help of the variable "*estimated losses in the main conveyance network*" (transport) included in the questionnaire.

For "total losses" (conveyance/transport and distribution), the sample differences between the volumes of water actually available and those used in the plot (by crops and irrigation techniques) have been estimated.

The convention has been established that distribution losses cannot exceed 10% of the water collected.

This applies to concessionary irrigation lands, that is operated by irrigation entities/communities. With regard to "private irrigated lands" which is to say, those whose agricultural holdings are self-supplied with water (usually underground), their total losses are considered not to be significant as compared to those that occur in concessional irrigated lands.

The information contained in the National Irrigation Plan,"Horizon 2008" and "Horizon 2015" has been used as external sources for comparison. The latter, published in July 2010, is based on the data contained in the section "*Outlines of Important Topics*" of the hydrological plans. These data come from different years according to each River Basin District, so they are not directly summable.

The approximate estimates for the percentage of average total losses are presented below.

- Galicia - Costa, Miño - Sil , Cantábrico Occidental, Cantábrico Oriental : 20%
- Guadiana, Guadalquivir : 30%
- Ebro, Basins II of Cataluña, Tajo, Júcar, Segura, Basins MM. Andaluzas, Guadalete – Barbate, Tinto - Odiel - Piedras, Baleares, Canarias: 35%

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- Duero : 45%

As regards the volume collected in the River Basin District of the Tajo, it will be added the magnitude of 350 hm^3, which is the average volume transferred to the River Basin Districts of the Júcar and of the Segura during the period considered in this study.

For the calculation of private water collection volumes, these percentages will be applied to the volumes of water used (applied on a plot) estimated by the EUASA. These estimates should be taken with caution and with the warnings already explained in the pilot methodology, due to the complexity of the agronomic parameters that make up its state and temporal evolution.

As far as the source of water is concerned, the ratio *surface water / groundwater / other sources* shown in the EUASA results for available water will be applied, calibrating the results obtained to the volumes of water abstracted.

In the case of irrigation water, most of the water from "*other sources*" is regenerated water from WWTP's. Water abstracted from the sea, lagoons and marine estuaries is not considered, although brackish groundwater is.

6.1.2 WATER ABSTRACTION FOR THE SUPPLY OF PUBLIC NETWORKS

The ESSA provides estimates of the variable "*available drinking water*" for the supply of public networks. This variable is defined as the volume of water collected from the environment with the own means of the company, entity or public body, plus that purchased (purified and not purified) from other entities / bodies, less that sold to them. Therefore, this variable can be assimilated to the water collected from the environment for its use, regardless of whether it is actually used in its entirety for the said supply.

For the estimation of water volumes broken down by its source, the structure (surface / underground / desalinated) of the volumes collected by own means estimated in the ESSA has been applied to the total available drinking water.

The information collected by the ESSA by Autonomous Communities has been converted to River Basin Districts on the basis of population conversion coefficients between these two spatial scopes, since the demand for "*urban water*" is strongly correlated with the population.

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6.1.3 DIRECT ABSTRACTION OF WATER BY ECONOMIC SECTORS

With regard to extractive industries, their abstraction will not be considered since most of the volumes of water coming from mine dewatering, leaks from tunnels and quarries, etc., return to the environment without being used and help to compensate–according to the water balance–its use by this economic sector.

With respect to the services sector, the direct abstraction of water from nature, mostly from groundwater sources such as wells or boreholes, occurs in leisure and entertainment activities such as irrigation of golf courses, water parks, etc. The volumes abstracted can be considered as not significant, tending to decrease due to the increasing use of regenerated water.

On the other hand, manufacturing industry abstracts significant quantities of surface water and groundwater for its own uses. There may be other water sources (regenerated water, rainwater, settling basins, water contained in the raw material itself, supply by tankers or trucks), but their volume is not significant. Water collection for cooling of thermal and nuclear power plants, as well as for hydroelectric power generation is excluded. Seawater for desalination is also excluded.

The study on use of water in manufacturing industry (2007-2010) http://www.ine.es/en/daco/daco42/ambiente/aguaindu/uso_agua_indu0710_en.pdf

estimated for the year 2010 the total volume of water directly collected at 514.5 hm^3 (334.1 surface and 180.4 underground). The breakdown by River Basin District has been carried out on the basis of the provincial distribution of employed persons in the Industrial Companies Survey according to the approximate spatial distribution reflected in section 6.2.2.2.2.1.

For the year 2011, the estimated total volume reached 498 hm^3 (317 surface and 181 underground). This estimation has been carried out by establishing the correlation between the total collection and use of water in each branch of economic activity.

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Total volume of water abstracted by the manufacturing industry. Year 2010

Unit: hm^3

	Volume	Percentage of total
Galicia- Costa	18.3	3.6
Miño- Sil	4.6	0.9
B. Occidental	112.1	21.8
B. Oriental	36.6	7.1
Duero	33.3	6.5
Ebro	95.6	18.6
Basins II of Cataluña:	77.2	15.0
Tajo	27.9	5.4
Guadiana	26.5	5.2
Júcar	36.6	7.1
Guadalquivir	25.3	4.9
Segura	4.8	0.9
MM.BB. Andaluzas	7.2	1.4
Guadalete-Barbate	2.1	0.4
Tinto-Odiel-Piedras	1.6	0.3
Baleares	0.6	0.1
Canarias	4.2	0.8
Ceuta and Melilla	0.0	0.0
National Total	**514.5**	**100**

For the year 2011, the percentage structure of volumes established in the previous table will be applied.

As regards the source of water (surface / groundwater) it has been applied the same breakdown criterion previously explained for surface water, obtaining the volumes of groundwater by difference from the total. Water from a WWTP (*regenerated water*) is not considered to be a possible source of water, since the volumes of such type of water used in manufacturing industry are not significant.

The volumes and percentage structure for the year 2010 are:

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Volume of surface water abstracted by the manufacturing industry. Year 2010

Unit: hm^3

	Volume	Percentage of total
Galicia- Costa	15.8	4.7
Miño- Sil	3.9	1.2
B. Occidental	95.8	28.8
B. Oriental	32.1	9.6
Duero	16.2	4.8
Ebro	59.5	17.8
Basins II of Cataluña:	28.7	8.6
Tajo	23.8	7.1
Guadiana	22.1	6.6
Júcar	10.1	3.0
Guadalquivir	16.7	5.0
Segura	2.0	0.6
MM.BB. Andaluzas	4.8	1.4
Guadalete-Barbate	1.4	0.4
Tinto-Odiel-Piedras	1.0	0.3
Baleares	0.2	0.1
Canarias	0.0	0.0
Ceuta and Melilla	0.0	0.0
National Total	**334.1**	**100**

Volume of groundwater abstracted by the manufacturing industry. Year 2010

Unit: hm^3

	Volume	Percentage of total
Galicia- Costa	2.5	1.4
Miño- Sil	0.7	0.4
B. Occidental	16.3	9.0
B. Oriental	4.5	2.5
Duero	17.1	9.5
Ebro	36.1	20.0
Basins II of Cataluña:	48.5	26.9
Tajo	4.1	2.3
Guadiana	4.4	2.4
Júcar	26.5	14.7
Guadalquivir	8.6	4.8
Segura	2.8	1.6
MM.BB. Andaluzas	2.4	1.3
Guadalete-Barbate	0.7	0.4
Tinto-Odiel-Piedras	0.6	0.3
Baleares	0.4	0.2
Canarias	4.2	2.3
Ceuta and Melilla	0.0	0.0
National Total	**180.4**	**100**

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For the 2011 estimates, the percentage volumetric structure by River Basin District for 2010 will be applied.

6.2 Volumes of water used

6.2.1 IRRIGATION WATER

The entities that most frequently collect water from the environment for irrigation purposes are the irrigation communities/entities, although there may also be private water collection by agricultural holdings that do not belong to the irrigation communities. The main source of water for this "self-supply" is underground.

Water accounts estimates provide an approximate breakdown of volumes collected, *irrigation communities/self-supply* of 80/20. Regarding the source of water and as far as irrigation communities are concerned, between 10% and 15% of the total water collected comes from groundwater, while for agricultural holdings self-sufficiency, this source ranges from 40% to 50%.

The EUASA provides an estimate of the volume of irrigation water used on a plot ("water distributed to agricultural holdings"), a variable that can be assimilated to "*water used on a plot*", with the statistical warnings and cautions explained in the pilot methodology.

A small proportion of the water collected by irrigation communities (approximately 0.5%) can be used for non-agricultural purposes, such as livestock activities, industrial uses or urban supply. Estimates of the EUASA for the year were 96 hm^3 for this type of uses.

6.2 2 WATER FROM PUBLIC NETWORKS

6.2.2.1 Households

Bearing in mind that the volumes of water used by these users are strongly correlated with the resident population, their breakdown has been calculated by applying the population conversion coefficients Autonomous Community - River Basin District.

6.2.2.2 Economic sectors

The nomenclature used for the sections of branches of economic activity is that established by the current Classification of Economic Activities (CNAE-2009).

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Section A (agriculture, livestock and forestry)

As already indicated, this heading will include drinking water distributed by public water supply networks (understanding these to be municipal water, not the irrigation channels and pipes managed by the irrigation entities/communities) that provide for the needs of livestock and some agricultural crops (greenhouses, nurseries, family gardens). Water accounts estimates for 2010 of the volumes of water coming from the network for agricultural, livestock and forestry uses reach 48.1 hm3.

For the year 2011, this magnitude is estimated at 37.3 hm3. It is difficult to break down this magnitude by River Basin District because livestock consumption depends on the characteristics of the livestock population (bovine, sheep, pig). On the other hand, the source of water for irrigation of orchards and greenhouses comes in many cases from groundwater and not from the network, so it is problematic to rely on the "irrigated area" as a breakdown variable.

After the relevant studies, it has been decided to allocate two thirds of the volumes consumed to the livestock sector and the remaining third to greenhouse crops. Livestock consumptions will be broken down according to the number of heads of cattle, which is the largest water consumer (2011 data of heads of livestock by Autonomous Community published in the 2011 Statistical Yearbook of MAGRAMA) at a rate of 250 litres of water per head. For greenhouse crops, their surface area will be used in accordance with the ESYRCE 2011.

Volume of network water used by the agriculture. Year 2011

Unit: hm^3

	Volume	Percentage of total
Galicia- Costa	2.7	7.2
Miño- Sil	1.3	3.5
B. Occidental	2.4	6.4
B. Oriental	0.5	1.3
Duero	5.4	14.5
Ebro	1.9	5.1
Basins II of Cataluña:	2.3	6.2
Tajo	2.1	5.6
Guadiana	1.5	4.0
Júcar	0.8	2.1
Guadalquivir	6.6	17.7
Segura	1.1	2.9
MM.BB. Andaluzas	5.0	13.4
Guadalete-Barbate	1.3	3.5
Tinto-Odiel-Piedras	0.5	1.5
Baleares	0.3	0.8
Canarias	1.6	4.3
Ceuta and Melilla	0.0	0.0
National Total	**37.3**	**100**

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There are no estimates of drinking water consumption for the commercial maritime and fisheries sector (cleaning of tanks and containers, keel conditioning tasks, etc.).

Section C: (manufacturing industry)

As previously mentioned, the results of the ESSA published by the INE are grouped under the heading "*economic sectors*". Information on water use in the manufacturing sector is only available for the period 2007-2010, which comes from a module that was introduced in the questionnaire of the *Survey on the Environment in Industry* carried out by the INE. For this reason, it has been deemed appropriate to break down the use of water in manufacturing industry by River Basin District and to do the same for water use for sections D and F, in order to later calculate by difference the water used in the services sector (excluding municipal consumption).

In the case of water use in manufacturing industry, it is not possible to make a correspondence between Autonomous Communities (AACC) and River Basin Districts (RBD) based on the number of employees in the sector. This is because these volumes are not correlated with the number of employed persons in these territorial areas, but with the implementation of the branches of economic activity, with no information being available on the number of employed persons in each branch per province.

For this reason, it has been necessary to establish an approximate correspondence between AACC and RBD. When there are Autonomous Communities or provinces that overlap with several River Basin Districts, within each Autonomous Community the weight of the population employed in the industry has been taken into account in each portion of the crossing AACC - RBD. To this end, there have been useful the estimates of the Economically Active Population Survey (APS) (annual average 2011) at the provincial level with respect to the number of employed persons in the industrial sector and the information provided by the statistical operation "Urban Indicators" derived from the *Urban Audit* project.

The proposed breakdown is as follows:

- ANDALUCÍA: 63% *Guadalquivir*; 16% *MMBB Andaluzas*; 15% (Huelva) *Guadalete/Barbate*; 6% (Cádiz) *Tinto / Odiel / Piedras*.
- ASTURIAS: 100% *Cantábrico Occidental*
- ARAGÓN: 90% *Ebro*; 10% *Júcar*
- ILLES BALEARS: 100% *Baleares*
- CANARIAS: 100% *Canarias*
- CANTABRIA: 100% *Cantábrico Occidental*
- CASTILLA Y LEÓN: 100% *Duero*
- CASTILLA – LA MANCHA: 50% *Tajo*; 28% *Guadiana*; 20% *Júcar*; 2% *Segura*
- CATALUÑA: 94% BB II of Cataluña; 6% *Ebro*.

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- COMUNITAT VALENCIANA: 95% Júcar; 5% *Segura*
- EXTREMADURA: 59% (Badajoz*) Guadiana*; 41% (Cáceres) *Tajo*
- GALICIA: 79% (La Coruña and Pontevedra) *Galicia Costa*; 21% (Lugo and Orense) *Miño Sil*
- MADRID: 100% *Tajo*
- MURCIA: 100% Segura
- NAVARRA: 100% Ebro
- PAÍS VASCO: 78% (Vizcaya and Guipúzcoa) *Cantábrico Oriental*; 22% (Álava*) Ebro*
- LA RIOJA: 100% *Ebro*

Notes on some provinces with portions between different RBD

- *80% of Tarragona and 5% of Lérida are assigned to the BB II of Cataluña.*
- *75% of Albacete and 80% of Cuenca are assigned to the Júcar. The rest to the Guadiana, except 5% of Albacete that is assigned to the Segura.*
- *90% of Alicante is assigned to the Júcar and the rest to the Segura.*
- *20% of Granada is assigned to the MMCC Andaluzas.*
- *80% of Almería is assigned to the MMCC Andaluzas.*

Once the correspondence of the number of employed persons is established it is applied to the water data by AACC. As a result, the following table and its percentage structure are obtained.

Volume of network water used by the manufacturing industry. Year 2010

Unit: hm^3

	Volume	Percentage of total
Galicia- Costa	15,508	4.6
Miño- Sil	4,122	1.2
B. Occidental	35,361	10.6
B. Oriental	18,659	5.6
Duero	13,044	3.9
Ebro	36,515	11.0
Basins II of Cataluña:	78,503	23.6
Tajo	24,042	7.2
Guadiana	6,090	1.8
Júcar	26,827	8.0
Guadalquivir	35,047	10.5
Segura	15,084	4.5
MM.BB. Andaluzas	8,901	2.7
Guadalete-Barbate	8,344	2.5
Tinto-Odiel-Piedras	3,338	1.0
Baleares	1,448	0.4
Canarias	3,017	0.9
Ceuta and Melilla	0	0.0
National Total	**333,850**	**100**

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For the year 2011, the volume of water used will be calculated for the national total, applying the amounts of water demand per employed person and economic activity (*Study on use of water in manufacturing industry 2007-2010*). The calculated figure amounts to 321.7 Hm^3. To this magnitude, the breakdown structure by River Basin District presented in the previous table will be applied.

Section D: (electricity, gas, steam and air conditioning supply)

In the 2010 Water Accounts–last calculated year–the volume used by this branch has been estimated at 31.2 hm^3. To this magnitude, the percentage structure explained in the previous section will be applied by default. As already mentioned above, the volumes of water used for hydroelectric power generation and for cooling the circuits of thermal and nuclear power plants are not included. Based on the variations in the total number of employed persons in this economic sector in the period 2011-2010 (0.6%), the volume for 2011 has been estimated at 31.4 hm^3.

Section F (construction)

In order to calculate the structure of use by River Basin District, the same methodology as that used for the manufacturing industry has been applied, but using as breakdown auxiliary variable the annual average number of employed persons per province from the 2011 EAPS. Given that the use of water in this economic sector is closely correlated with the number of people employed in it, the percentage structure of the values of this variable will be applied to the 2011 data (12.5 hm3) estimated by the ESSA.

Number of employed persons in the construction sector
Year 2010

Unit: hm^3

	Employed persons	Percentage of total
Galicia- Costa	64.8	4.6
Miño- Sil	26.5	1.9
B. Occidental	55.7	4.0
B. Oriental	51.7	3.7
Duero	81.8	5.8
Ebro	111.9	8.0
Basins II of Cataluña:	221.7	15.8
Tajo	231.4	16.4
Guadiana	43.6	3.1
Júcar	156.0	11.1
Guadalquivir	132.1	9.4
Segura	50.5	3.6
MM.BB. Andaluzas	33.5	2.4
Guadalete-Barbate	31.4	2.2
Tinto-Odiel-Piedras	12.7	0.9
Baleares	44.3	3.2
Canarias	51.4	3.7
Ceuta and Melilla	2.9	0.2
National Total	**1403.9**	**100**

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6.2.2.3 Municipal consumption

These consumption mainly refer to watering of gardens, street cleaning, sewer cleaning, supply to municipal buildings, fire-fighting water, etc., and are strongly correlated with the population.

6.2.3 WATER FROM DIRECT ABSTRACTION OF WATER

Given that the intake points for direct water abstraction from the environment used by manufacturing industrial establishments are close to the points of use, for the purposes of this study, it is agreed that water losses are not significant. Therefore, it is assumed that the demand for water is equal to the use.

