Analysis of Food Availability for Griffon Vulture (*Gyps fulvus)* and their Foraging Behaviour as Function of Food and Land Cover in Cadiz Province, Andalusia, Spain

MARIJANA DEMAJO
March, 2017

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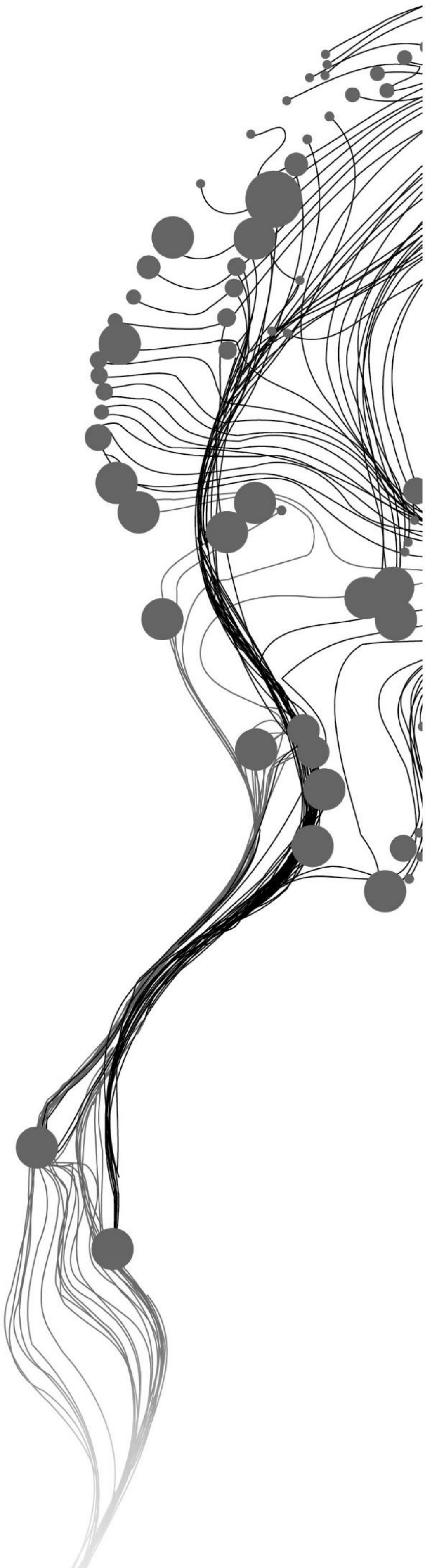

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MARIJANA DEMAJO
Enschede, the Netherlands, March, 2017

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
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ABSTRACT

The largest population of Griffon vulture (*Gyps fulvus)* in Europe is located in Spain with approximately 80.000 individuals. Cadiz Province in Andalusia, Southern Spain, has the highest density of breeding Griffon vultures. The tightening of the European Union sanitary legislations established limitations on the amount of dead animals left in the field, and there is insufficient knowledge how it has influenced the amount of available dead biomass for Griffon vultures. Changes in extensive livestock farming that took place in Spain, in the past few decades, have had an impact on the amount of available livestock as potential food for Griffon vultures. The aim of this study is to assess food availability for Griffon vultures and understand their foraging behaviour as function of land cover and available dead biomass in wet and dry season, within the context of flying and sitting.

The amount of dead biomass available for Griffon vultures in wet and dry season was determined by using livestock census data of cattle, goats and sheep and information from the farmers. Spatial analysis tools were applied in order to redistribute livestock within present land cover classes within municipalities. Parameters such as percentage mortality rate in two seasons, carcass removal and average animal weight were used for producing total dead biomass distribution in two seasons. Telemetric data of Griffon vulture was filtered based on speed and season criteria in order to get observations of flying and grounded Griffon vulture in two seasons. The observations were further used for analysis of relationship between observations of flying and sitting Griffon vulture and land cover and available dead biomass in two seasons in order to understand their foraging behaviour.

In this studied area the land cover is as follows: built-up (3%), crops (40%), grass (8%), shrubs (21%), forest (16%), mixture of trees and shrubs with crops or grass (3%), olives and other fruits (4%), bare ground (1%), marshes (2%), surface water (2%). The total available biomass significantly differs between wet and dry season. There is 31% (277kg) less biomass available for Griffon vultures in dry season as compared to wet season. On average, 56% (3840kg) less of biomass is available in the field than before carcass removal from the field is applied. Based on frequency of observations per ha of each land cover in both seasons, the Griffon vultures have a preference for areas under grass, shrubs, forest and areas with mixture of trees and shrubs with crops or grass. These habitats are used for extensive grazing and are important foraging habitat for Griffons. The amount of biomass is not the only factor in foraging but also vegetation coverage. Maintenance of extensive grazing systems and monitoring the impact of carcass removal policy should be taken into consideration in order to improve conservation of Griffon vultures in Cadiz, an important roosting, breeding and migratory area for this species.

Keywords: Griffon vulture, Cadiz, land cover, available biomass, carcass removal

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1. Background

Human activities have always influenced the environment leading to changes in this complex system. As the human population has been growing and developing, the impact on environmental change reached global conditions, with high consequences on biological diversity on the Earth. Within biodiversity changes, those concerning species diversity changes are happening at a very rapid rate. Species diversity has an important role in ecosystems function and an effect on the resilience and resistance of ecosystems to environmental changes. Many species became extinct or are on the edge of extinction. This is a natural process, however, by human activities, it has been accelerated to an unnatural level. Already 5-20% of the species of many groups of organisms disappeared (Chapin et al., 2000).

The most important hotspot region based on species richness, threat, and endemism in Southwest Europe is the Mediterranean biogeographical region. The Iberian Peninsula as part of this region is rich in species of various taxa: mammals, breeding birds, reptiles, and amphibians. Iberian Peninsula shows richness especially in breeding birds that account for 62% of all species present in this area. Beside the Iberian mountain ranges, most of the hotspots of species richness of this particular taxon are located in southwestern Spain- Andalusia (Pascual, Luigi, Alessandra, Emilio, & Luigi, 2011). Andalusia, also the focus of this research, is characterized by a network of protected areas that cover 20% of its territory (Morillo & Gómez-Campo, 2000). This mountainous region in Southern Spain is an important refuge, roosting and feeding area for young European vultures (Garrido & Moleon, 2010).

Griffon vultures, also known as Eurasian griffons (*Gyps fulvus*) are large raptors that play an important role in ecosystem functioning. They belong to scavengers that feed on carcasses of large and medium sized-animals: livestock and wild mammals. Griffon vultures are carnivorous species that do not hunt their prey. They feed on the soft tissue and entrails of dead animals. A large percentage of the diet of griffon vultures in Andalusia in terms of frequency of prey and biomass make cows, horses, goats and sheep (Grubac, 2014). Transhumance, traditional livestock farming based on the movement of livestock within different habitats between winter and summer, has an important role in providing food for griffon vultures. Griffon vulture population can be maintained through a system based on this traditional livestock farming (Olea & Mateo-Tomás, 2009). They also feed on mammals that died of various diseases which are infectious only to mammals, as such, these vultures have a sanitizing function in nature (Marinkovic & Karadzic, 2008). Griffons breed on cliffs forming small or larger colonies. In order to reduce energy consumption, when lifting to the desired altitude, they rely on soaring flight and use thermal and cross winds (Marinkovic & Karadzic, 2008). They have wide distribution ranges, over Western Palearctic from India, Pamirs and Altai in the east, to Portugal and Spain in the west (Slotta-Bachmayr, Bögel, & Cardenal, 2004).

According to the information provided by ("Griffon Vulture (Gyps fulvus) - BirdLife species factsheet," 2016), the global population size of griffon vultures counts approximately 100.000 individuals. The largest population in Europe is located in Spain with approximately 25,000 breeding pairs or 80.000 individuals (Del Moral, 2009). This species is listed in The IUCN Red List of Threatened Species under the category Least Concern (LC), (BirdLife International, 2015). They are also protected under international Conventions and Directives: EU Birds Directive, Bern Convention and CITES (Slotta-Bachmayr et al., 2004).

Figure 1. Griffon vultures in Cadiz Province.

Pictures were taken by Antonio Roman Muñoz Gallego (left) and Juan Ramírez Román (right) in October, 2016.

" Figure 1 shows griffon vultures gathered around the cow carcass (on the left). On the right is shown flock of Griffon vultures waiting for convenient weather conditions to cross Strait of Gibraltar and migrate to Africa."

The European population of griffon vultures is threatened by lack of food as consequence of abandonment of extensive livestock farming and stricter sanitary and veterinary regulations. These factors with a high impact on their population could lead to the extinction of the species in 20 years or less (Tavares, 2013).

Figure 2. Griffon vultures feeding on carcass.

Pictures were taken by Juan Ramírez Román on March, 2016 (left) and February, 2017 (right).

1.2. Research problem and justification

Young European vultures cross the Strait of Gibraltar to winter in Africa (Garrido & Moleon, 2010). These birds cross long distances, thus as such analysis of available food is necessary, especially considering that food availability is the main factor in population regulation of this species (Parra & Tellería, 2004).