6.3 Water volume summary tables by user type

- **Breakdown "industry" / services**

For 2011, the summary of volumetric estimates by River Basin District is as follows:

Volume of network water used by the industry and other economic activities.
Year 2011
Unit: thousands of m^3

	Manufacturing Industry	Energy	Construction	Agriculture	Total industry and o. ec. ac.
Galicia- Costa	14,938	1,513	578	2,687	19,716
Miño- Sil	3,967	402	236	1,306	5,911
B. Occidental	22,283	2,258	496	2,389	27,426
B. Oriental	17,975	1,821	460	485	20,741
Duero	12,583	1,275	729	5,412	19,999
Ebro	35,176	3,564	996	1,904	41,640
Basins II of Cataluña:	75,651	7,665	1,974	2,314	87,604
Tajo	23,182	2,349	2,060	2,090	29,681
Guadiana	5,857	593	389	1,493	8,332
Júcar	25,847	2,619	1,389	784	30,639
Guadalquivir	33,781	3,423	1,176	6,607	44,987
Segura	14,535	1,473	450	1,082	17,540
MM.BB. Andaluzas	8,585	870	299	5,002	14,756
Guadalete-Barbate	8,027	813	280	1,306	10,426
Tinto-Odiel-Piedras	3,223	327	113	560	4,223
Baleares	1,395	141	395	299	2,230
Canarias	2,913	295	458	1,605	5,271
Ceuta and Melilla	82	0	26	0	108
National Total	**310,000**	**31,401**	**12,504**	**37,325**	**391,230**

** In the case of the AACC of the Principado de Asturias, it has been observed that the use data of the manufacturing industry corresponding to 2010, estimated in the study on use of water in manufacturing industry (2007-2010), might be overestimated. For this reason, its average use has been estimated for the period 2007-2010, resulting in a decrease of the national total from 321.7 to 309.9 cubic hectometres.*

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The following table shows the breakdown of the volumes used by economic sectors (excluding municipal consumption) estimated by the ESSA. The volume of water used by the services sector (sections G to U) is calculated by difference with "industry and o. ec. ac.".

Volume of network water used by economic sectors, industry and services.
Year 2011
Unit: thousands of m^3

	Economic sectors	Industry and o. ac. ec.	Services
Galicia- Costa	25,513	19,716	5,797
Miño- Sil	11,488	5,911	5,577
B. Occidental	33,573	27,426	6,147
B. Oriental	50,787	20,741	30,046
Duero	45,056	19,999	25,057
Ebro	76,462	41,640	34,822
Basins II of Cataluña:	122,838	87,604	35,234
Tajo	114,176	29,681	84,495
Guadiana	19,156	8,332	10,824
Júcar	60,131	30,639	29,492
Guadalquivir	50,713	44,987	5,726
Segura	25,481	17,540	7,941
MM.BB. Andaluzas	31,060	14,756	16,304
Guadalete-Barbate	12,072	10,426	1,646
Tinto-Odiel-Piedras	4,533	4,223	310
Baleares	22,817	2,230	20,587
Canarias	33,044	5,271	27,773
Ceuta and Melilla	2,775	108	2,667
National Total	**741,675**	**391,230**	**350,445**

- **Domestic sector (households/services/municipal consumption)**

By adding up households, services and municipal consumption, we will calculate the volume of water used by the domestic sector, as defined in section 5.3.2 of the pilot methodology.

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Volume of network water used by the domestic sector. Year 2011

Unit: thousands of m^3

	Households	Services	Municipal consumption	Total domestic sector
Galicia- Costa	104,202	5,797	17,473	127,472
Miño- Sil	44,122	5,577	7,657	57,356
B. Occidental	102,769	6,147	17,467	126,383
B. Oriental	85,793	30,046	31,269	147,108
Duero	142,923	25,057	27,747	195,727
Ebro	161,243	34,822	40,130	236,195
Basins II of Cataluña:	338,358	35,234	52,088	425,680
Tajo	440,725	84,495	70,148	595,368
Guadiana	101,736	10,824	18,667	131,227
Júcar	294,833	29,492	36,236	360,561
Guadalquivir	226,062	5,726	42,718	274,506
Segura	113,412	7,941	13,233	134,586
MM.BB. Andaluzas	138,270	16,304	26,259	180,833
Guadalete-Barbate	53,742	1,646	10,206	65,594
Tinto-Odiel-Piedras	20,181	310	3,833	24,324
Baleares	52,880	20,587	6,825	80,292
Canarias	121,199	27,773	17,799	166,771
Ceuta and Melilla	10,599	2,667	2,443	15,709
National Total	**2,553,049**	**350,445**	**442,198**	**3,345,692**

- **Breakdown domestic sector / industry and other ec. activities.**

The total volume of water used by users in each River Basin District is:

Volume of network water used by all sectors. Year 2011

Unit: thousands of m^3

	Domestic sector	Industry and o. ac. ec.	Total sectors
Galicia- Costa	127,472	19,716	147,188
Miño- Sil	57,356	5,911	63,267
B. Occidental	126,383	27,426	153,809
B. Oriental	147,108	20,741	167,849
Duero	195,727	19,999	215,726
Ebro	236,195	41,640	277,835
Basins II of Cataluña:	425,680	87,604	513,284
Tajo	595,368	29,681	625,049
Guadiana	131,227	8,332	139,559
Júcar	360,561	30,639	391,200
Guadalquivir	274,506	44,987	319,493
Segura	134,586	17,540	152,126
MM.BB. Andaluzas	180,833	14,756	195,589
Guadalete-Barbate	65,594	10,426	76,020
Tinto-Odiel-Piedras	24,324	4,223	28,547
Baleares	80,292	2,230	82,522
Canarias	166,771	5,271	172,042
Ceuta and Melilla	15,709	108	15,817
National Total	**3,345,692**	**391,230**	**3,736,922**

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7 Correlations between volumes of water used and conversion variables

Once the calculation of the volumes used has been completed, the question arises as to what type of random relationship exists between them and the conversion variables that have underpinned the spatial change from Autonomous Community to River Basin District (*irrigated area and resident population*, respectively).

For the first year of the calculated time series (2011) and in order to visualize the random dependence between these two variables, the calculation of the linear regression lines that adjust the scatter plot ("point cloud") of the values taken by the studied two-dimensional variables have been carried out.

We will proceed to adjust by linear regression the two-dimensional variable (Y, X), (*volume of water / conversion variable*) with "*y*" representing the value of the first characteristic Y, and "*x*" being the value of the second X, for each River Basin District. The regression lines of *y* on *x* will be calculated. It is to be expected that at increasing values of the variable "*resident population*" (variable X) also correspond proportionally increasing values of the variable *"volume of network water used"* (variable Y). This is due to the fact that the volume used by households is strongly linked to the number of inhabitants, and that it represents almost two thirds of the total water used.

With regard to the two-dimensional variable (Y, X), (*"volume of irrigation water used", "irrigated area"*), the goodness of fit of the proposed linear adjustment could be lower, since the parameters that conform the use of irrigation water depend on the water requirements of the crops, with great variability in their nature according to River Basin District.

To measure the intensity of the random dependence defined by the regression lines previously calculated, we will proceed to calculate the linear correlation coefficients between the values of the characteristics X and Y. This coefficient will measure the intensity of the correlation between the two variables. Values of this coefficient close to one would indicate the existence of a strong dependence between these two variables. On the contrary, values away from unity would indicate a strong degree of independence between them.

Volume of irrigation water used and irrigated area

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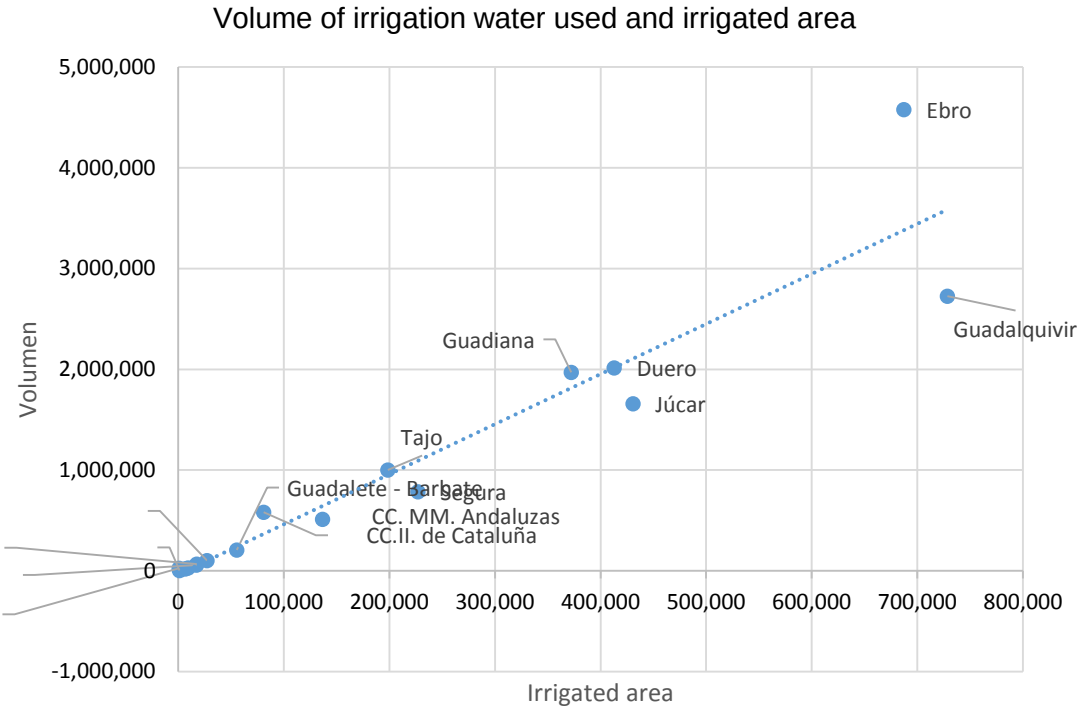
The calculated regression line is expressed as: **y = 4.973 x – 36,473**

Units:
X: thousands of hectares
Y: thousands of cubic meters



It is observed that the regression line does not accurately match the values of the two-dimensional variable corresponding to the River Basin Districts of the Ebro and of the Guadalquivir. The reason for this fact may be the great variety of crops–and therefore of water volumes demanded to cover their requirements–that exist in these two River Basin Districts.

The correlation coefficient is **0.949,** indicating a medium degree of dependence between the values of the two-dimensional variable studied.

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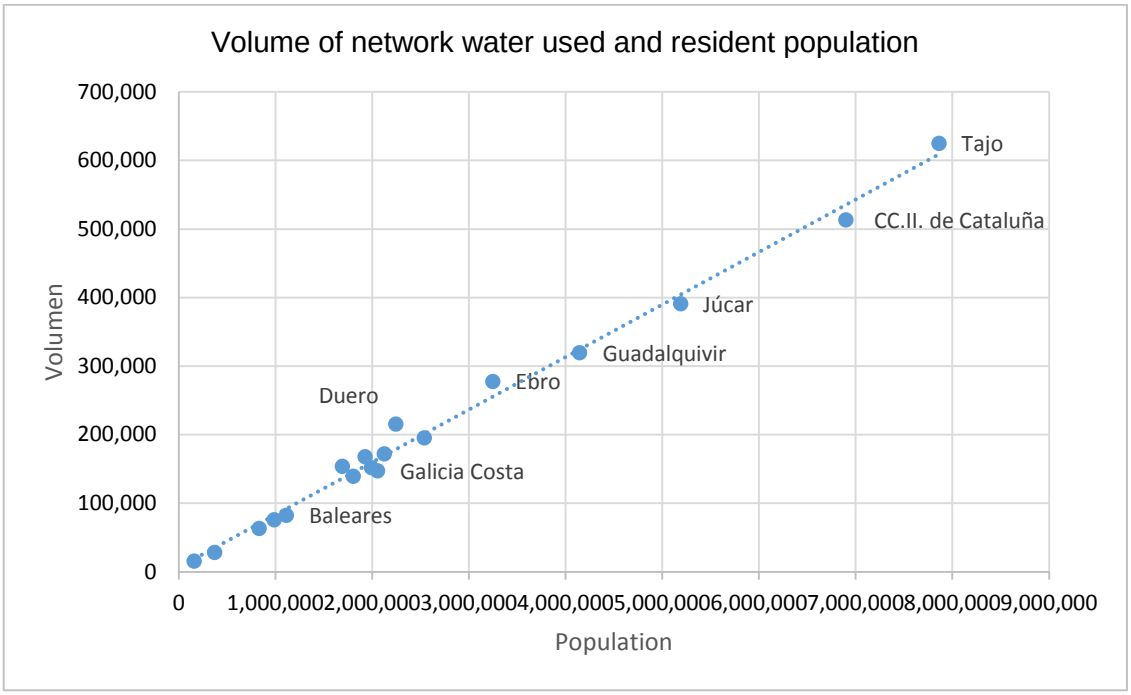
Volume of network water used and resident population

The calculated regression line is expressed as: **y = 0,077 x + 6.767**

Units:
X: millions of inhabitants
Y: thousands of cubic meters



It is observed that the trend line fits the *point cloud* with great accuracy. The calculated correlation coefficient is **0.996** indicating a very high degree of dependence between the values of the two-dimensional variable studied.

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Annexes

Mapping of river basin districts

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Annex 1

Physical maps: river basin districts and main hydrographic network

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DEMARCACIONES HIDROGRÁFICAS

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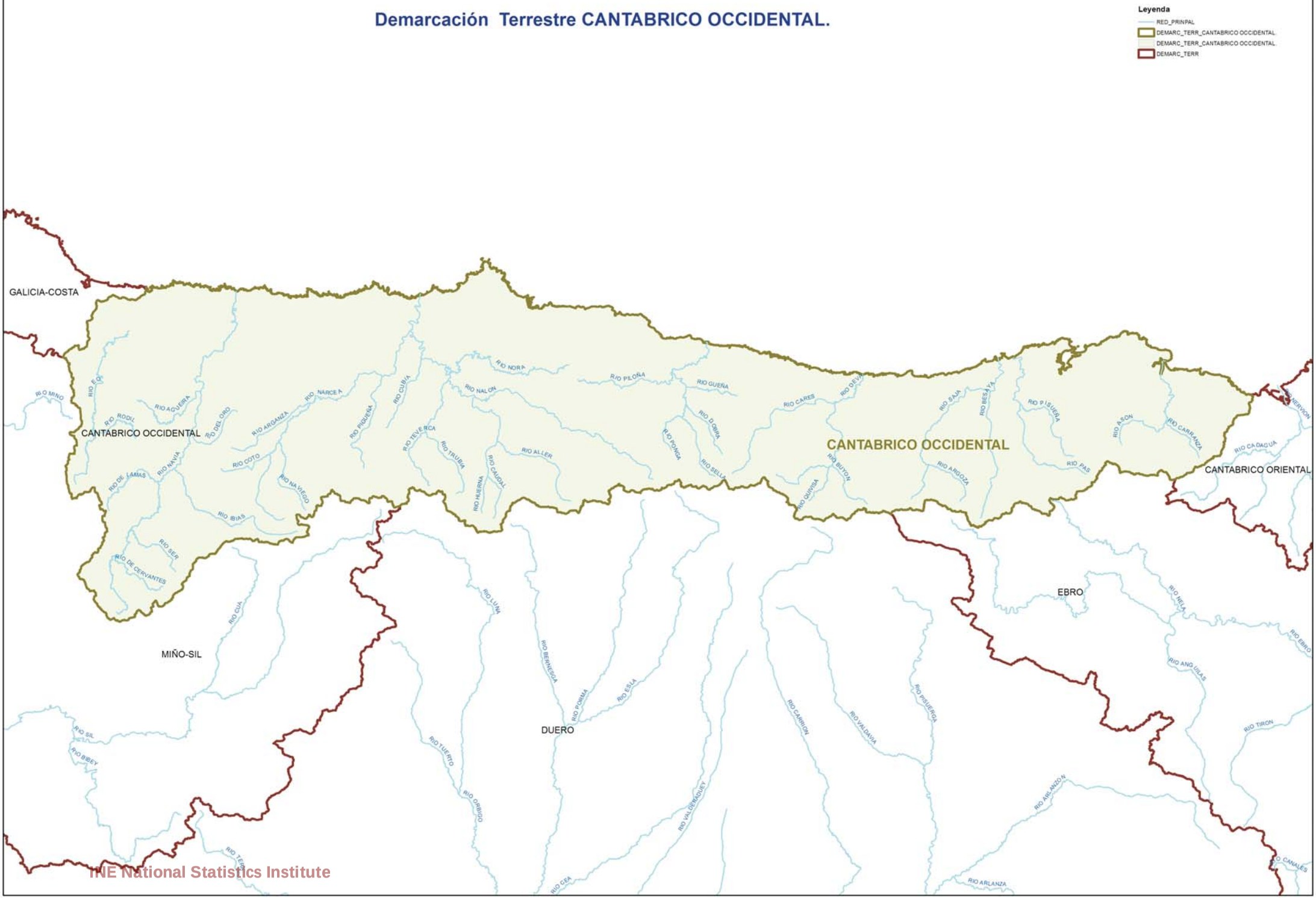
Demarcación Terrestre CANTABRICO OCCIDENTAL.



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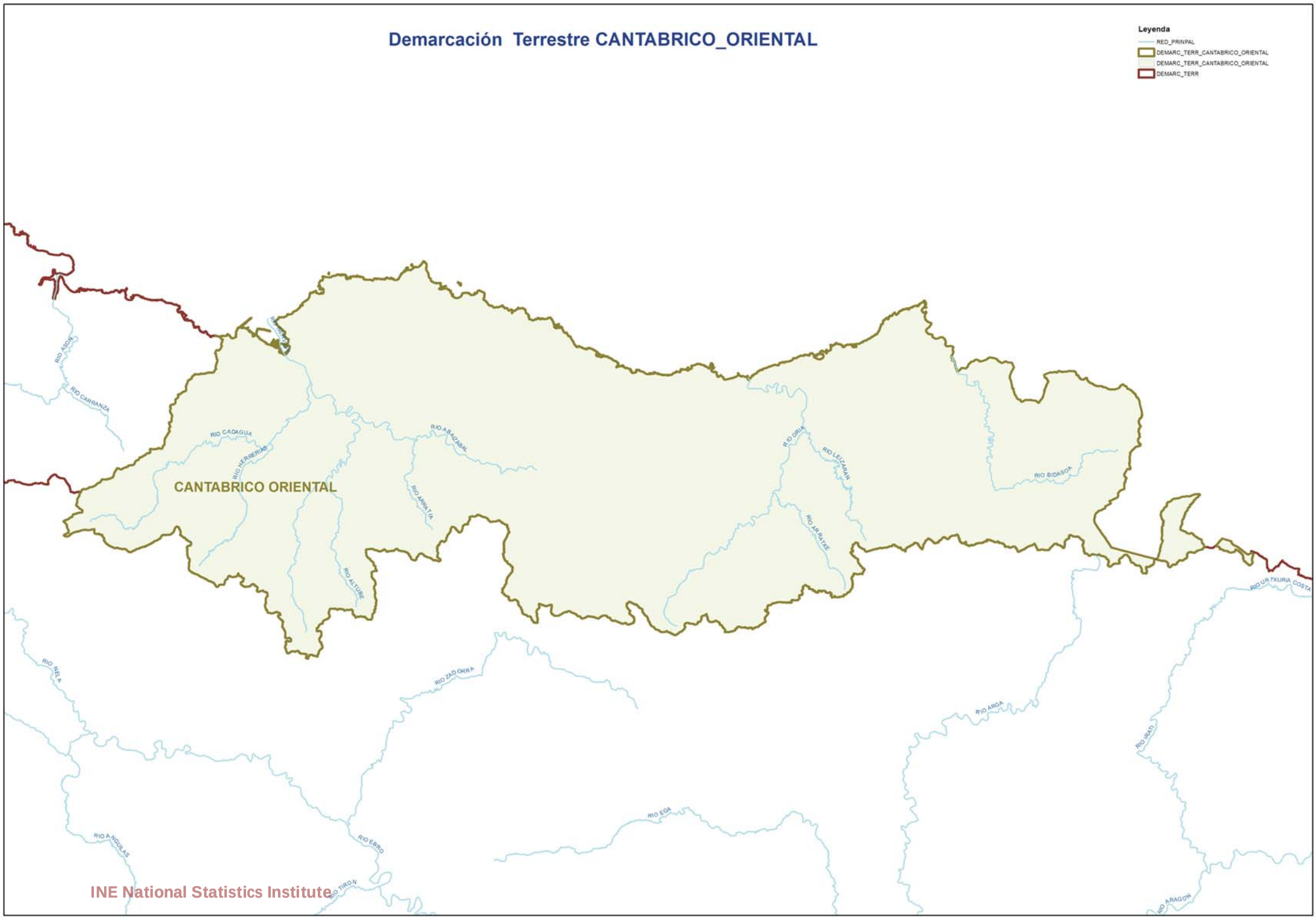
Demarcación Terrestre CANTABRICO_ORIENTAL



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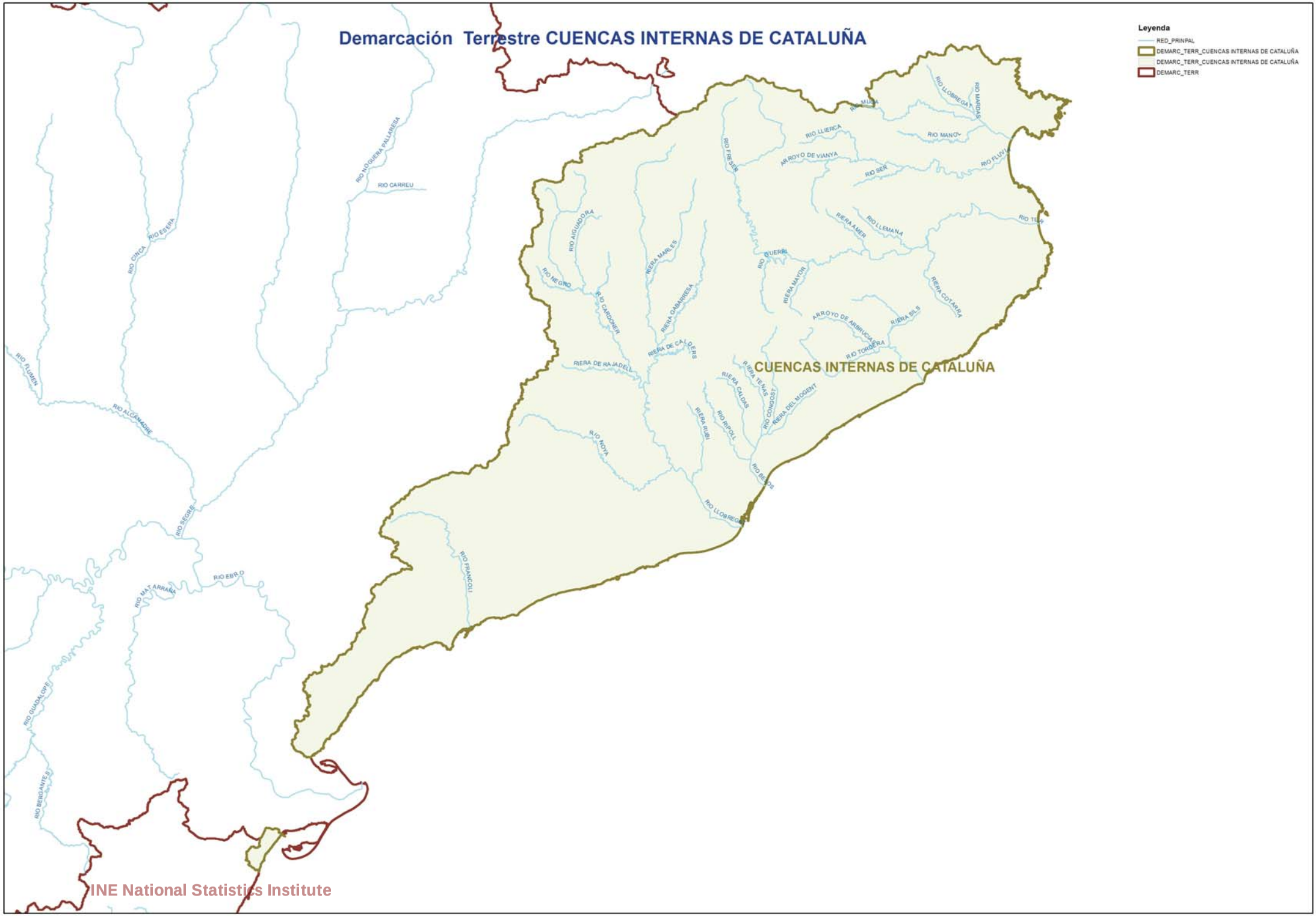
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Leyenda
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DEMARC_TERR
CUENCAS INTERNAS DE CATALUÑA
RIO NOGUERA PALLARESA
RIO CARREU
RIO CINCA
RIO ESERA
RIO FLUMEN
RIO ALCANADRE
RIO SEGRE
RIO EBRO
RIO MATARRAÑA
RIO GUADALOPE
RIO BERGANTES
RIO FRANCOLI
RIO NOYA
RIO LLOBREGAT
RIO BESOS
RIERA DE RAJADELL
RIERA DE CALDERS
RIO CARDONER
RIO NEGRO
RIO AIGUADORA
RIERA MARLES
RIERA GABARRESA
RIO RIPOLL
RIERA RUBI
RIERA CALDAS
RIERA TENAS
RIO CONGOST
RIERA DEL MOGENT
RIO TORDERA
RIERA SILS
ARROYO DE ARBRUCIAS
RIERA COTARA
RIO GUERRI
RIERA MAYOR
RIERA AMER
RIO LLEMANA
RIO TER
RIO SER
RIO FLUVIA
ARROYO DE VIANYA
RIO LLIERCA
RIO MANOL
RIO SORRAIA
RIO LLOBREGAT
RIO FRESER
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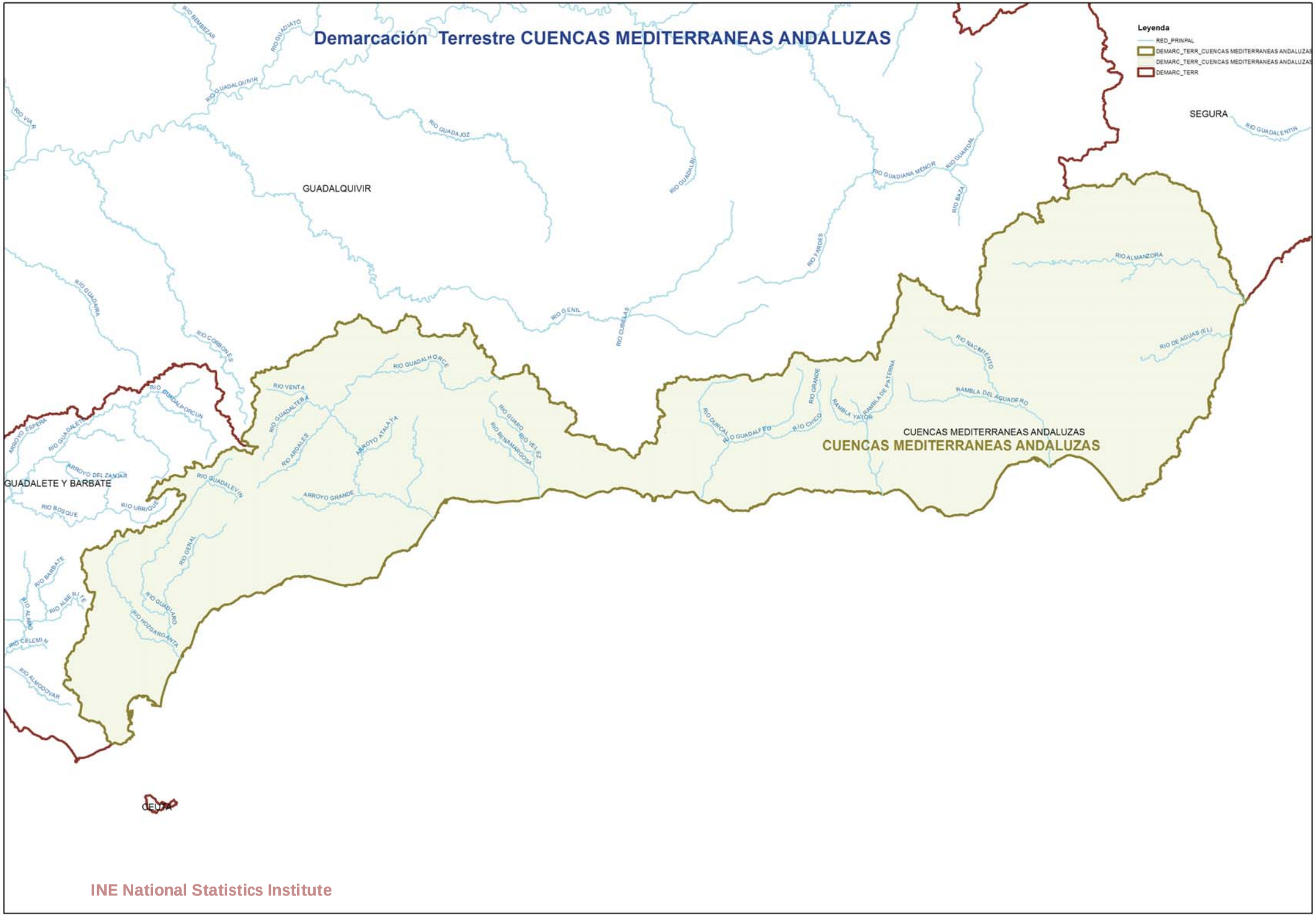

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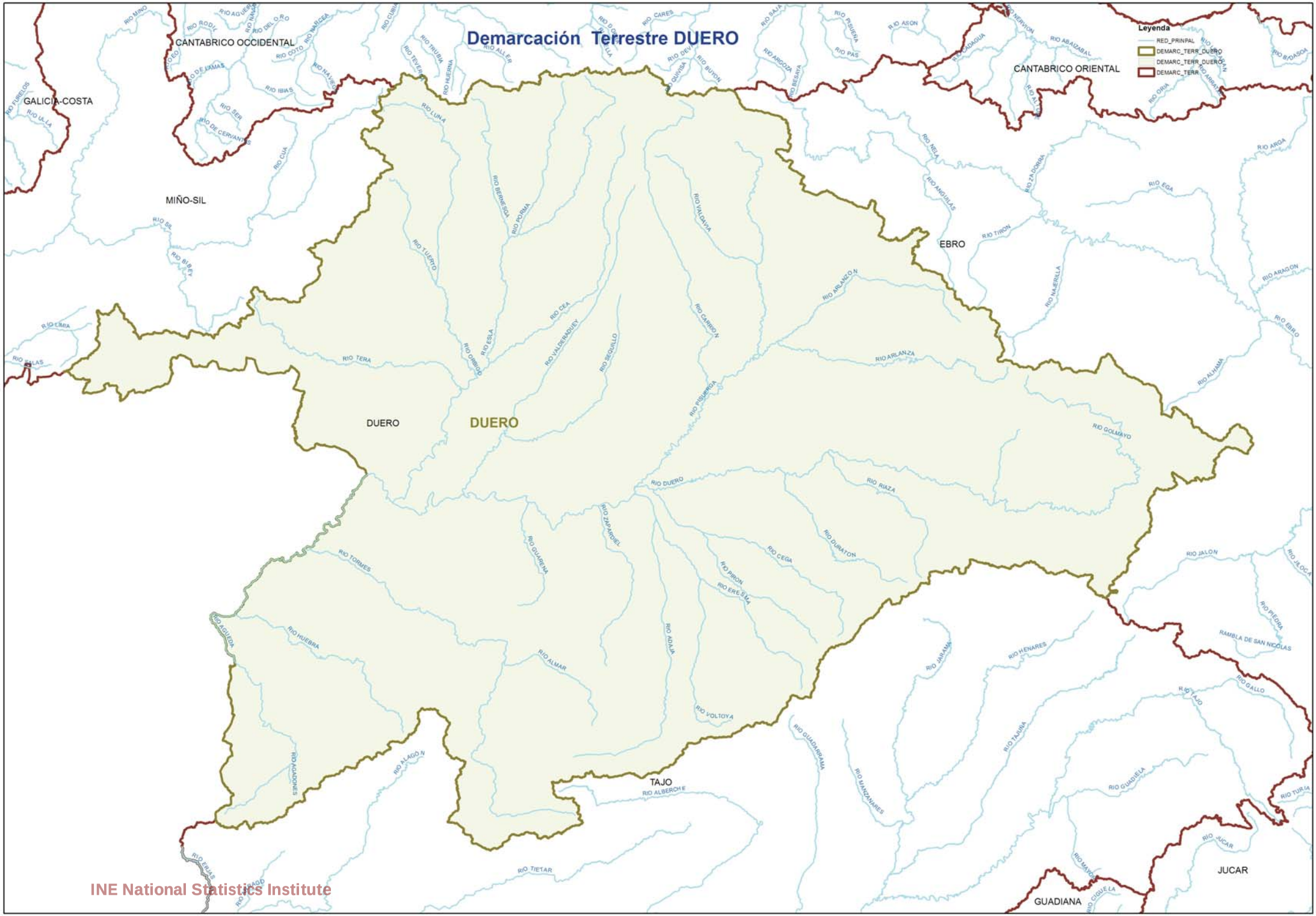

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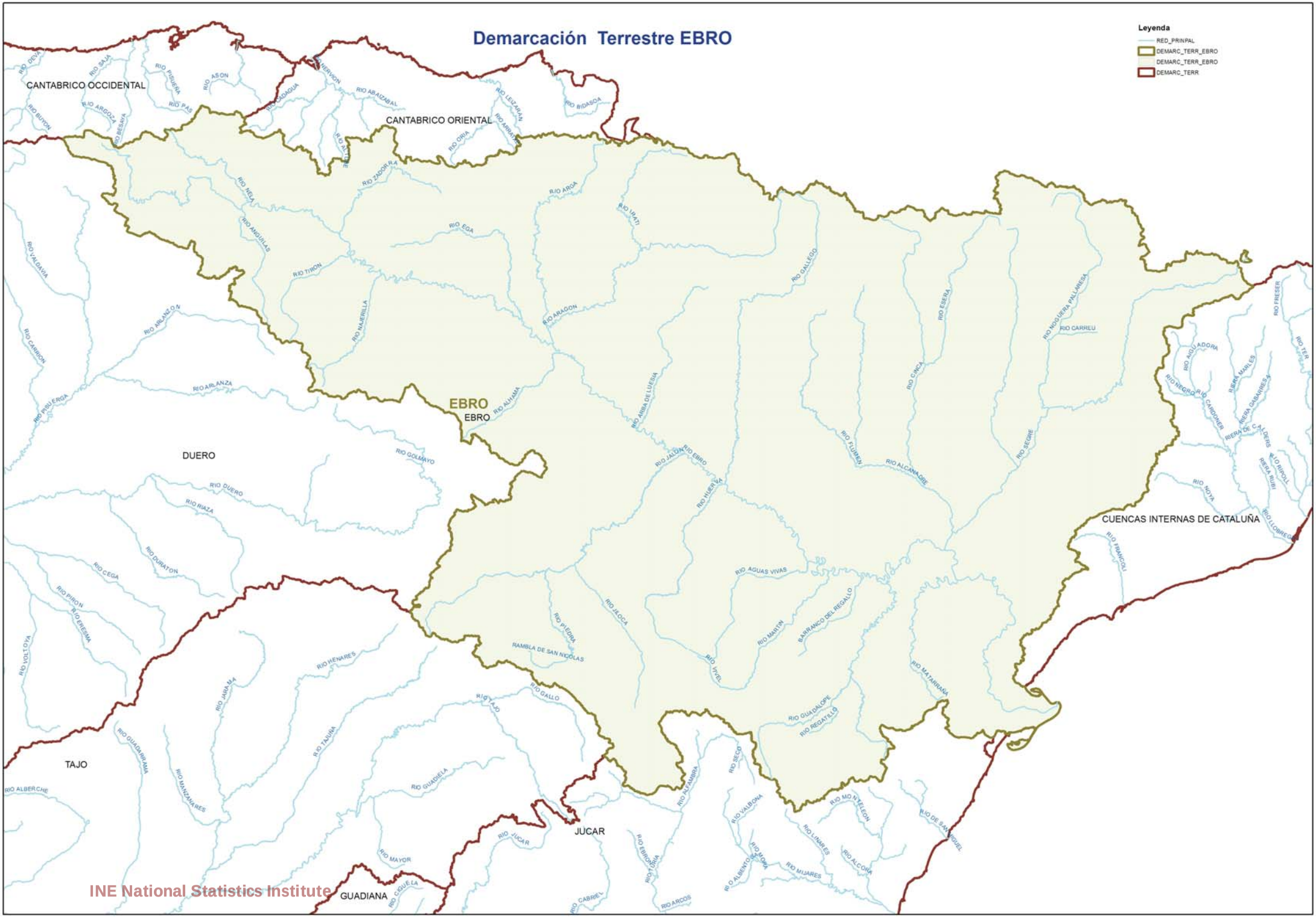