The main source of food for Griffon vultures are livestock carcasses disposed around farms and on open grasslands (Monsarrat et al., 2013). However, the appearance of mad cow disease led to the tightening of the European Union sanitary legislation (Regulation CE 1774/2002) which established limitations on the amount of dead animals left in the field and supplementary feeding stations "vulture restaurants" (Donázar, Cortés-Avizanda, & Carrete, 2010). In some parts of Spain, 80% of carcasses from the farms have been removed for industrial disposal (Margalida, Donázar, Carrete, & Sánchez-Zapata, 2010). There is some evidence of the decrease in breeding success, increase in mortality of young vultures and halt in population growth as the consequence of carcass removal. However, there is still insufficient knowledge about the ecological effect of this activity on Griffon vulture population (Donazar, Margalida, Carrete, & Sanchez-Zapata, 2009). There is also lack of knowledge on how much the implementation of this sanitary policy has influenced the amount of available biomass within Cadiz.

According to Caballero (2007), cattle farming is decreasing in Europe and Iberian Peninsula, including Spain, which has a negative consequence on the amount of available food of good quality for raptors. Changes in traditional livestock farming practices, in Spain, took place in the past few decades. Transhumance is declining, so farmers move cattle by the traditional way (move on foot) only for short distances (Donázar, Naveso, Tella, & Campión, 1997). This further has an impact on available livestock as potential food. Extensive livestock farming plays an important role in food availability for these birds. The presence of Griffon vultures in Spain is highly related to the existence of extensive livestock farming (Donázar et al., 1997). Mosaic land cover types such as grassland, arable land, dehesa, shrubs, and forest are important foraging habitats for these raptors. These land cover types are differently used in between the seasons for livestock grazing.

There is insufficient knowledge about the temporal aspect of livestock distribution within land cover types and how it is related to the distribution and abundance of Griffon vultures. Some research has been done on estimating the relationship between transhumance (traditional livestock farming based on the movement of livestock between winter and summer pastures) and vultures (Olea & Mateo-Tomás, 2009). However, this research does not include a temporal aspect of livestock mortality rate, which influences the quantity of dead biomass available in different seasons. The research on foraging distribution modelling of Griffon vultures has been done on the island of Crete (Mcintyre, 2010). The author of this research took as an assumption that all carcasses are left in the field not taking into consideration the ratio between removed carcasses and amount that is left in the field.

Cadiz, a Province in Southern Andalusia and study area of this research, has the highest density of breeding Griffon vultures, therefore it is necessary to estimate food availability for these species. The research will focus on livestock distribution per land cover types in two different seasons, wet and dry. Variation in livestock mortality rate in both seasons and impact of carcass removal policy on the amount of total dead biomass available for Griffon vultures will also be analysed.

Knowing the food availability for Griffons is of vital importance for the stability and future evolution of their populations. Moreover, the relationship between the observations of Griffon vulture and available dead biomass will be analysed. Griffon vulture uses not only, exclusively eyesight in search for food, but also movements and behavior of other birds. While foraging (searching for food) Griffons observe relief below them. Ability to discover carcass in the field depends on openness of the area (Konig, 1974). Therefore, the preference for certain land cover in searching for food of this species will be analysed.

1.3. Implementation of GIS and tools in biodiversity conservation

Geographic-information system (GIS) has a large implementation in various scientific and professional fields. Nowadays, GIS opens for ecologists many opportunities for their research. It provides wide range of tools which help in understanding and analysing the environment as a complex system and patterns of changes in space and time. (Radovic et al., 2014).

GIS incorporates spatial techniques which can improve level of information necessary for conservation decision making within a certain ecosystem. It represents an indispensable tool for understanding complex ecosystems and for practical management in a region where human impact is influential for biodiversity (Vogiatzakis, Mannion, & Griffiths, 2006).

In this research, spatial analysis were carried out, using GIS tools, for understanding and mapping distribution patterns of livestock in a relationship to different habitats that are used for grazing. This was further useful for mapping distribution of carcasses and total dead biomass in order to assess available food for Griffon vultures in Cadiz Province, Southern Spain. Finally, GIS tools were crucial for analysis in this research.

1.4. Research objectives

1.4.1. General objective

To assess food availability for Griffon vultures and understand their foraging behavior as a function of land cover and available dead biomass in wet and dry season, within the context of flying and sitting, in Cadiz province, Southern Spain.

1.4.2. Specific objectives

- Assessment of abundance and spatial distribution of livestock within land cover classes in wet and dry season within the study area.
- Assessment of carcass and total dead biomass availability and distribution in wet and dry season.
- Analysis of Griffon vulture observations as a function of land cover in wet and dry season, while either flying or sitting.
- Analysis of Griffon vulture observations as a function of available biomass, while either flying or sitting.

1.5. Research questions

- What is the abundance of livestock and how is it spatially distributed within present land cover classes in wet and dry season?
- Is the mortality rate of livestock different in wet and dry season?
- What is the quantity and spatial distribution of dead biomass in wet and dry season?
- Is the quantity of available dead biomass after application of the carcass removal from the field significantly different from the quantity before its application?
- What relationship exists between Griffon vulture observations and land cover in wet and dry season, while either flying or sitting?
- What relationship exists between Griffon vulture observations and available dead biomass, in wet and dry season, while either flying or sitting?

1.6. Research hypotheses

Hypothesis 1

- H_0: At $\alpha = 0.05$, There is no significant difference in land cover preference by flying or sitting Griffon vultures between wet and dry season.
- H_a: At $\alpha = 0.05$, There is a significant difference in land cover preference by flying or sitting Griffon vultures between wet and dry season.

Hypothesis 2

- H_0: At $\alpha = 0.05$, the total available dead biomass does not differs significantly between wet and dry season.
- H_a: At $\alpha = 0.05$, the total available dead biomass differs significantly between wet and dry season.

Hypothesis 3

- H_o: At $\alpha = 0.05$, the amount of available dead biomass before carcass removal does not differs significantly from the amount of available dead biomass after carcass removal from the field.
- H_a: At $\alpha = 0.05$, the amount of available dead biomass before carcass removal differs significantly from the amount of available dead biomass after carcass removal from the field.

2. METHOD AND MATERIALS

2.1. Study area

Andalusia is a region in the south of the Iberian Peninsula (coordinates 37˚23'N and 5˚59'W). It is the only European region that encompasses Mediterranean and Atlantic coastlines. The surface area of Andalusia is 87,268 kilometres. According to bioclimatic classification, macrobioclimate is Mediterranean, with dry summers and mild wet winters (Rivas-Martínez, Asensi, Díez-Garretas, Molero, & Valle, 2003).
The average annual temperature is above 16° C. The coldest month is January (6.4°C in Granada), while the hottest is August with 28.5°C recorded in Écija. Annual rainfall ranges from less than 250mm to 700mm. In Western Andalusia is situated one of the wettest villages, Grazalema, with an average annual rainfall of 2,153 mm (Lloyd, 2016).
Andalusia is a mountainous region. This region is characterized by two mountain ranges: Sierra Morena, the northern boundary, and Baetic Cordillera, to the south. Between these mountain ranges lies Guadalquivir Depression. Andalusia has Iberian Peninsula's highest mountains with Mulhacen 3478 m—the highest peak in this Peninsula (Rivas-Martínez et al., 2003).
This area is characterized by a network of protected areas of various categories, including two national parks; Donana and the Sierra Nevada. Andalusia consists of a high proportion of endemic species. (Morillo & Gómez-Campo, 2000). This region is an important roosting and feeding area for European vultures. About 11% out of the total Griffon population in Spain is recorded in Andalusia (Grubac, 2014). Cadiz is a province in the southern part of Andalusia and study area of this research (Figure 3). Cadiz lies on the migratory path of Griffon vultures and has a high density of breeding Griffon vultures.

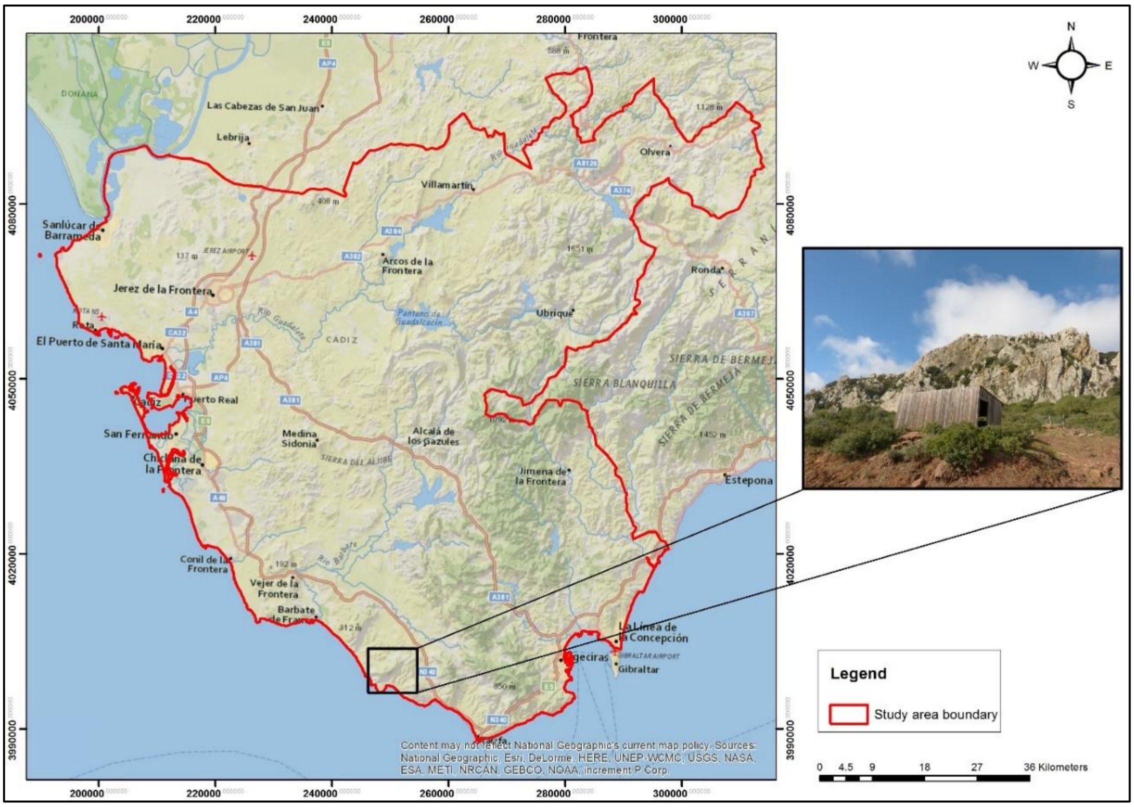

Figure 3. Study Area: Cadiz Province, with marked location of Griffon vulture breeding colony - Laya de la Zarga.