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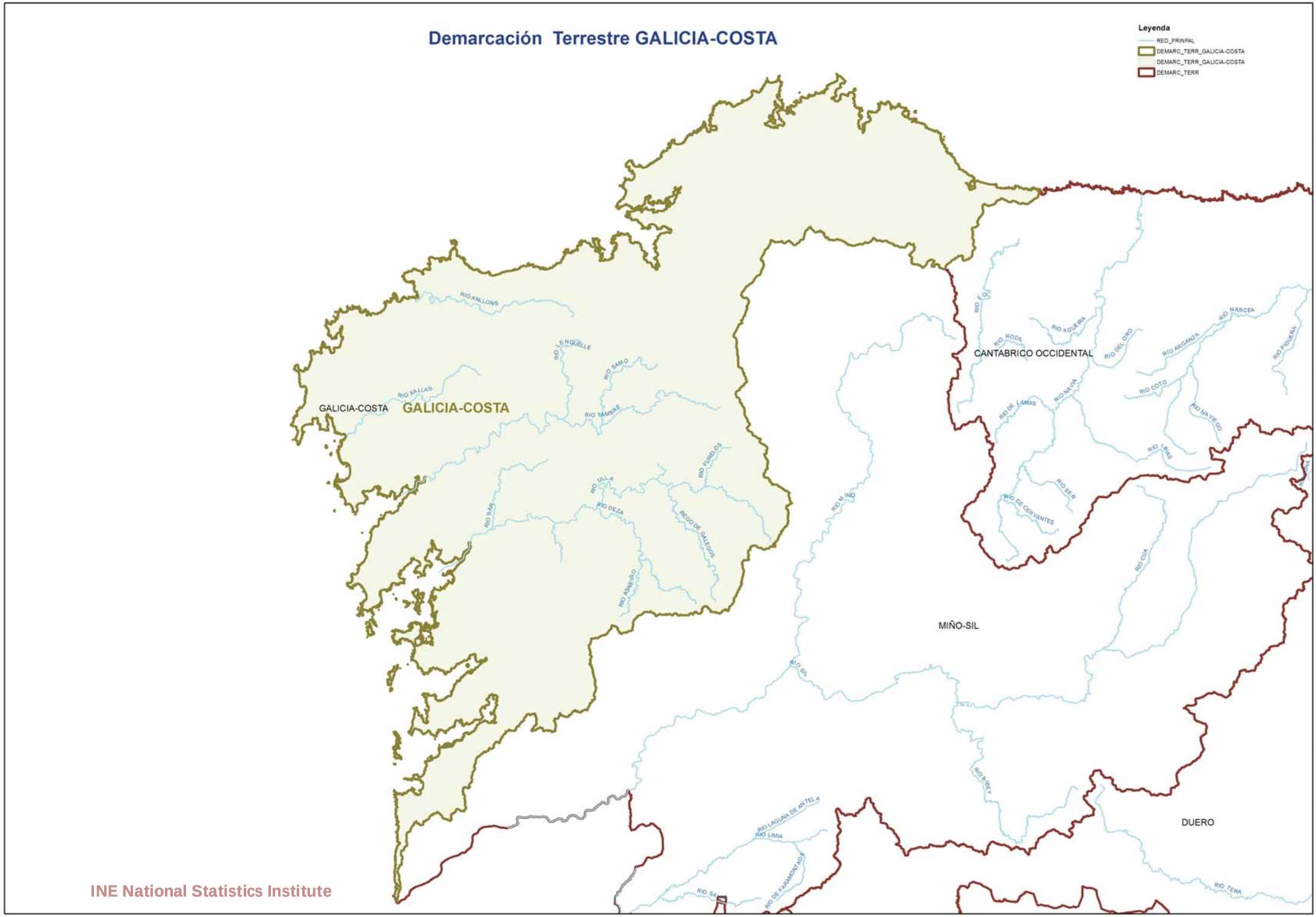

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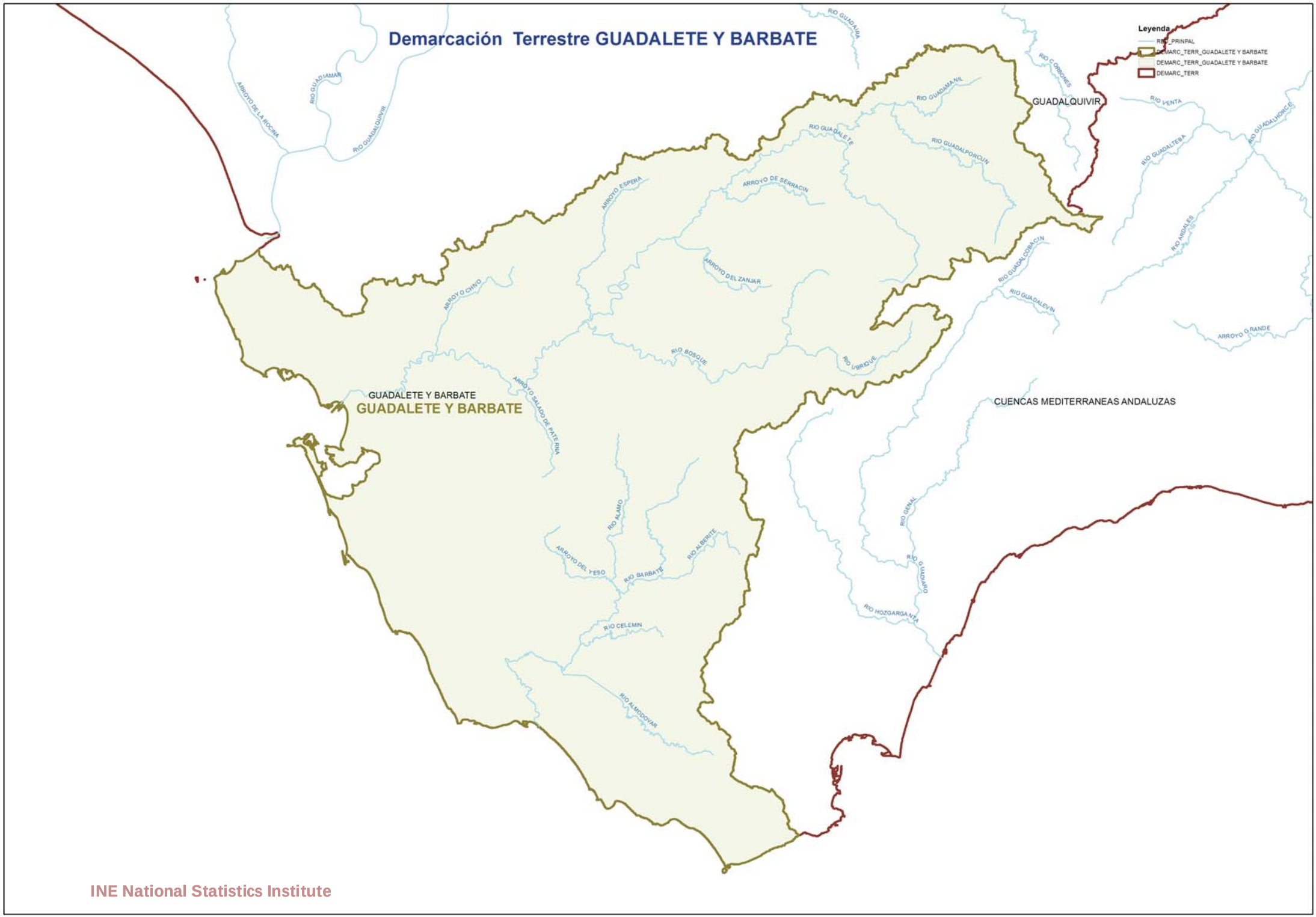

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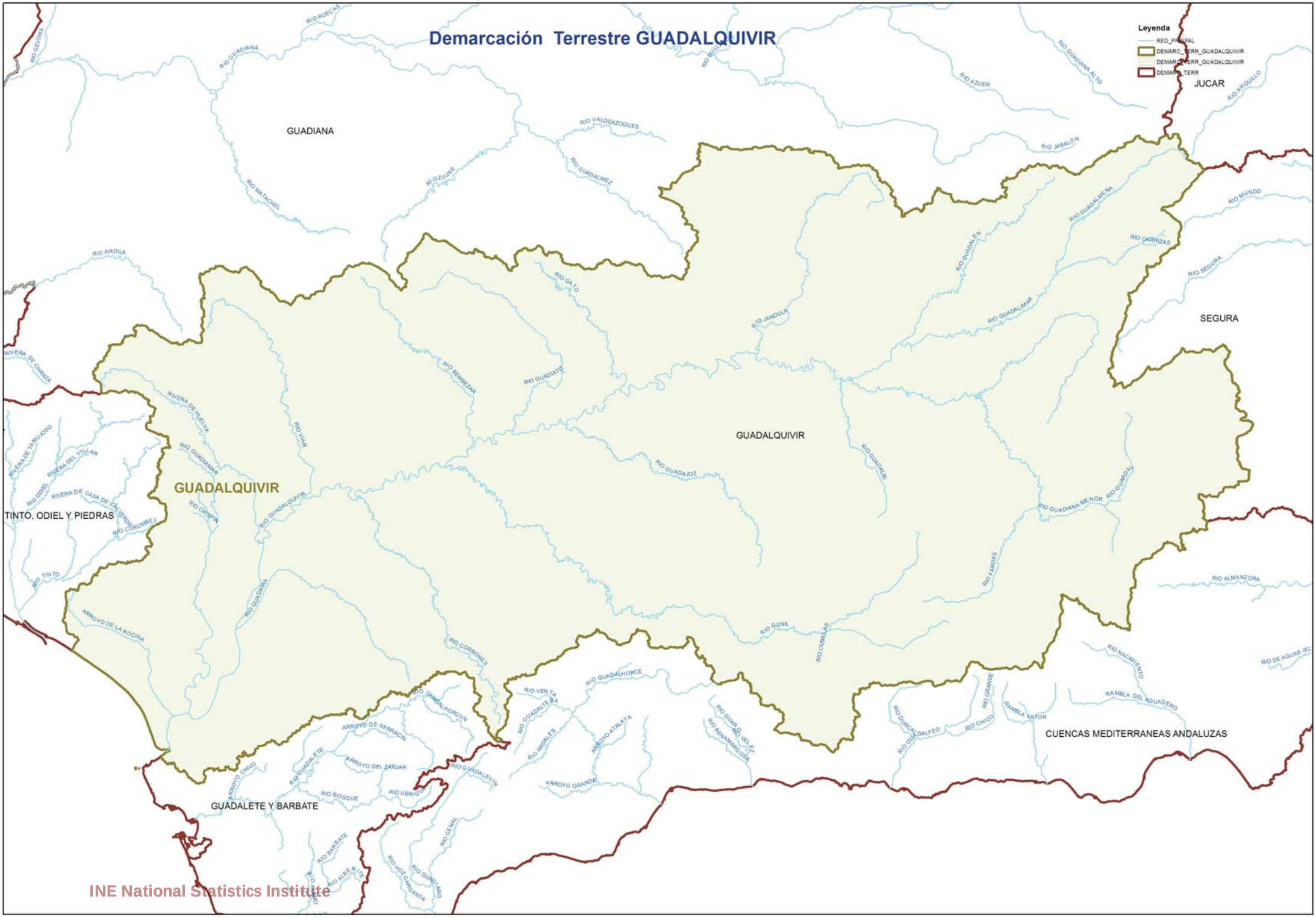
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GUADALETE Y BARBATE
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RIVERA DEL VILLAR
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RIVERA DE CASA DE VALVERDE
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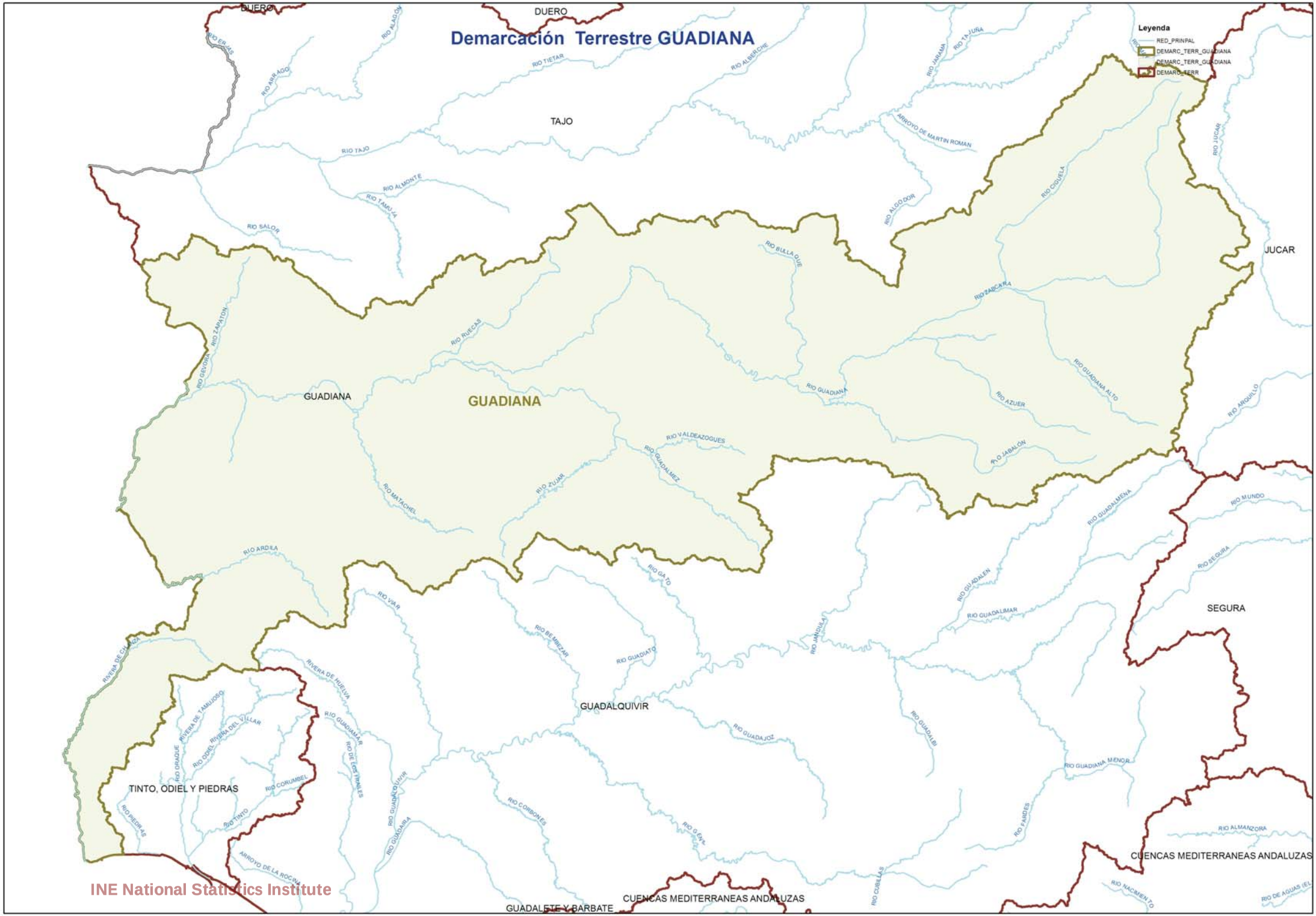
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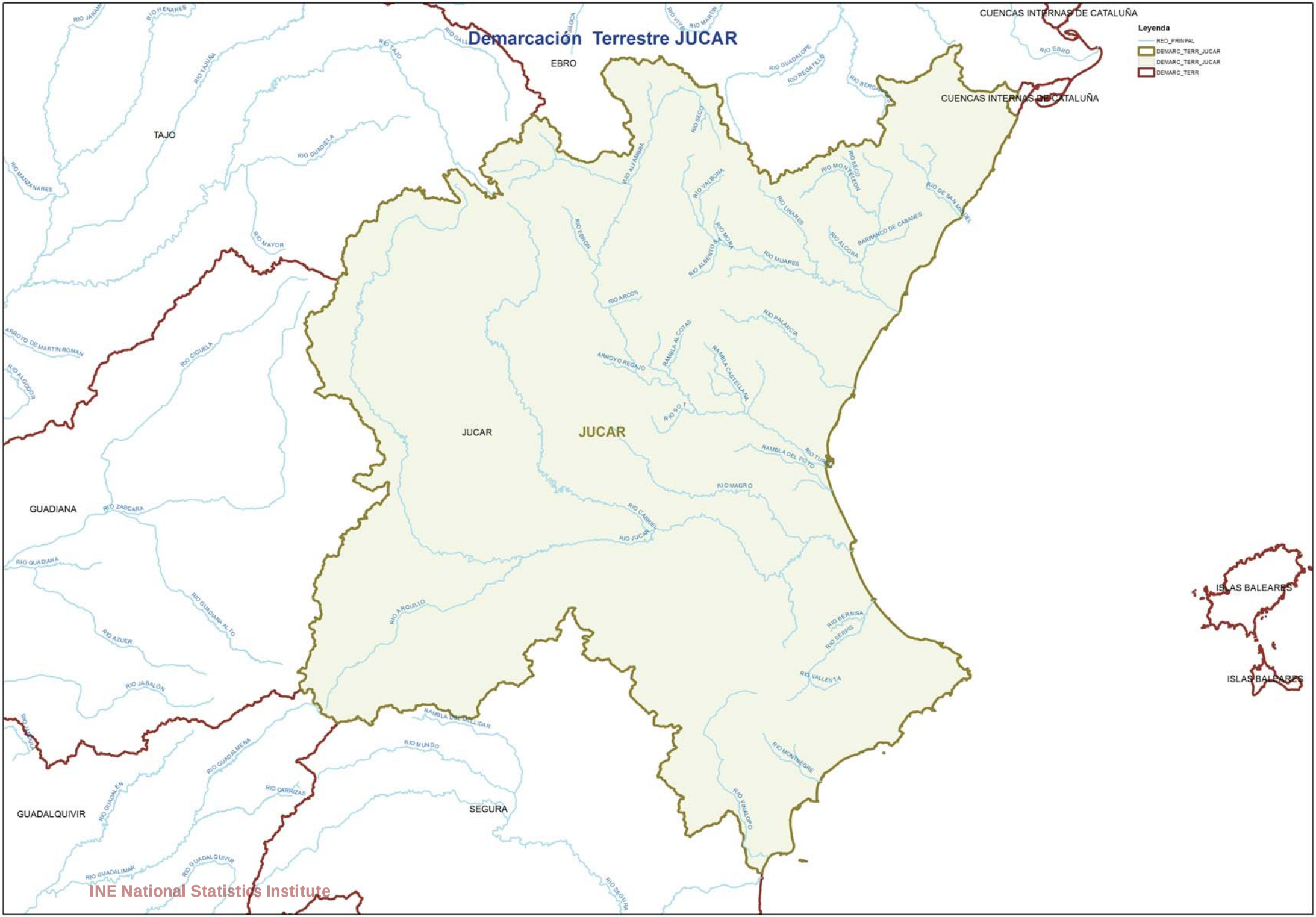
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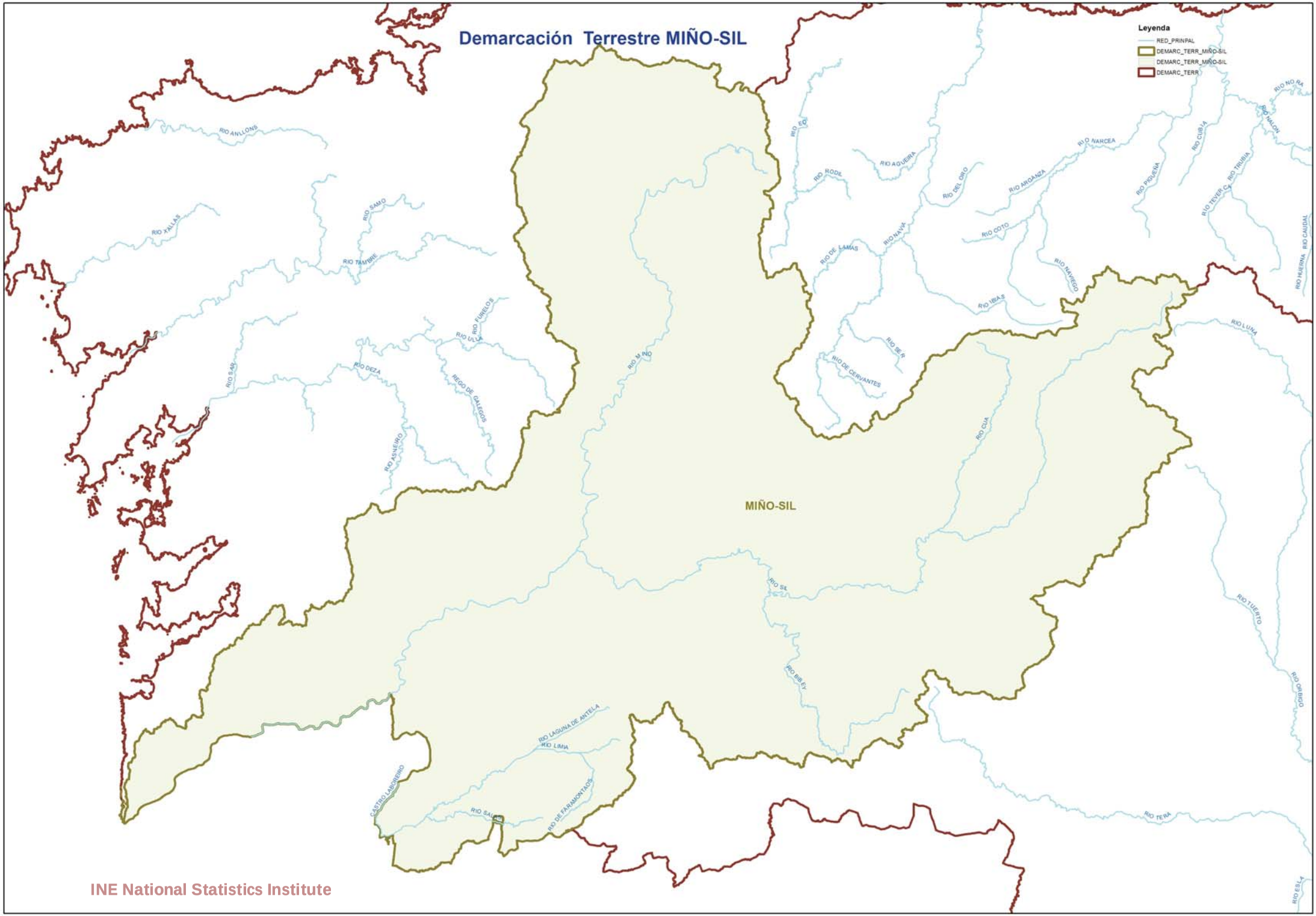

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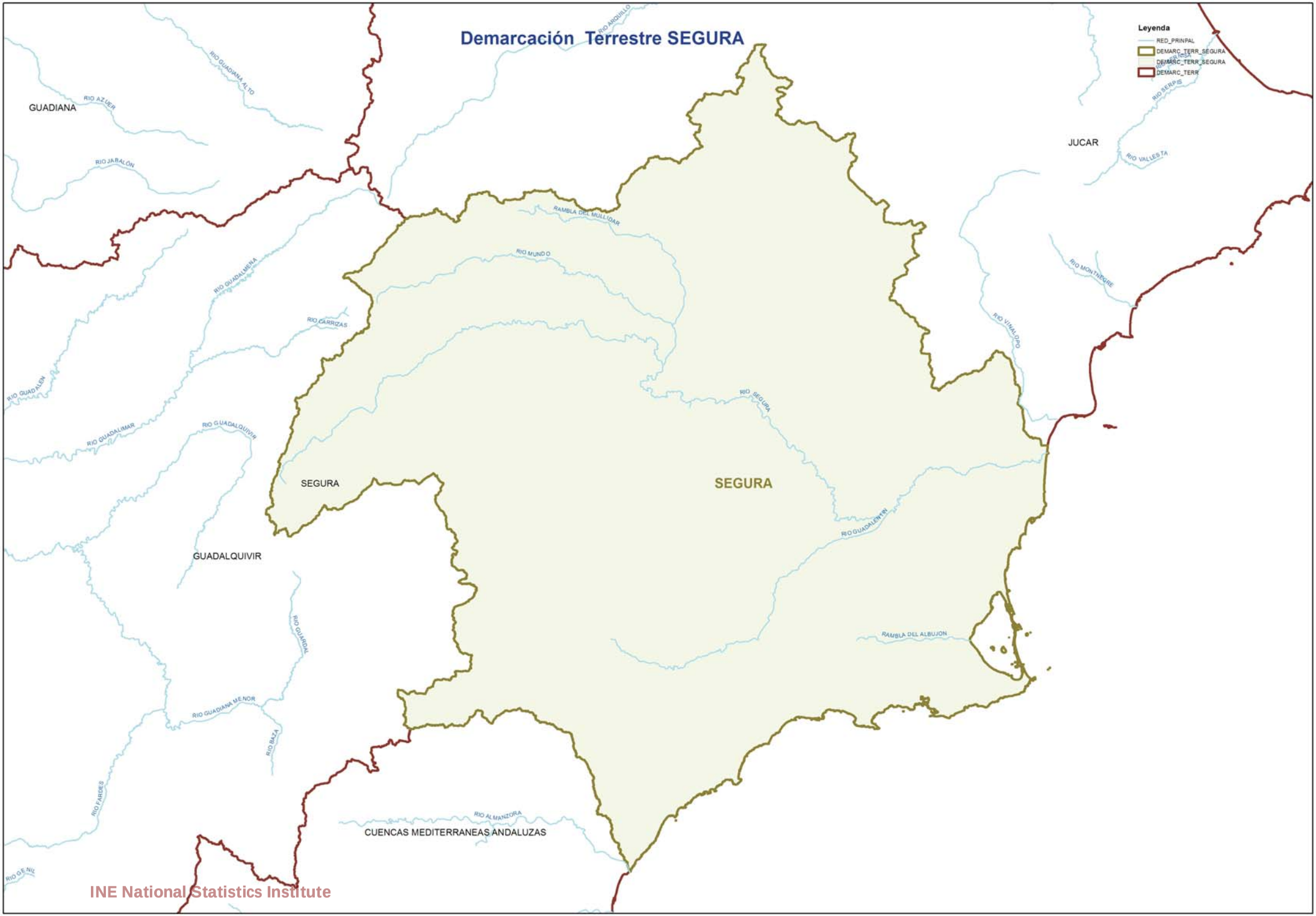
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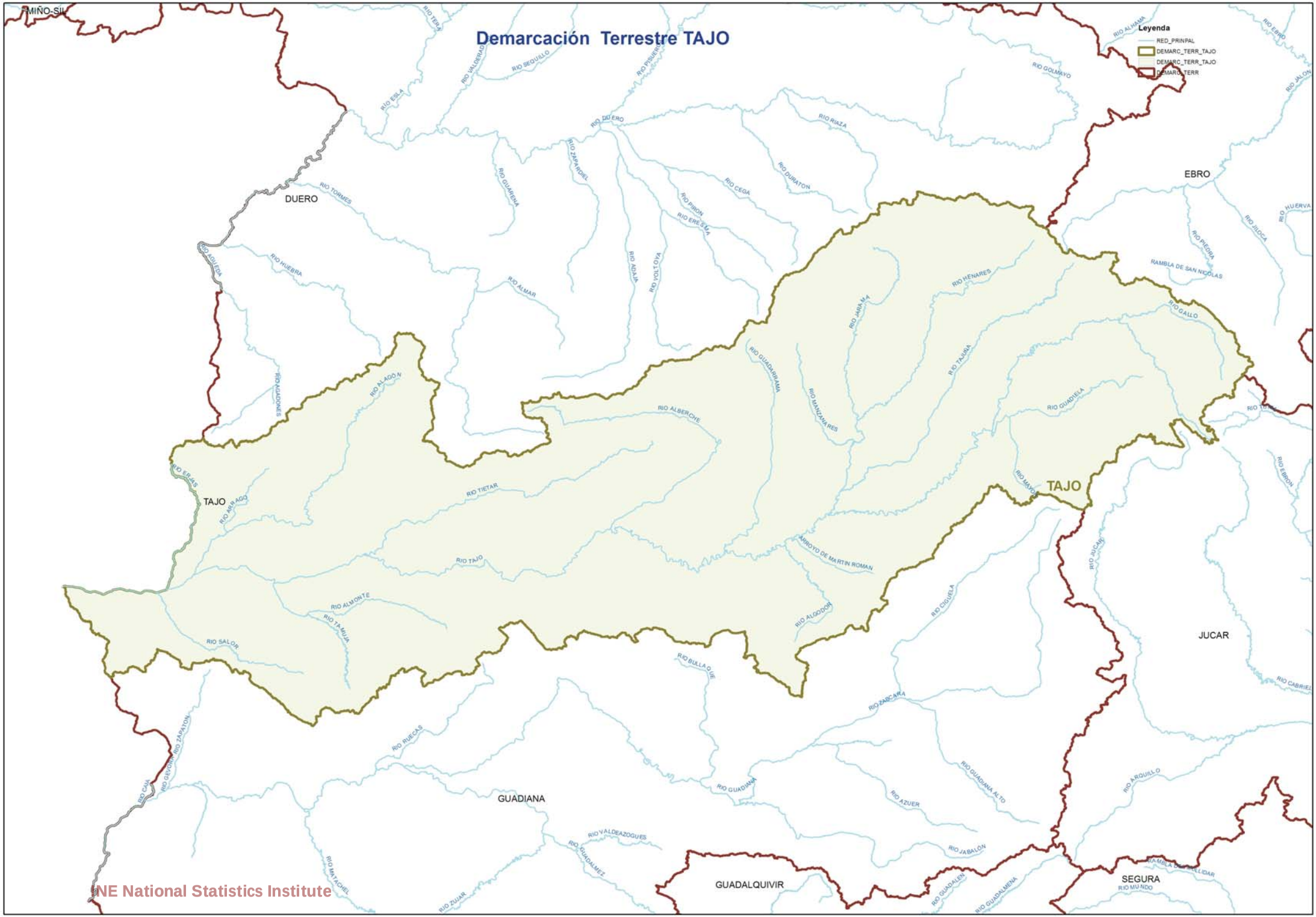

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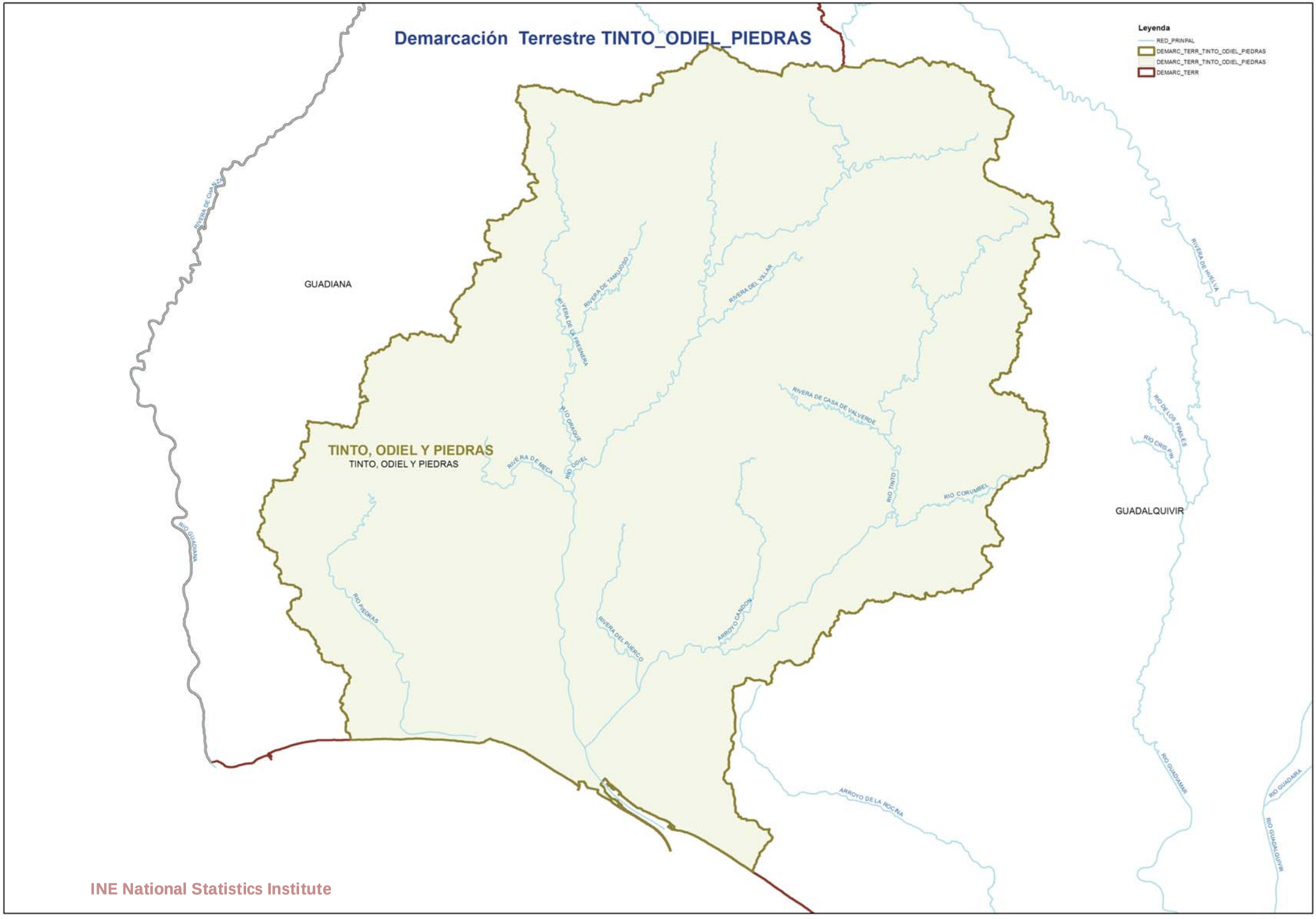

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Annex 2

Territorial maps: river basin districts and provincial limits

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DEMARCACIONES HIDROGRÁFICAS

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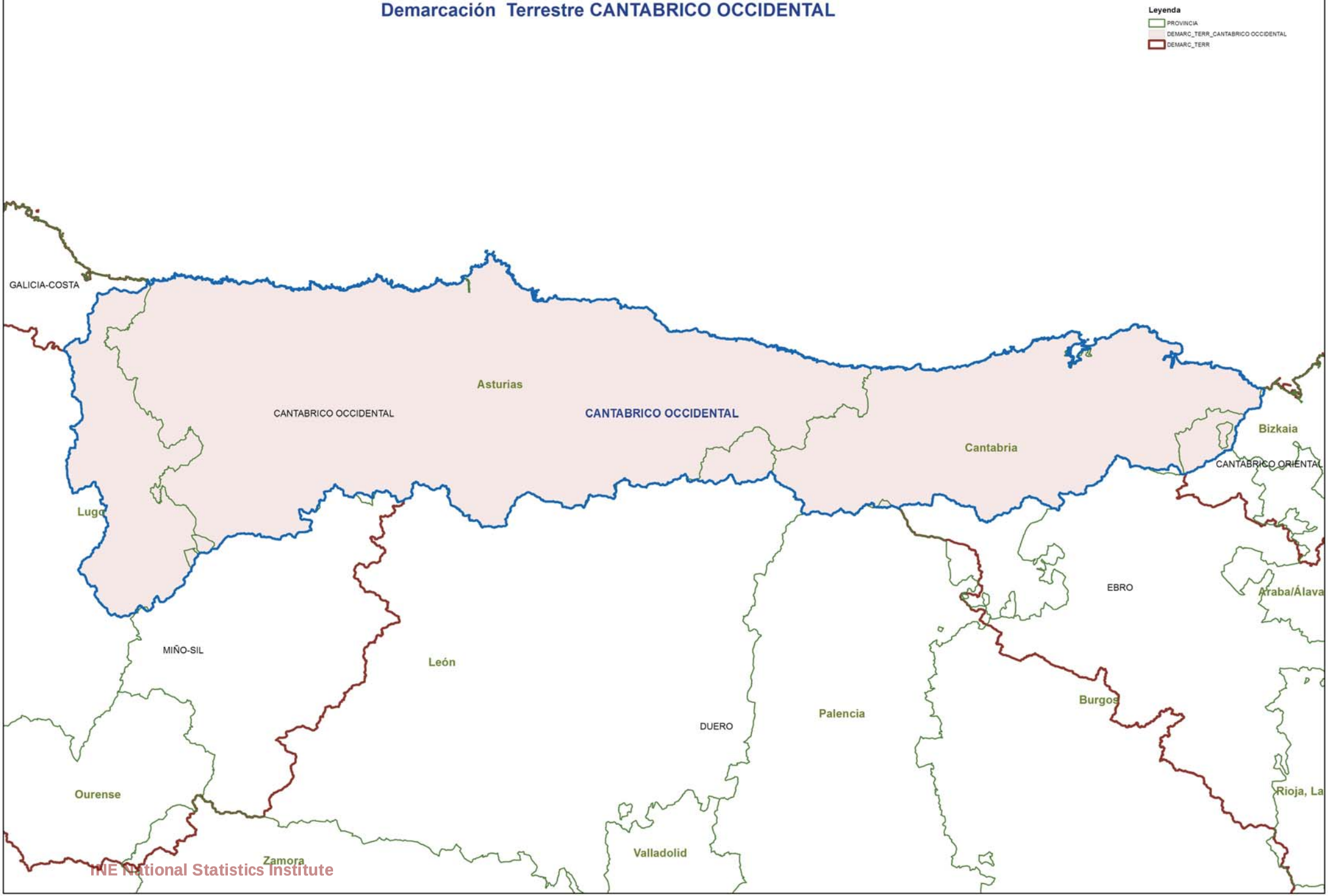