Picture of Laya de la Zarga was taken by Juan Ramírez Román, 2016.

2.2. Primary data collection

Cadiz, the study area, was visited during the month of October, in 2016, for the purpose of data collection. Livestock farms of cattle, goats, and sheep were visited. Questionnaires among farmers were conducted in order to obtain necessary information on livestock. Data obtained during the field work is as follows:

- The number of dead animals per farm, which was used for mortality rate calculation.
- Information on grazing areas in wet and dry season; this was used for analysis of spatial distribution of livestock within land cover classes in the wet and dry season.
- Land cover samples which were used for regrouping land cover classes within the study area.

In order to take samples on the land cover within the study area, random sampling technique was applied. Large areas are fenced as private property and no trespassing is allowed. Moreover, many areas could not be reached because of inaccessibility of the terrain. Therefore, random sampling showed as the most appropriate technique. As for visiting the farms, purposive and random sampling was applied. Many farms are not registered within the Cadiz Province, so random sampling needed to be applied.

Figure 4. Fieldwork, primary data collection in Cadiz Province.

"On Figure 4, in the upper left corner can be seen wide area covered by grass with cattle grazing on it. In the lower left corner can be seen a farmer interviewed in Tarifa municipality, during the fieldwork conducted in October 2016. In the upper right corner typical habitat for Southern and Western Spain is shown, a mixture of trees and shrubs with crops. In the lower right corner can be seen area covered by grass with trees and shrubs.

2.3. Secondary data acquisition

2.3.1. Administrative data

Administrative boundaries of provinces and municipalities within Spain were acquired from Global Administrative Areas database (Global Administrative Areas, 2014). This data was used for extraction of Cadiz provincial boundary and administrative boundaries of municipalities within Cadiz. This data was further used for analysis concerning the spatial redistribution of livestock.

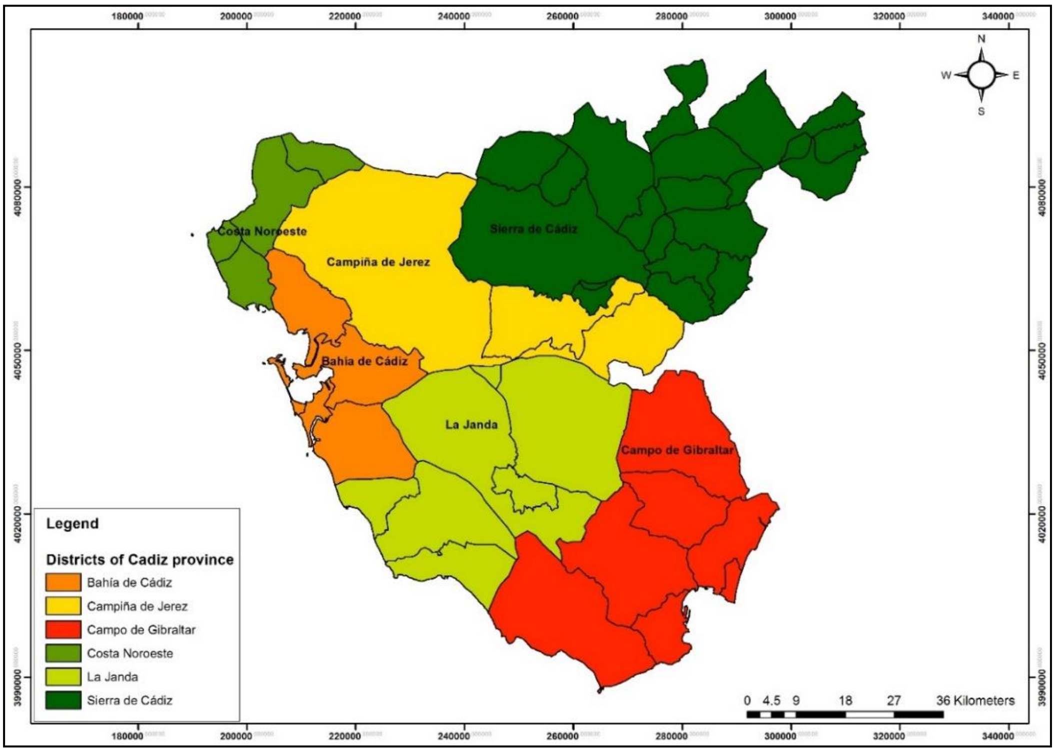

Figure 5. Districts within Cadiz Province and administrative boundaries of municipalities within each district.

2.3.2. CORINE land cover

CORINE Land Cover (CLC 2006) raster data, with a resolution of 250m, was acquired from European Environment Agency database ("Datasets — European Environment Agency (EEA)," 2016) . The year 2006 was the most recent available at the time when data was acquired. It contains 3 levels of land cover/land use classification. This was further used for livestock redistribution within land cover classes. Land cover map of 250m resolution was choose based on the research done by Mcintyre (2010). The author used CORINE land cover (250m resolution) for redistributing livestock per land cover.

2.3.3. Livestock census data

Livestock census data was obtained from Department of Agriculture, Fisheries and Rural Development of Cádiz (Appendix, page 38). Data on livestock population (cattle, goats, and sheep) within municipalities of Cadiz, for 2015 and 2016, was used. Census on cattle, goats, and sheep was used because these domestic animals make the majority of food for Griffons (Grubac, 2014). This served as an input for redistribution of livestock within certain land cover classes and also for redistribution of carcasses and biomass.

2.3.4. Telemetric data of Griffon vulture

Telemetric data on Griffon vulture was obtained from ITC database. This data consists of 19870 observations of one Griffon vulture, called Menzo, for the period between 2010 and 2015 for all the months of the year except July. The telemetric data was further used in the analysis of the relationship between the presence of Griffon vulture and land cover and available biomass.

2.3.5. Digital elevation model (DEM)

Digital elevation model (DEM 1 arc-second, approximately 30 meters) was obtained from the Shuttle Radar Topography Mission (SRTM) for Cadiz area (“EarthExplorer,” 2017). This was used for generating the slope map. Slope map was used for filtering Griffon vulture telemetric data.

2.4. Software and tools

For the purpose of data processing and analysis, during different phases of this research, various software packages and tools were used. The usage of different software packages and purpose of their use is shown in Table 1.

Table 1. Software packages used in research.

SOFTWARE	Version	PURPOSE OF USE
ArcMap	10.3.1	Data processing Spatial Analysis
ERDAS IMAGINE	2015	Data processing
Google Earth	7.1.8.3036	Data validation
R Studio	1.0.44	Statistical analysis
MS Office (Excel)	2010	Statistical analysis
MS Office (Word)	2010	Thesis writing

2.5. Methodology

2.5.1. Phases in methodology

Overall methodology, applied during this research, consists of several phases. The first phase consists of food availability analysis necessary for determining the distribution of dead biomass, available for Griffon vultures within the study area in wet and dry season. This phase also consists of statistical analysis carried out in order to determine differences in food availability between two seasons and impact of carcass removal policy on the total dead biomass availability. The second phase consists of analyses of the relationship between Griffon vulture observations and land cover and also the amount of biomass in two seasons. These analyses were necessary for understanding foraging behaviour of Griffon vultures. All data that was acquired, was projected into WGS 1984 UTM Zone 30 by applying Projection tool in ArcMap.

2.5.2. Food availability analysis

Set of analysis was carried out to determine food availability for Griffon vultures. A flowchart of food analysis can be seen on the Figure 17 (page 21). The final output is a map of livestock distribution, carcasses distribution, and biomass distribution in the wet and dry season. The period from January to April, and months November and December were defined as the wet season. The period from May to October is defined as the dry season.

Firstly, the land cover map, which was covering whole Europe, was set up to the extent of administrative boundaries of municipalities within the study area. Within initial attribute table of CORINE, three levels of classes were given. Based on sample points on land cover, collected in the field, classes were regrouped on 4th level as follows: built-up, crops, grass, shrubs, forest, mixture of trees and shrubs with crops or grass, olives and other fruits, bare ground, marshes and surface water. Land cover present within Cadiz Province can be seen on Figure 6 (page 11).

The area size of each land cover class within the study area can be seen in Table 2. Shrubs, forest and crops cover large area. Grass and mixture of trees and shrubs with crops or grass also occupy significant part of the study area. These land covers are used for extensive grazing, which implies that there is potential for large amount of available food for Griffon vultures.

Table 2. Area size of land cover classes within Cadiz province.

Land cover classes	Area size (ha)
Built-up	25963
Crops	300150
Grass	60025
Shrubs	156269
Forest	116006
Mixture of trees and shrubs with crops or grass	21169
Olives and other fruits	32356
Bare ground	4788
Marshes	14988
Surface water	11481

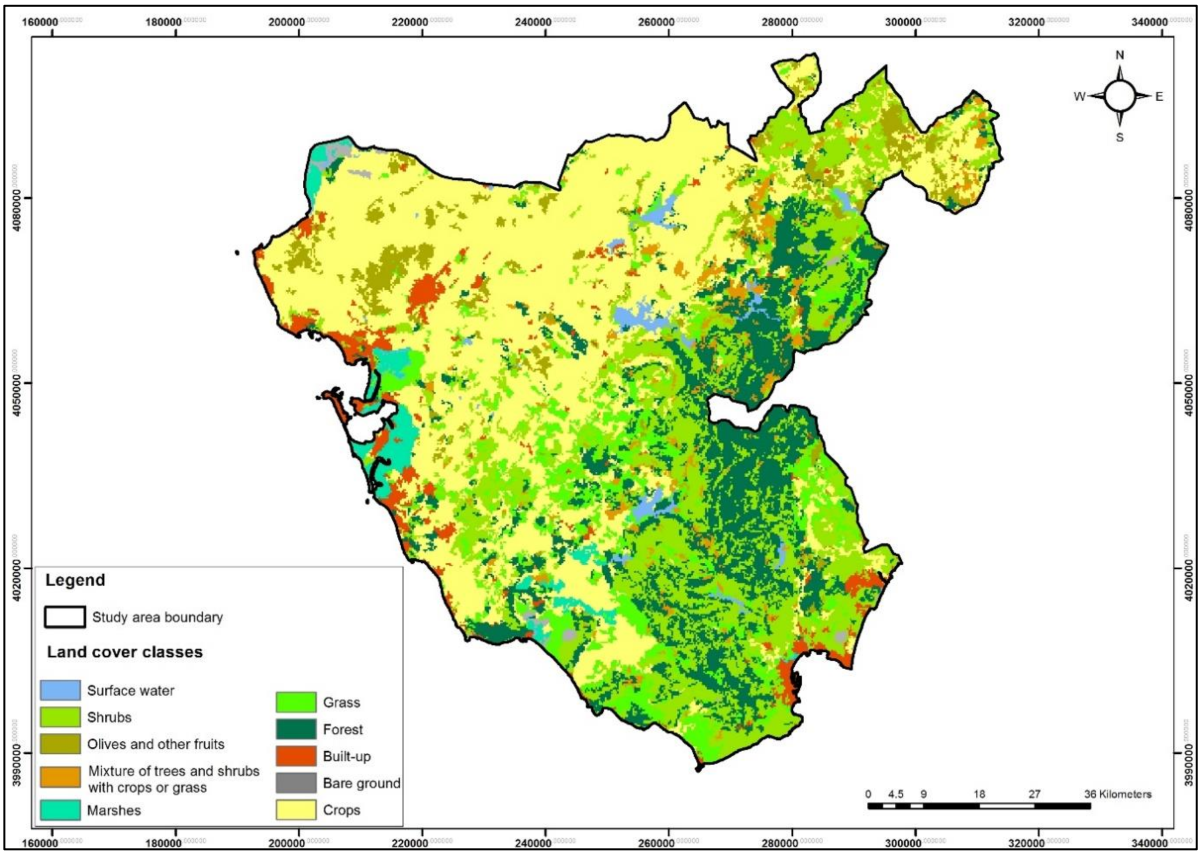

Figure 6. Land cover present within Cadiz Province.

Based on the answers given by the farmers during the fieldwork, certain land covers are used for grazing differently in wet and dry season (Figure 7 - page 12, Figure 8 - page 13, Figure 9 - page 14). Area size (ha) of each land cover type that is used for cattle, goats and sheep grazing in two seasons is shown in Table 3 (page 12), Table 4 (page 13) and Table 5 (page 14), respectively. The percentage of area used for grazing in wet and dry season was converted into fractions which were applied to livestock census data (cattle, goats, and sheep). Livestock census was available for each municipality. Finally, livestock census data was redistributed within the land cover per each municipality in wet and dry season (Figure 19 - page 23, and Figure 20 - page 24). The calculation used for redistributing the livestock within the land cover per each municipality is as follows:

Livestock distribution = fraction of land cover x livestock census data per each municipality

The land cover classes that are not used for grazing by livestock are as follows: built-up, bare ground, olives and other fruits, marshes and surface water. These land cover classes were assigned with zero value. This was taken as an assumption based on an expert knowledge and the responses given by farmers through questionnaires.

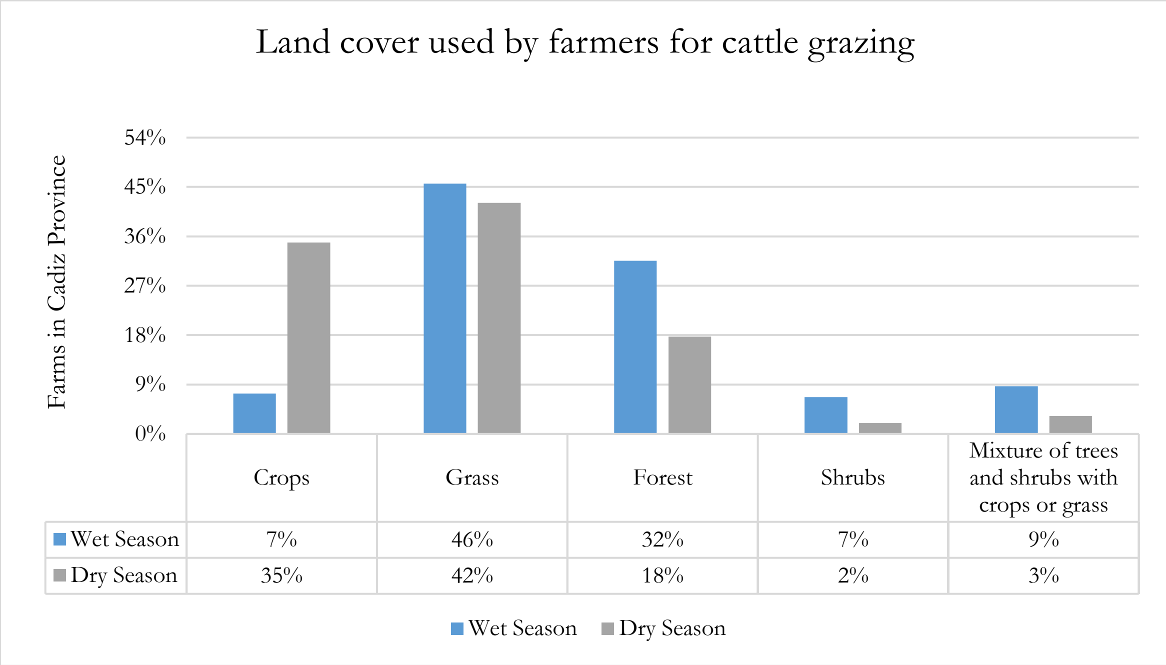

Figure 7. Percentage of each land cover used for cattle grazing by farmers in wet and dry season.

Table 3. Area size of each land cover type used for cattle grazing, in two seasons.

Land cover	**Area size (ha) used for cattle grazing in wet season**	**Area size (ha) used for cattle grazing in dry season**
Crops	21011	105053
Grass	27612	25211
Forest	37122	20881
Shrubs	10939	3125
Mixture of trees and shrubs with crops or grass	1905	635

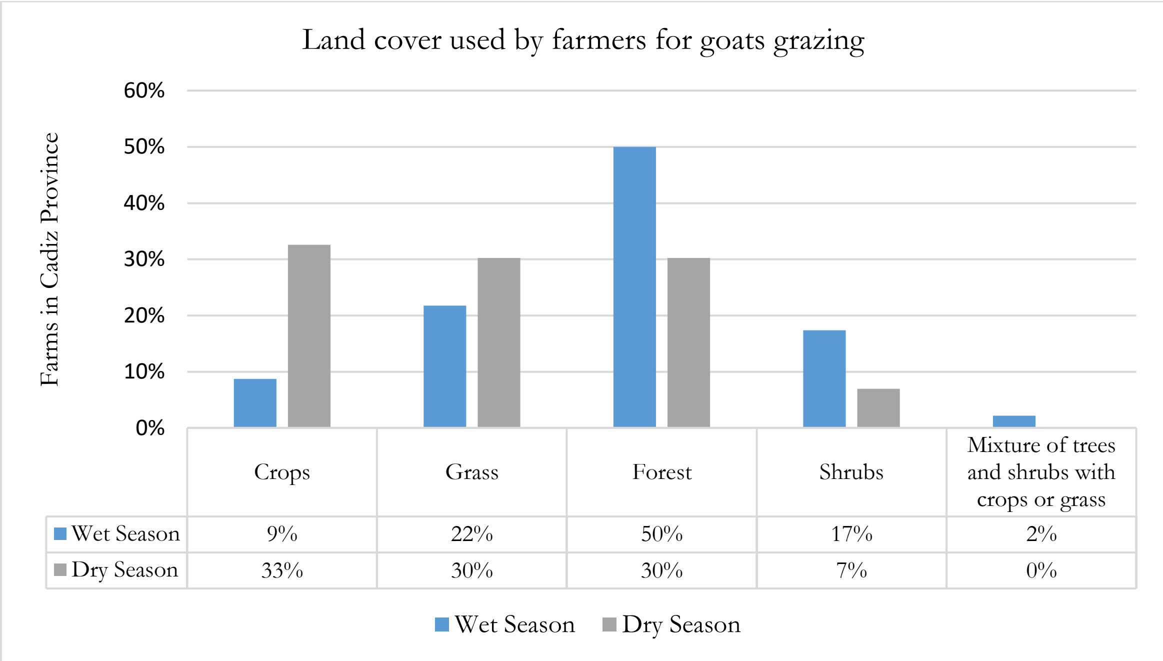

Figure 8. Percentage of each land cover used for goats grazing by farmers, in wet and dry season.