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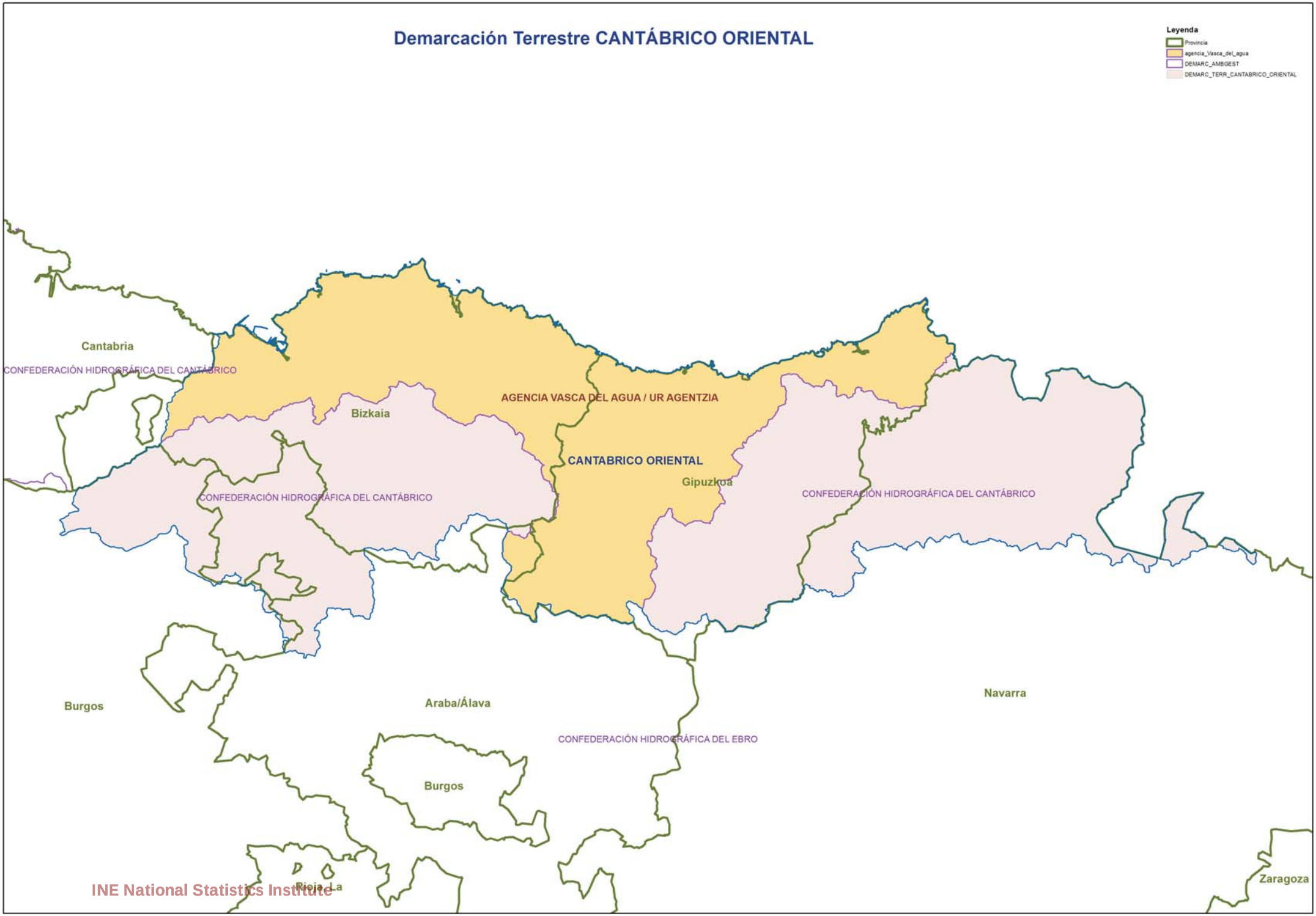

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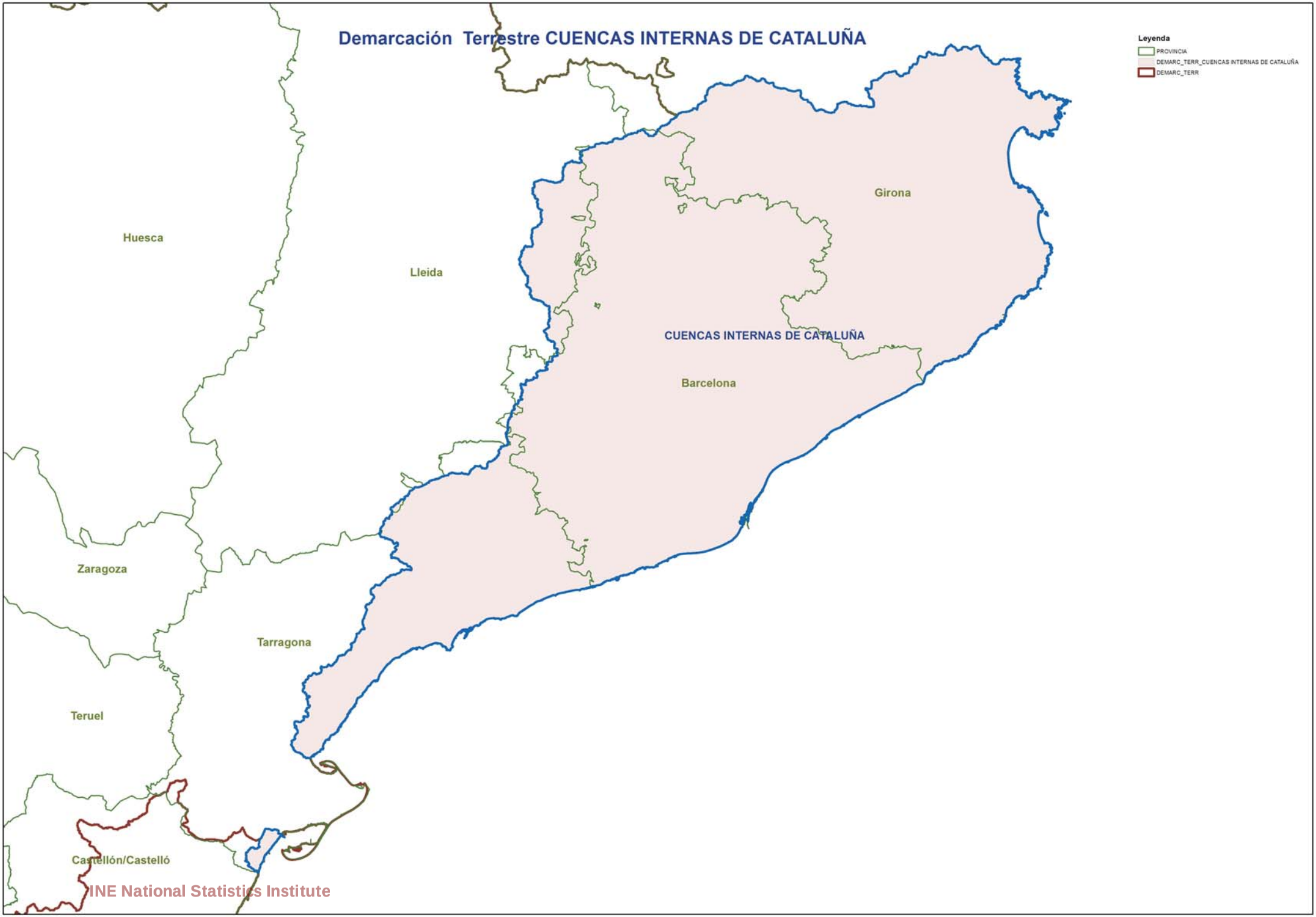
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Tarragona
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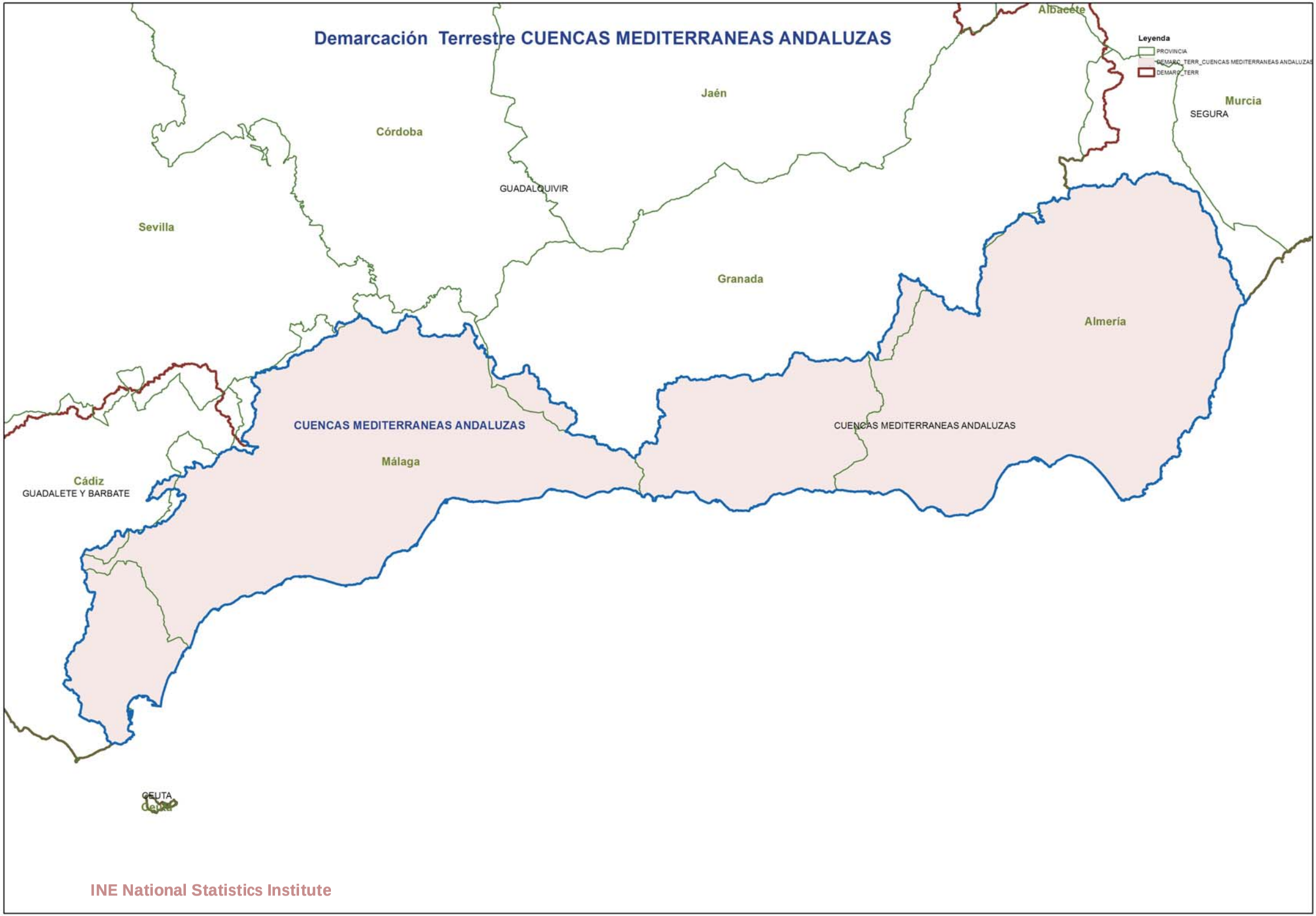
Castellón/Castelló
INE National Statistics Institute



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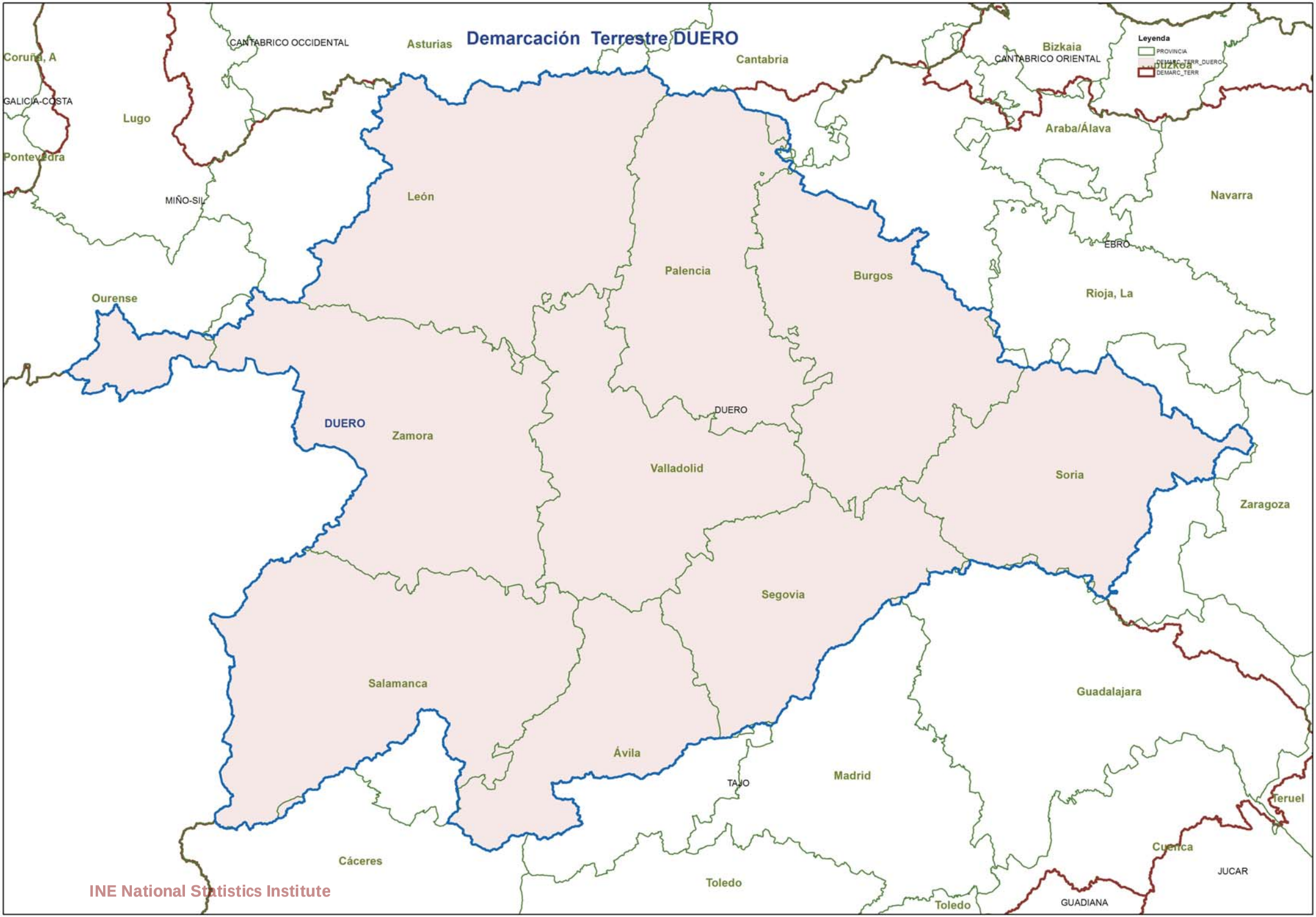
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León
Araba/Álava
Navarra
EBRO
Palencia
Burgos
Rioja, La
Ourense
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Zamora
Valladolid
Soria
Zaragoza
Segovia
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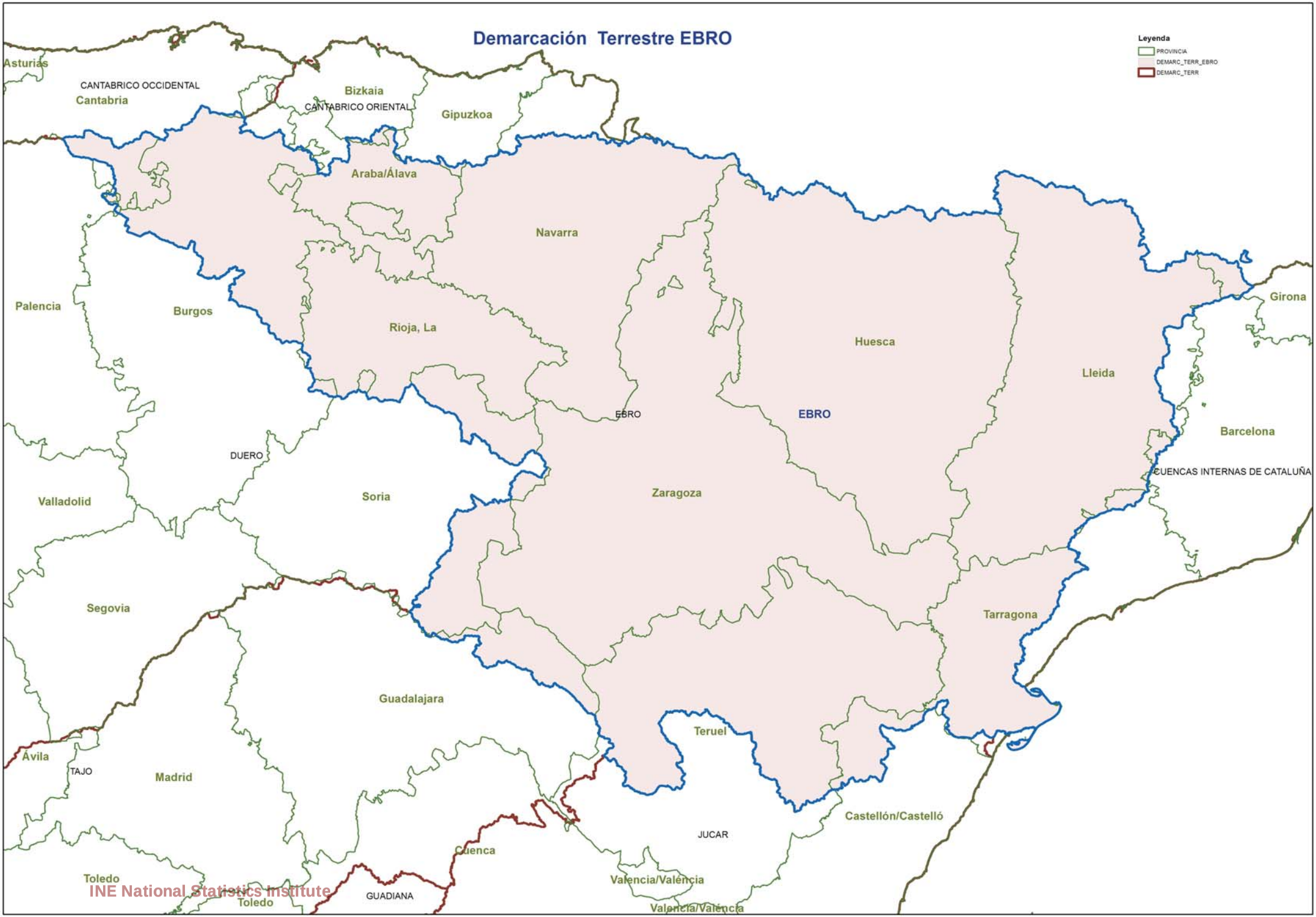