Table 4. Area size of each land cover type used for goats grazing, in two seasons.

Land cover	**Area size (ha) used for goats grazing in wet season**	**Area size (ha) used for goats grazing in dry season**
Crops	27014	99050
Grass	13206	18008
Forest	58003	34802
Shrubs	26566	10939
Mixture of trees and shrubs with crops or grass	423	0

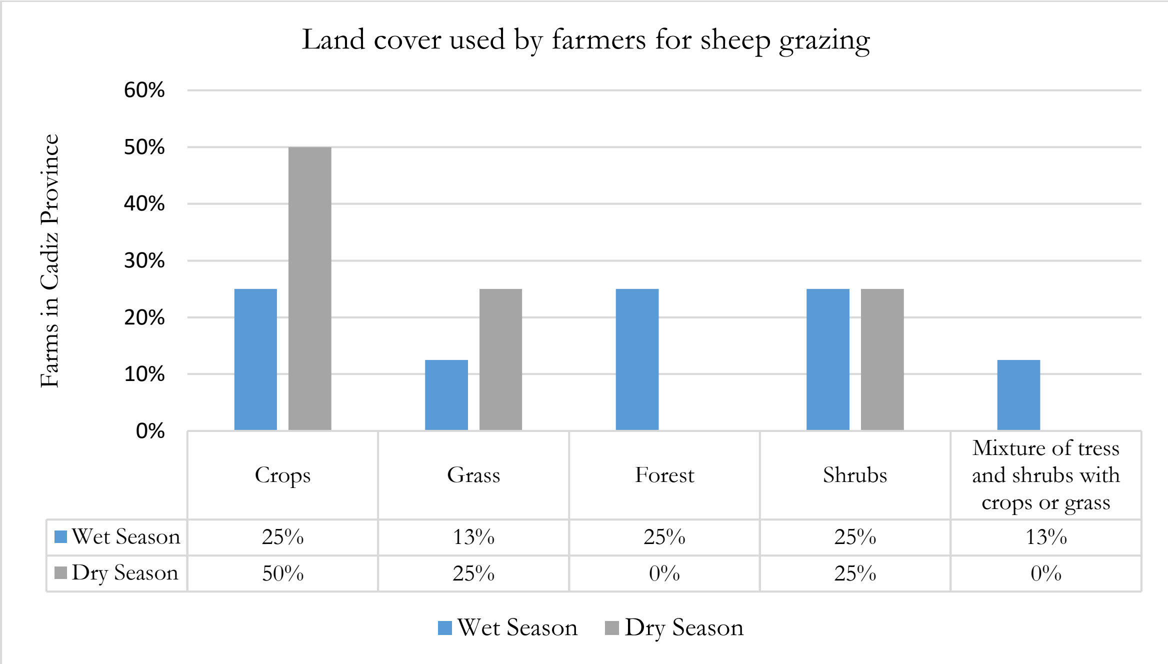

Figure 9. Percentage of each land cover used for sheep grazing by farmers, in wet and dry season.

Table 5. Area size of each land cover type used for sheep grazing, in two seasons.

Land cover	**Area size (ha) used for sheep grazing in wet season**	**Area size (ha) used for sheep grazing in dry season**
Crops	75038	150075
Grass	7803	15006
Forest	29002	0
Shrubs	39067	39067
Mixture of trees and shrubs with crops or grass	2752	0

Secondly, the map of carcass distribution in wet and dry season was produced. This was done by the application of a mortality rate to the livestock distribution. The mortality rate was calculated based on the ratio of dead animals to animal population (cattle, goats, and sheep). The number of dead animals was obtained from farmers. Number of dead cattle and goats differs between wet and dry season within Cadiz Province (Figure 10). The number of dead sheep, however, does not differ between wet and dry seasons. Based on the questionnaires, number of dead sheep over the year within Cadiz Province is 550. Furthermore, the percentage carcass removal was taken into consideration. The percentage of carcass removal was obtained from questionnaires conducted among farmers (Figure 11). This can give insight into the impact of carcass removal policy on the amount of livestock carcasses that could serve as food for Griffon vultures.

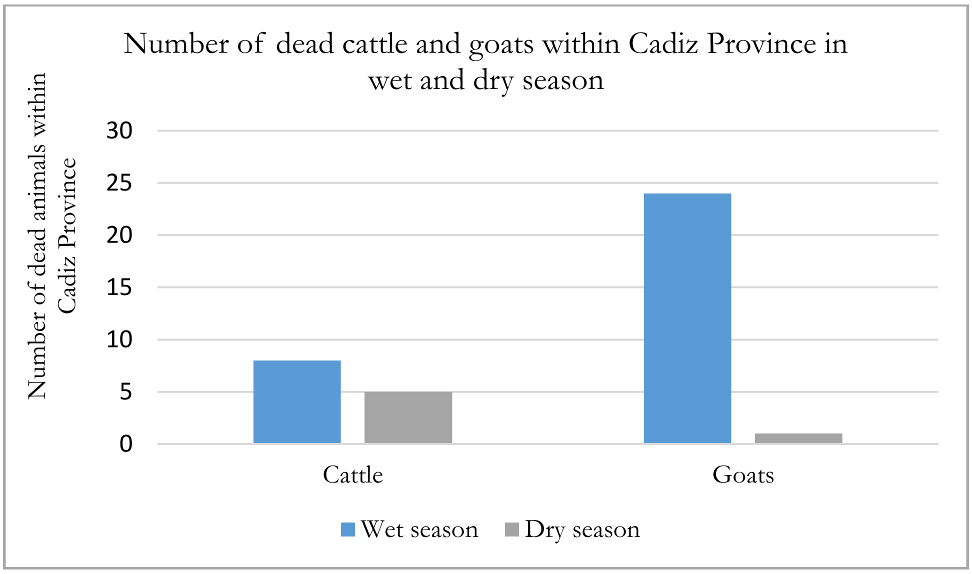

Figure 10. Number of dead cattle and goats within Cadiz Province in wet and dry season, used for mortality rate calculation.

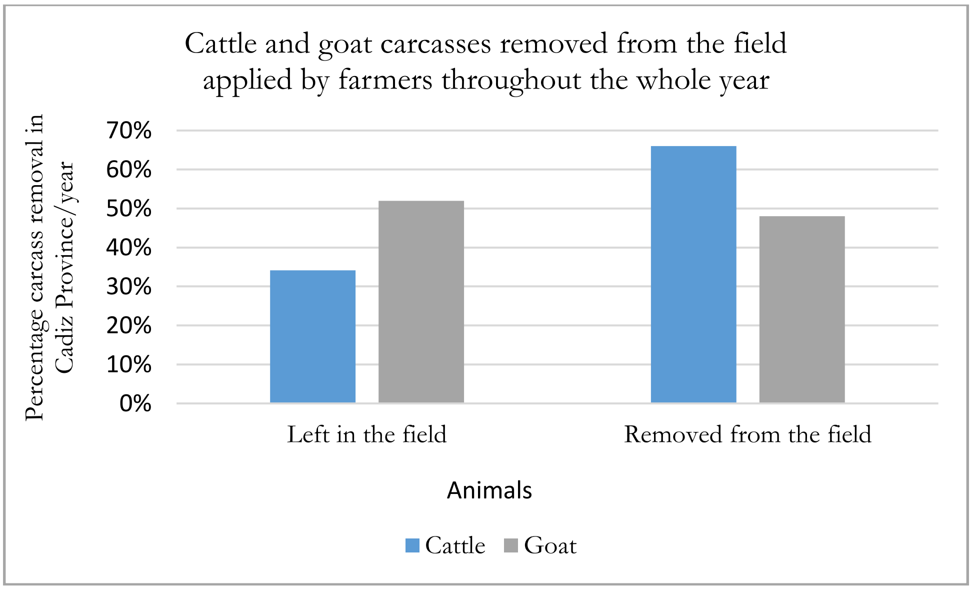

Figure 11. Percentage of cattle and goat carcasses removed from the field in Cadiz Province throughout the whole year.