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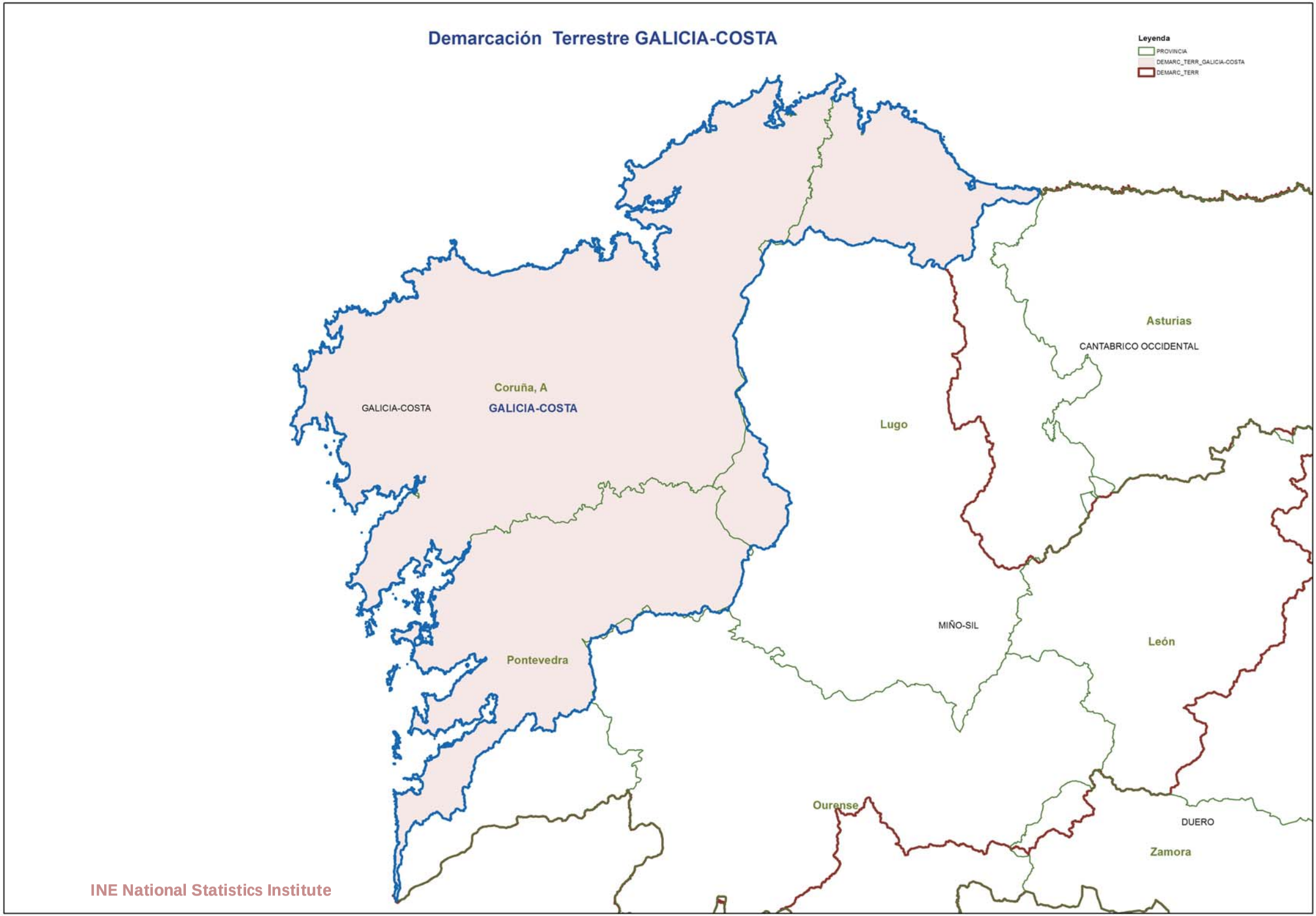

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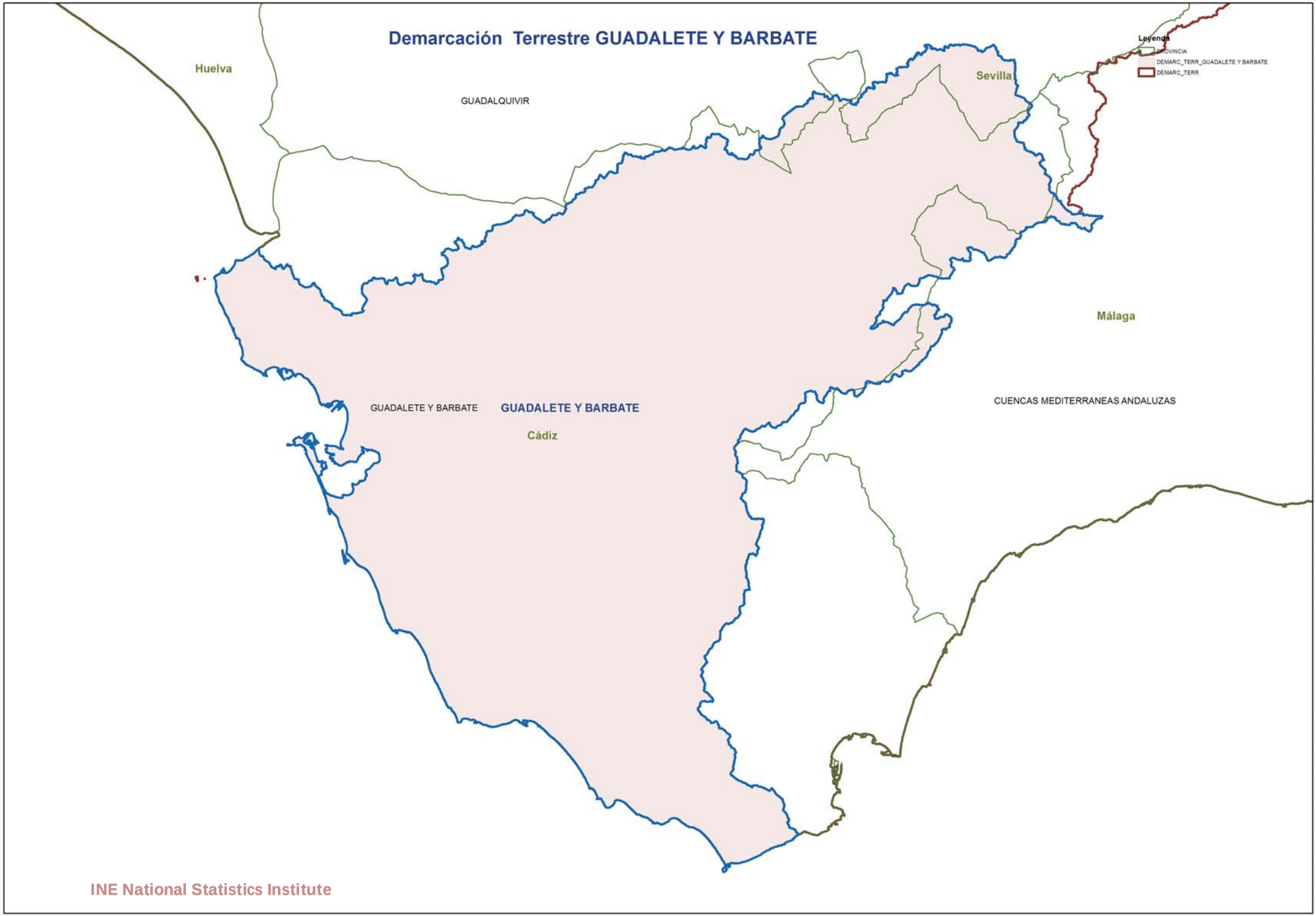

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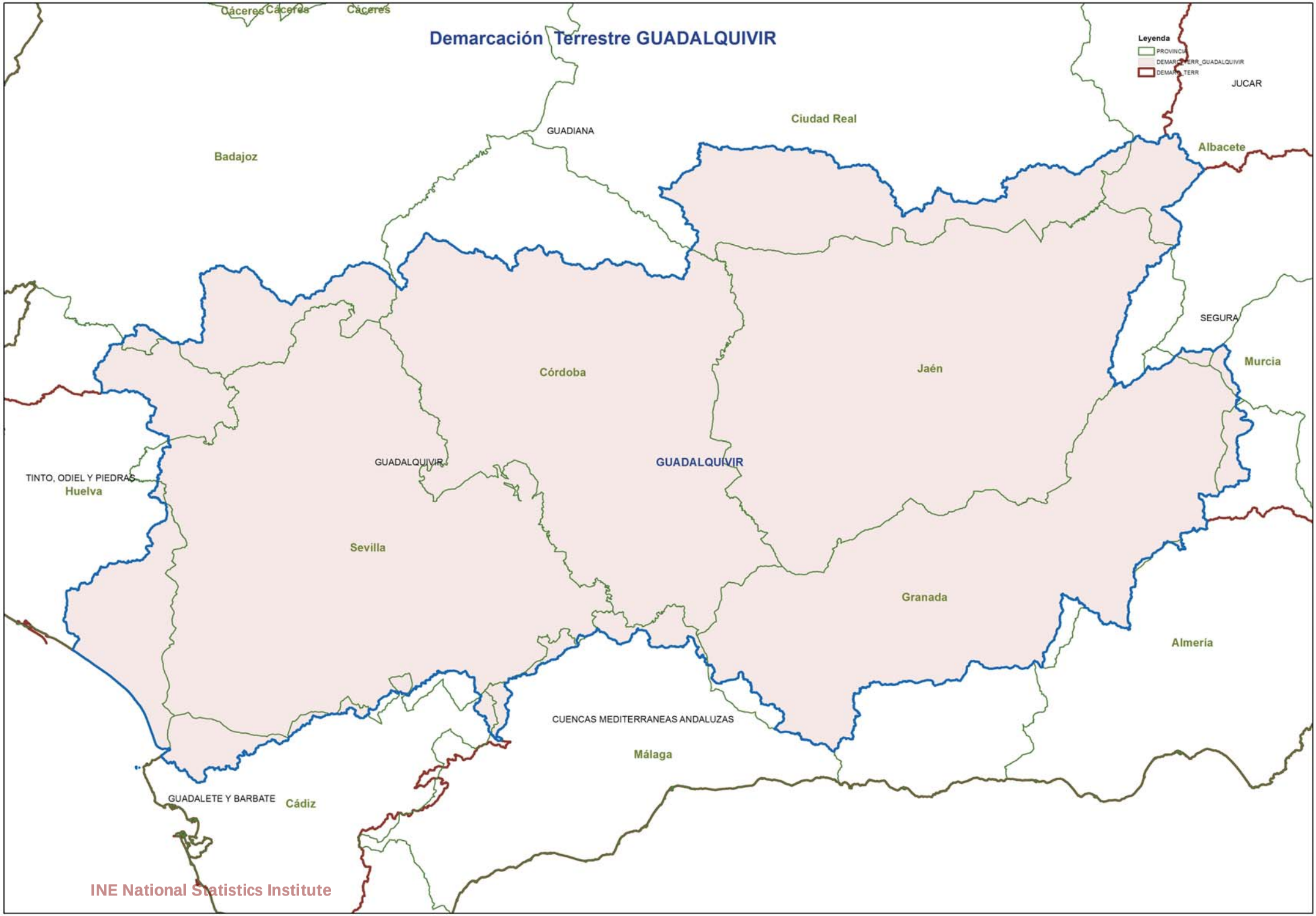
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Albacete
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Murcia
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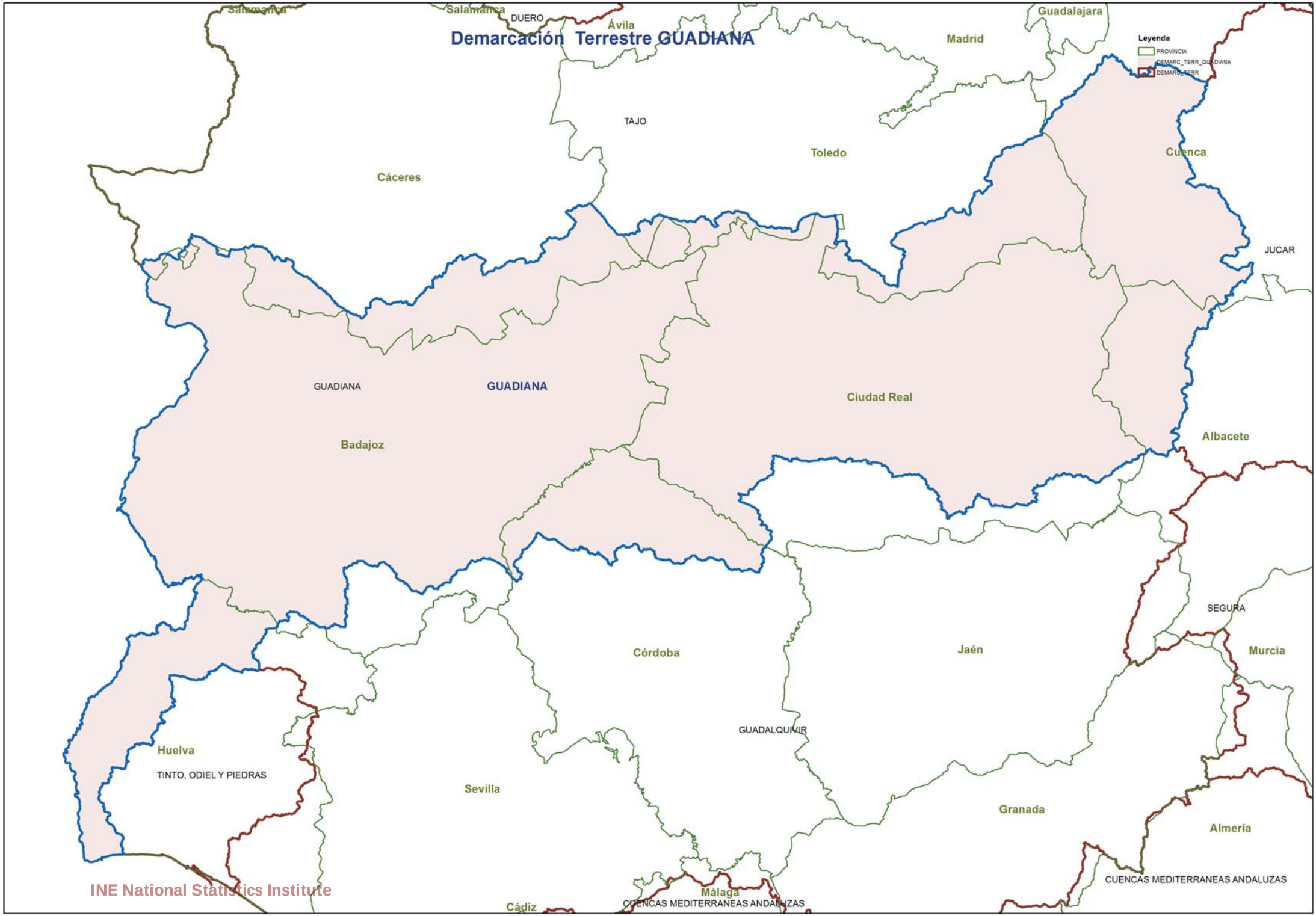
INE National Statistics Institute