Finally, carcass distribution maps (i.e. cattle, goats and sheep carcasses together) in the wet and dry season were produced (Figure 21 - page 25, Figure 22 - page 26). Calculations for mortality rate and carcass distribution can be seen below:

Mortality rate = (Number of dead animals / animal population) x 100

Carcass distribution within municipalities = Mortality rate x number of livestock per municipality x percentage carcass removal

Thirdly, average animal weight was applied to carcass distribution. The information on livestock weight, differing among the types of animals, were obtained from questionnaires. The average weight of cattle (607kg) was derived from the average for cows and bulls together. The same was applied for goats and sheep. The average weight of goats is 54kg and of sheep is 48kg. Body composition is a function of many factors such as stage of growth, nutrition, genetics, pregnancy, alimentary canal and presence of abnormalities (Topel & Kauffman, 1988). These factors that have an impact on the animal weight were not taken into consideration for this research. Moreover, only adult animals were taken into account. According to van Beest, van den Bremer, de Boer, Heitkönig, & Monteiro (2008), Griffons feed only on meat and entrails, so the potentially available biomass of total cattle body weight is 31%. As for sheep and goats, according to Donázar & Carmelo (1990), as cited in van Beest et al.(2008), the available biomass of total body weight is 27%. These percentages were applied in the research, taking as an assumption that the same amount of dead biomass is available (cattle, goats and sheep) for Griffons in the study area of Cadiz. The biomass distribution maps in the wet and dry season (i.e. total dead biomass of cattle, goats and sheep together) were produced as final output (Figure 23 and Figure 24, page 27). Biomass calculations can be seen below:

Total dead biomass distribution within municipalities = Number of carcasses per municipality x average animal weight x percentage available biomass of total animal weight

Maps of livestock, carcass and biomass distribution in wet and dry season were reclassified. Initial classes had values given in ranges. For each range of values of old classes, mean value was calculated and taken as final value for the new class. Biomass classes were further used for analysis of relationship between Griffon vulture observations and the amount of biomass in two seasons.

2.5.3. Comparison of biomass taking into account seasonality and carcass removal policy application

After the total dead biomass was calculated in wet and dry season, the comparison analysis were carried out. In order to analyse whether the difference between total amounts of biomass available for Griffon vultures between two seasons is significant, paired 2-sample t-test was carried out at 95% confidence level (Table 6, page 28). Next, analysis focus on assessment of impact that carcass removal policy has on the total amount of available biomass for Griffon vultures was carried out. The comparison analysis was done between the amount of biomass available for Griffon vultures without carcass removal from the field and the amount of biomass left after carcass removal from the field. This was done by applying paired 2-sample t-test at 95% confidence level, so the significance of difference could be estimated and assessment of whether carcass removal policy leads to significant reduction of available biomass in the field for Griffons (Table 7, page 28).

2.5.4. Filtering Griffon vulture telemetric data

In order to use observations of Griffon vulture for further analysis, a few steps were carried out. Firstly, telemetric data was split based on speed criteria. The speed indicates whether the bird is flying or it is grounded. By splitting the data into two sets, sitting and flying, it is possible to analyse foraging behavior of the bird in two different conditions. The speed from 0 to 1 m/s was used to single out observations for the grounded Griffon. The speed above 1m/s was criteria to single out observations for flying Griffon. Secondly, both set of data, flying and sitting, was split into wet and dry season in order to analyse seasonal differences in behaviour. Seasons were defined in the same way as it was done in previous analysis. The period from January to April, and months November and December were defined as wet season. Dry season covers period from May to October.
Observations of flying Griffon vulture in wet and dry season within study area are shown below on Figures 12 and 13 (page 18).

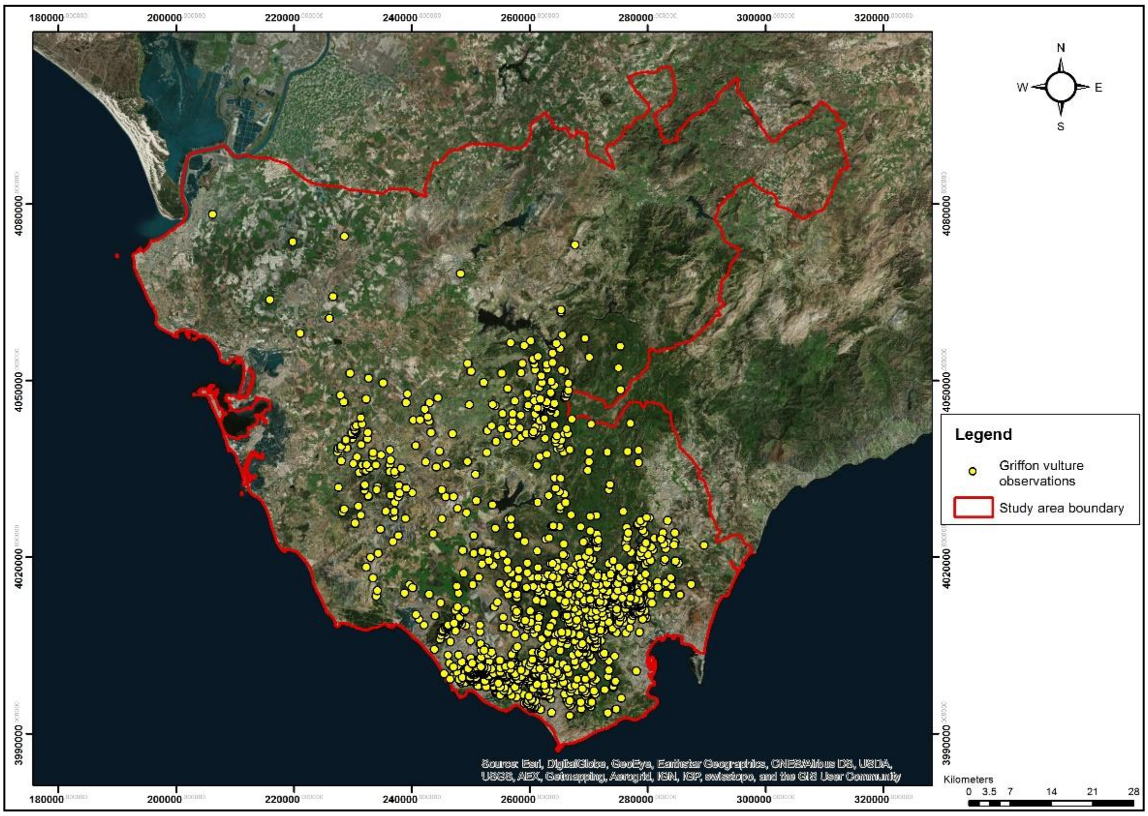

Figure 12. Observations of flying Griffon vulture in wet season within Cadiz Province.

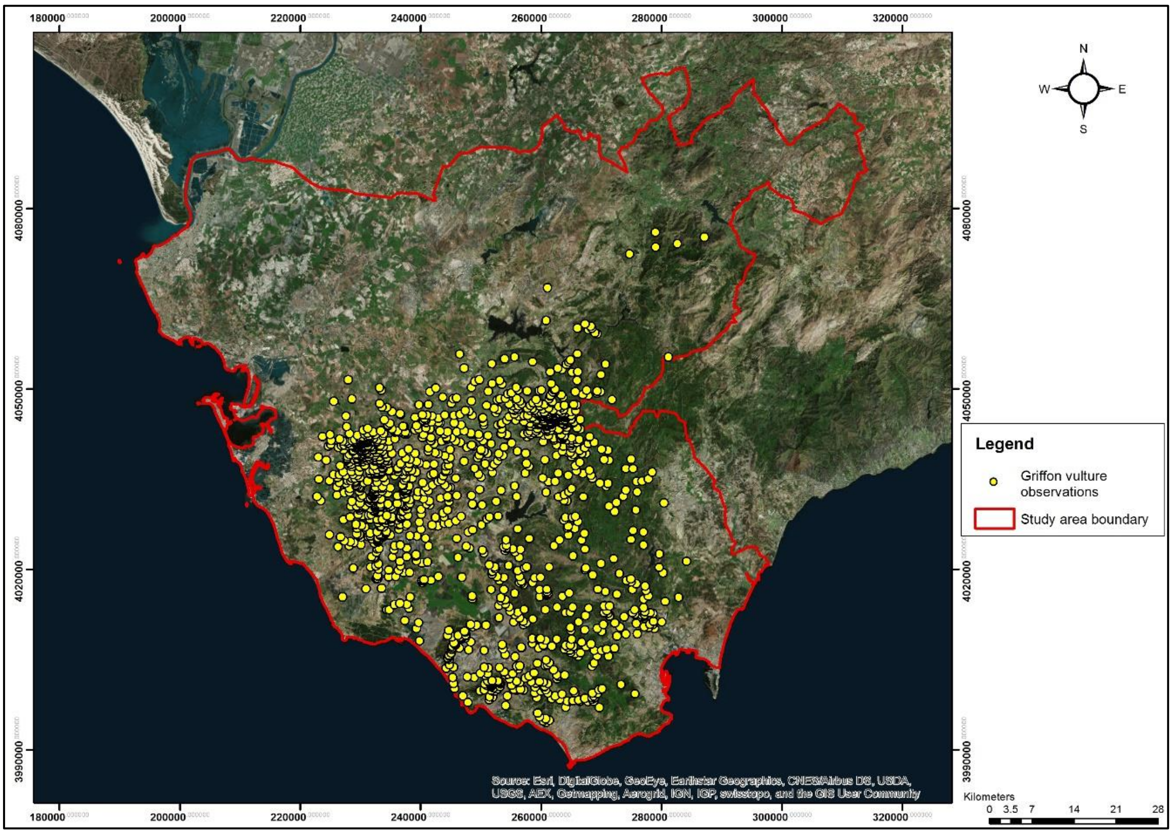

Figure 13. Observations of flying Griffon vulture in dry season within Cadiz Province.

Next, the sitting Griffon data (grounded Griffon) was filtered based on the period of the day when the bird was tracked. Within the data set, tracking time is given in hours. Since Griffons feed during daytime, the observations from dawn to dusk were selected. The differences in length of day (measured in hours) between months over the year were taken into account. Observations of Griffon vulture during night time are excluded. Figure 14 (page 19) shows the scale which was used to select daytime in different months ("Sunrise and Sunset Times," 2017).

Observations of sitting vulture that are within areas which are considered as potential breeding locations were excluded. Griffon vultures breed on steep slopes, thus, the slope is an important factor for breeding site selection (Grubac, 2014). For breeding purposes, Griffon vultures occupy slopes from 15 degrees and above as cited in Gavashelishvili & McGrady (2006). Every observation that falls within 15 degrees and above were considered to be located on potential breeding sites, so those observation points were excluded. This was done because analysis on breeding of Griffon vultures do not fall within the scope of this research. Filtered data of sitting and flying Griffon were used for further analysis. Observations of sitting Griffon vulture in wet and dry season within study area are shown on Figure 15 (page 19) and Figure 16 (page 20). Observation points (for sitting and flying Griffon) were converted into count and frequency of observations per unit area (250 x 250 m or 6.25 ha) was obtained. This was further used for analysis of the relationship between Griffon vulture observations and available biomass and land cover. For the flow of activities that were carried out see **Error! Reference source not found.** (page 22).

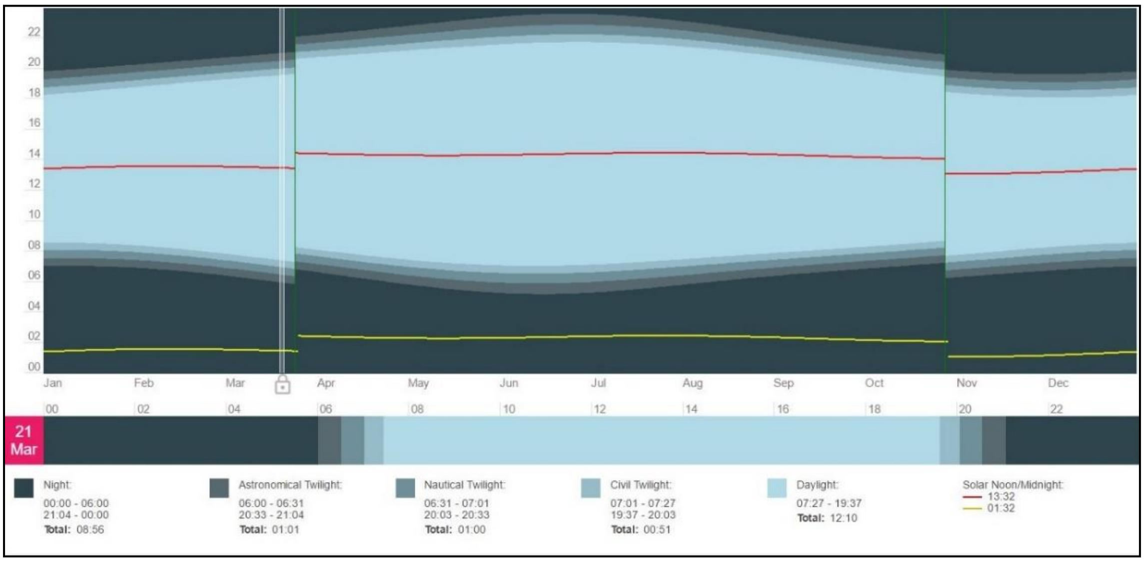

Figure 14. Scale used for sitting data filtering based on daytime.

"On Figure 14, a section on the scale that refers to daylight was used to select period from dawn to dusk. Time on the scale is expressed in hours. Scale also offers choice of certain month. Before selecting daytime specific month needs to be defined above the scale. "

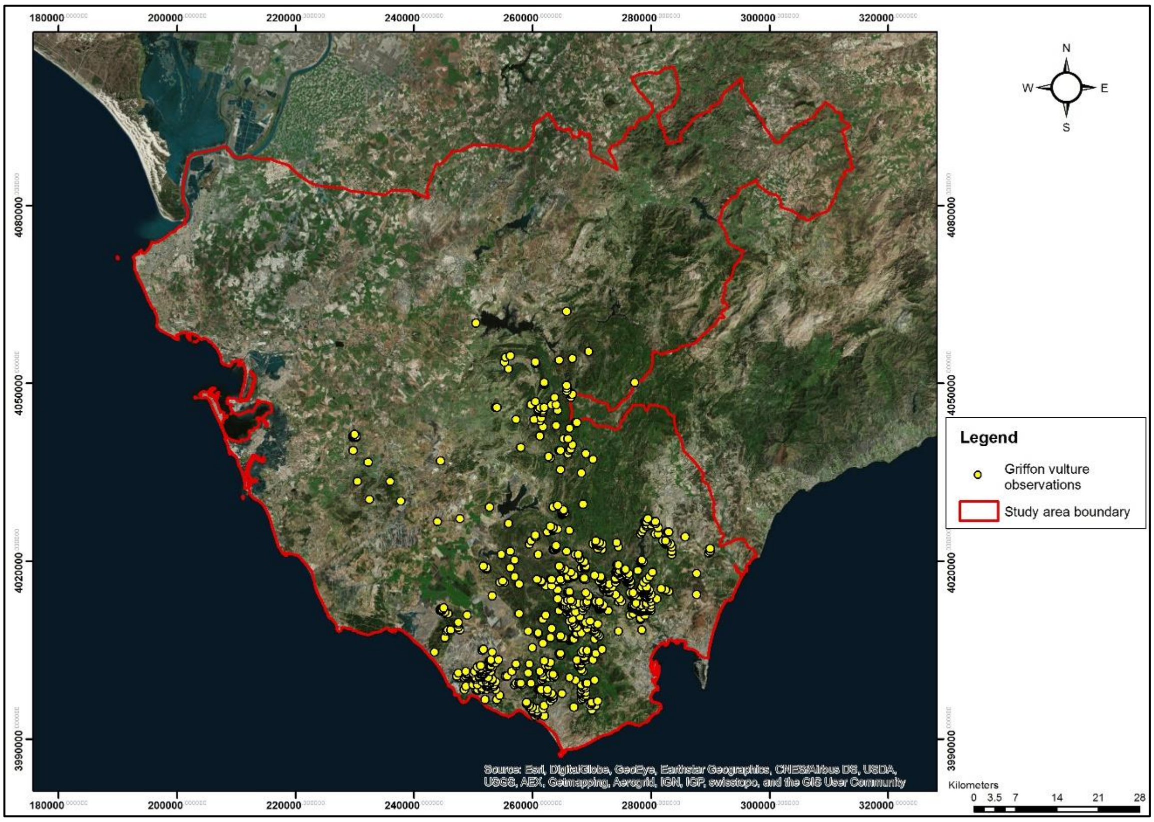

Figure 15. Observations of sitting Griffon vulture in wet season within Cadiz province.

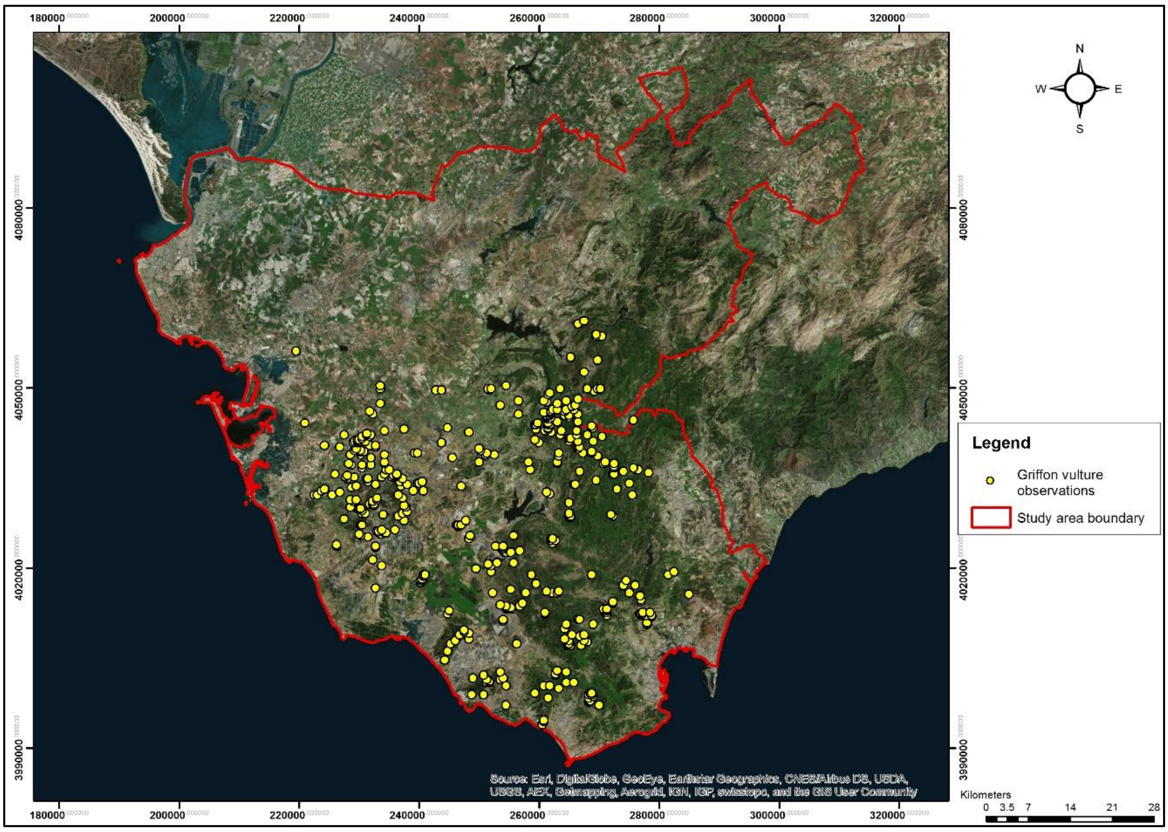

Figure 16. Observations of sitting Griffon vulture in dry season within Cadiz province.