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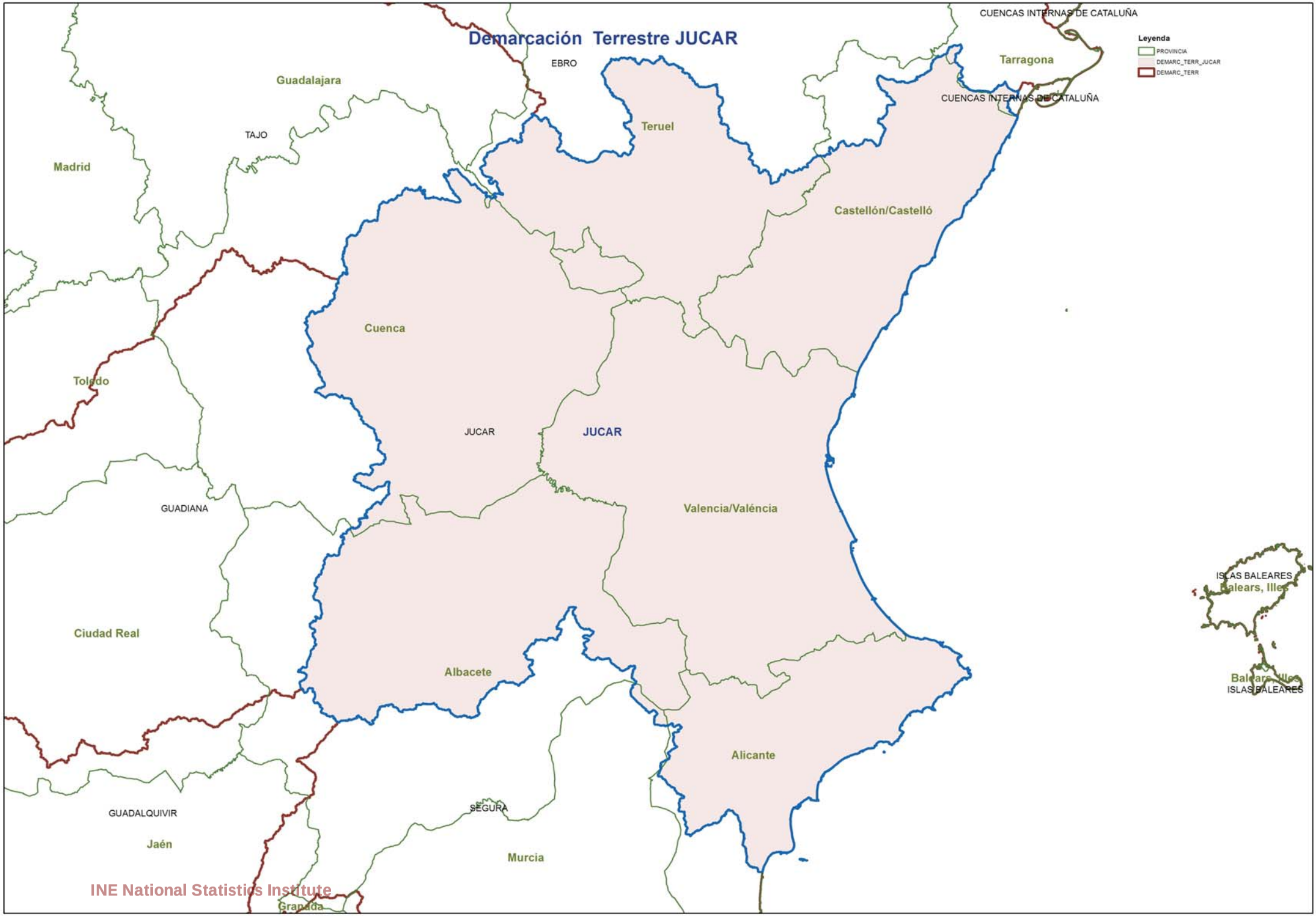
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Cuenca
Toledo
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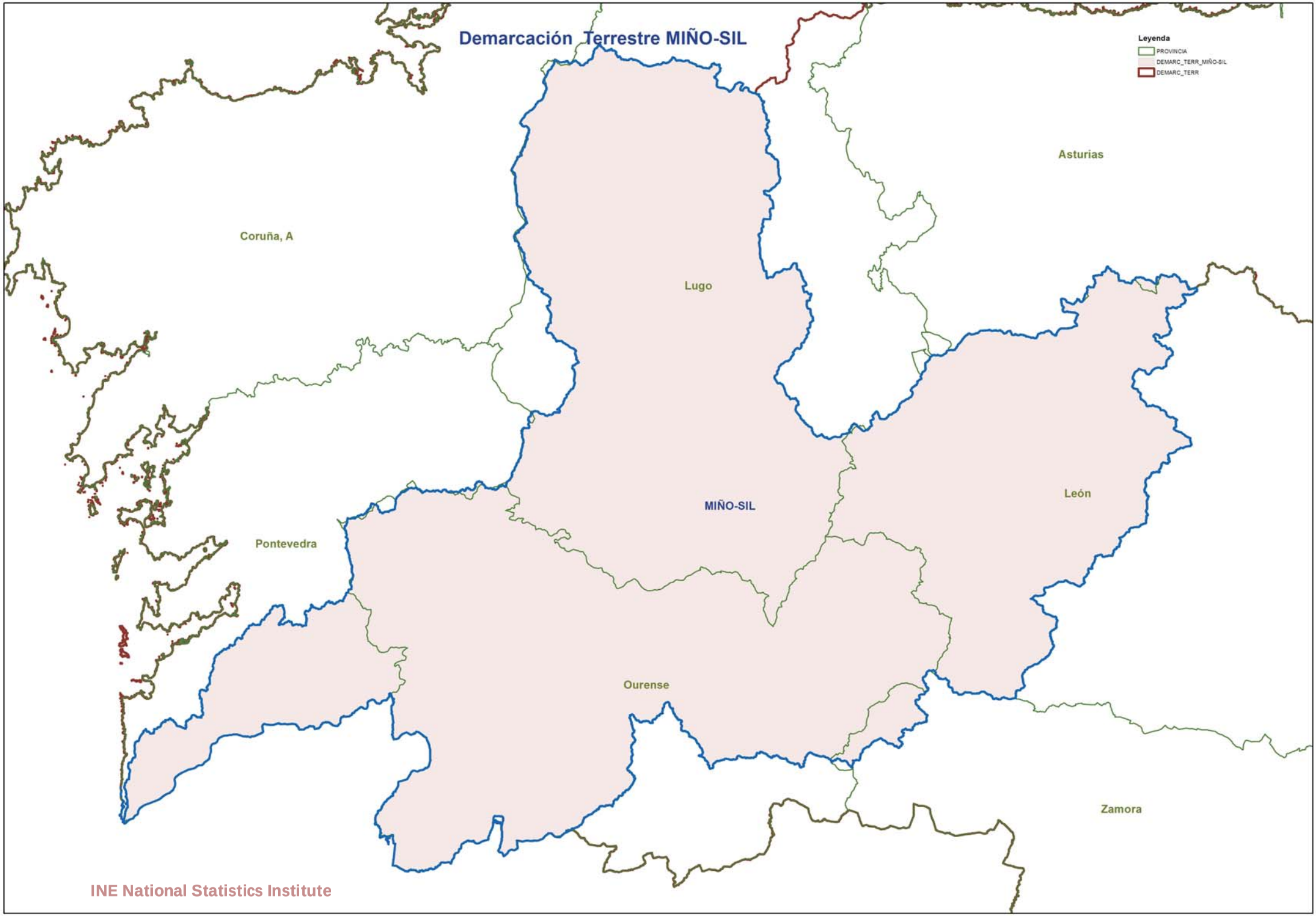
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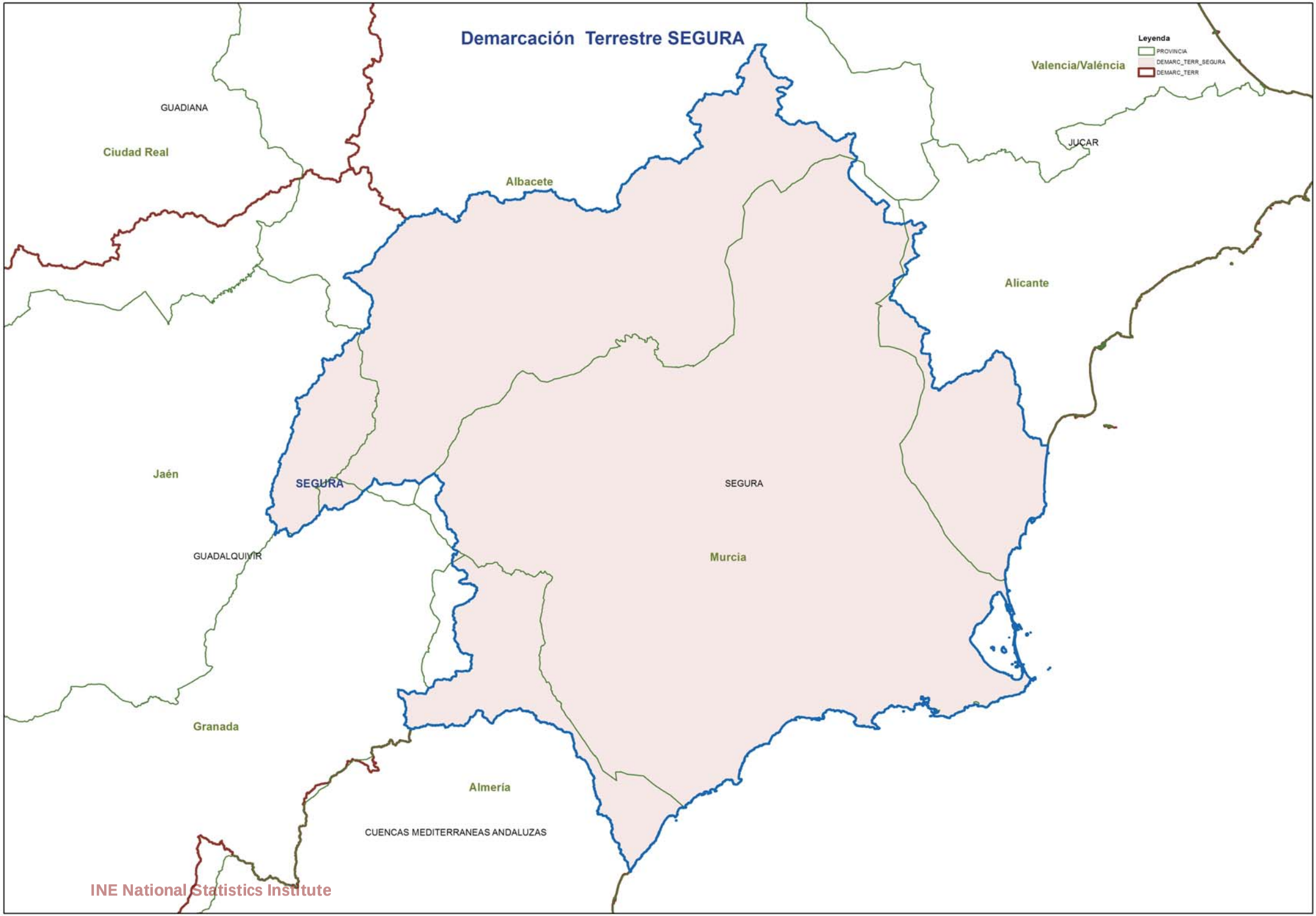

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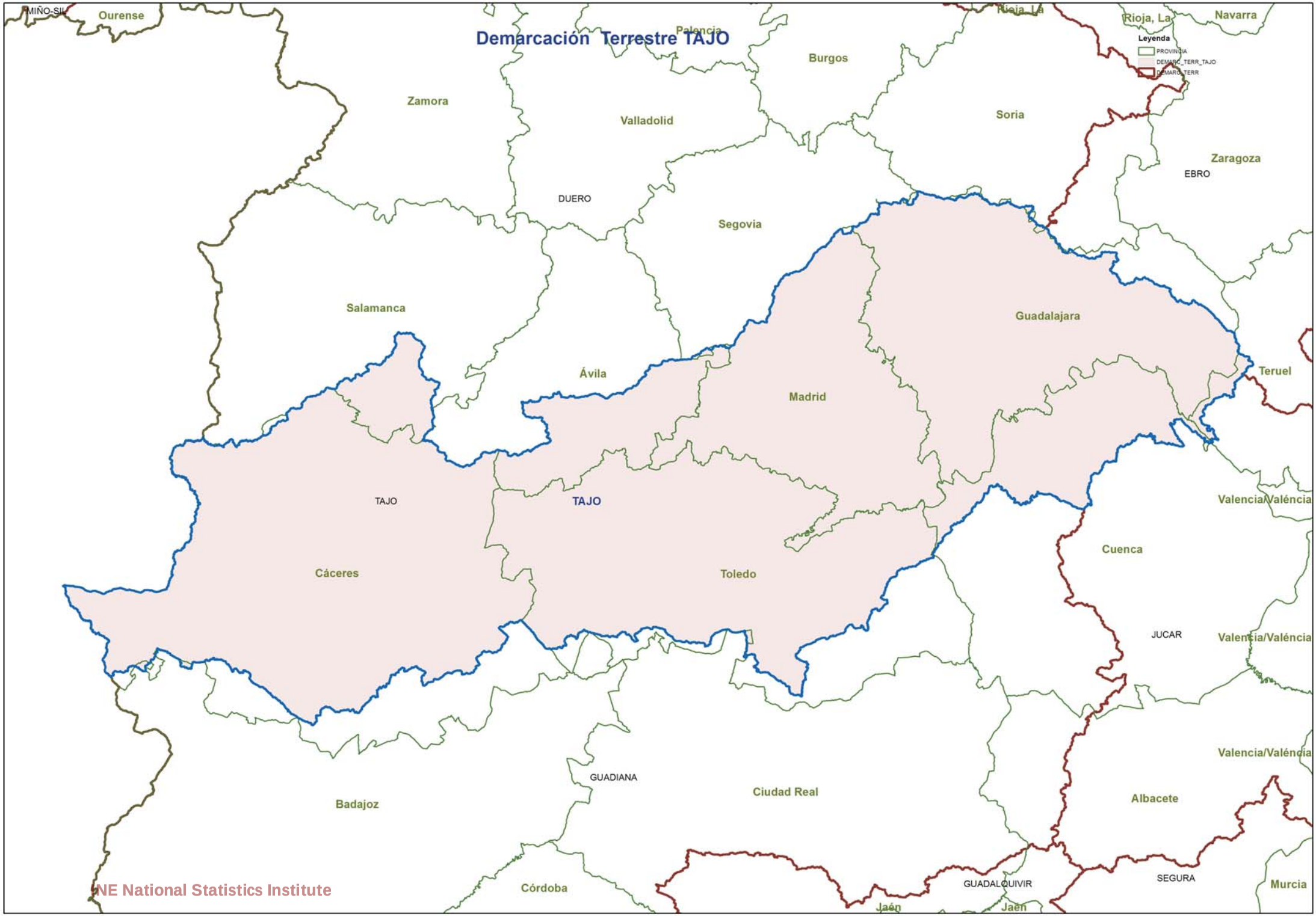
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Zamora
Valladolid
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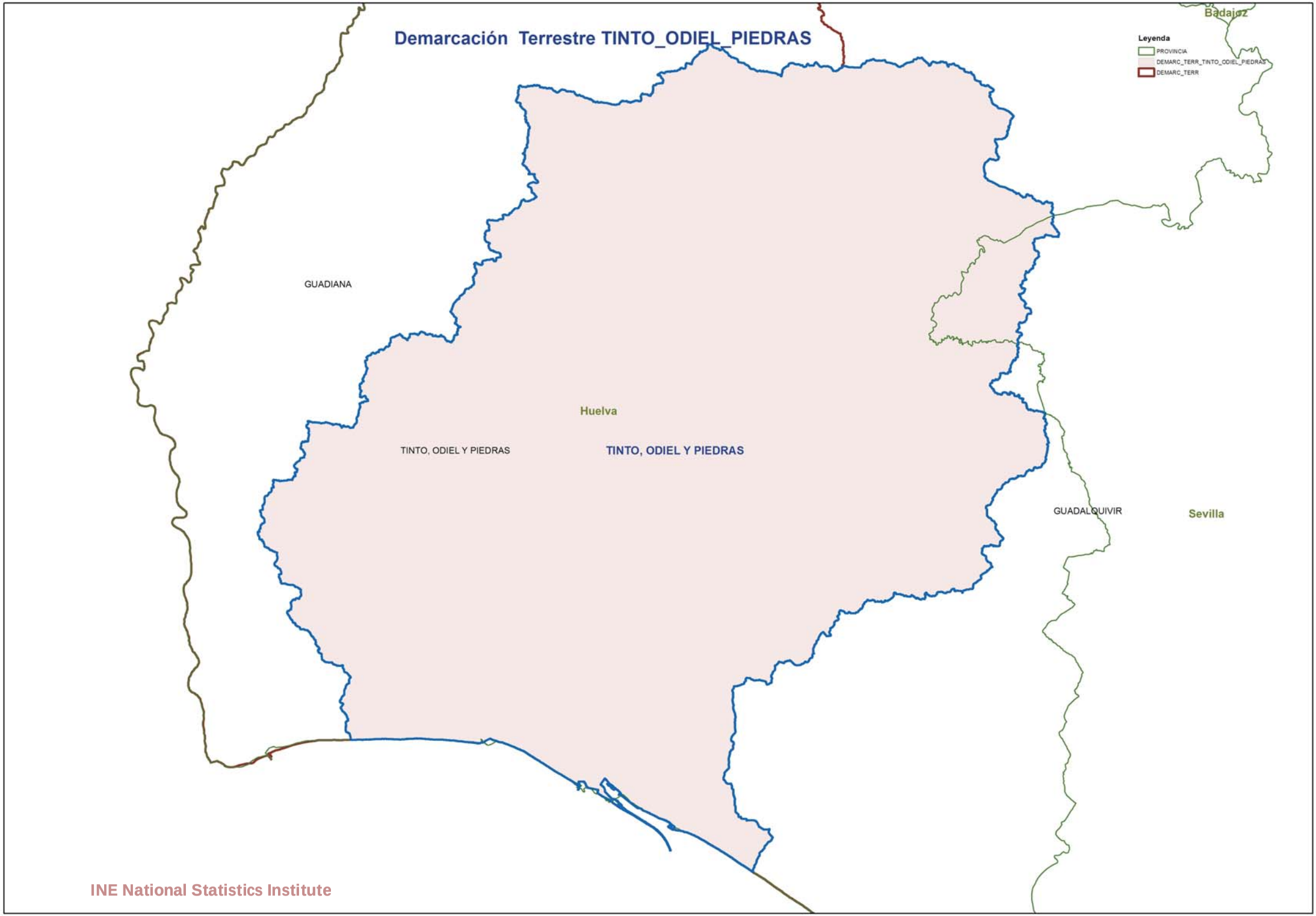

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