2.5.4.1. Analysis of relationship between Griffon vulture observations and land cover

Analysis of relationship between Griffon vulture observations and land cover were carried out with the aim to assess Griffon vulture preference for certain land cover types in wet and dry season (Figure 25 - page 30 and Figure 26 - page 30). These analysis were carried out separately for sitting and flying Griffon vulture observations. The division between observations and area size of each land cover class was done in order to obtain observations per unit area (observations per ha/season). This was further standardized in order to get the range of values from o to 1. Values closer to one indicate larger number of observations per unit area within certain land cover class. Observations in wet and dry season as function of land cover were compared in order to assess whether there is a significant difference in land cover preferences by Griffon vulture between the two seasons. Due to non-normal distribution of data and small sample size (n< 30), nonparametric Wilcoxon Signed Rank test was carried out for this analysis (Table 8).

2.5.4.2. Analysis of relationship between Griffon vulture observations and the amount of dead biomass

The analysis of relationship between Griffon vulture observations and available dead biomass in wet and dry season were carried out, taking into consideration two conditions; flying and sitting (Figure 27 and Figure 28, page 31). The aim of these analysis is to understand the relationship between Griffon vultures and the amount of dead biomass in order to analyse if there is a preference for a specific amount of biomass. In order to obtain observations per unit area (observations per ha/season), division was done between observations and area size of each biomass class. Same was applied to biomass in order to obtain amount of biomass per unit area (kg/ha). By applying this method, an assumption on uniformly distributed biomass within study area was made. Observations were further standardized in order to get the range of values from o to 1. Values closer to one indicate larger number of observations per unit area containing a specific amount of biomass.

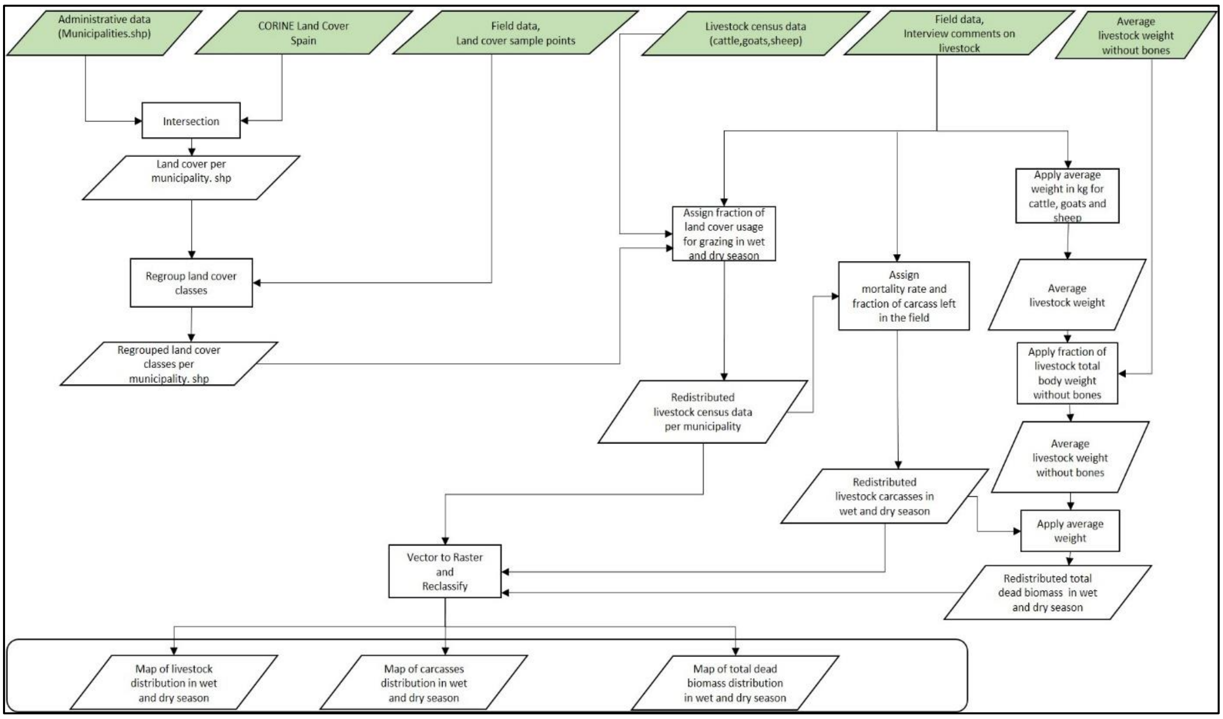

Figure 17. Flowchart showing food availability analysis.

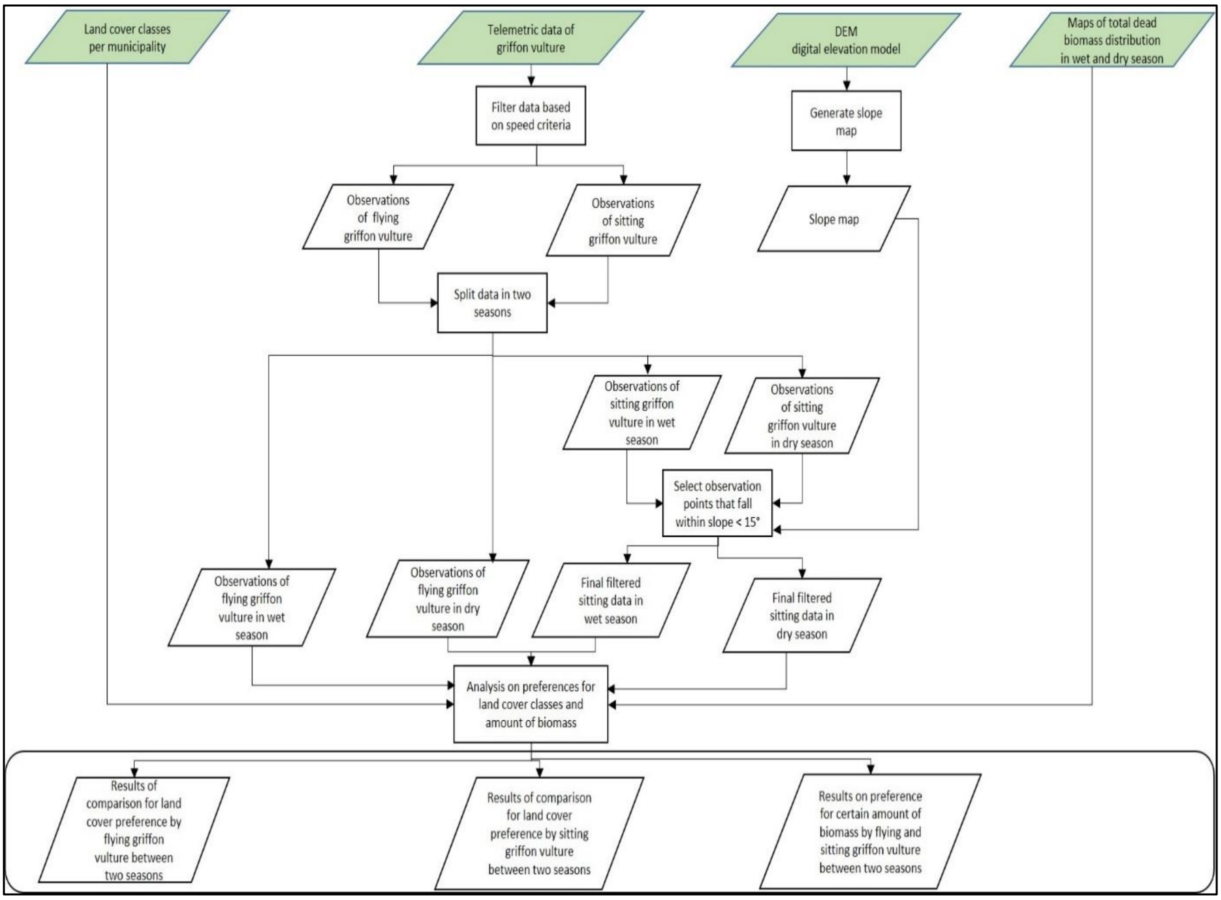

Figure 18. Flowchart of preparation of observation data for flying and sitting Griffon vulture for the analysis on preference for land cover and biomass.

3. RESULTS

This chapter is divided into a few sections referring to different sets of analysis that were carried out. First section contains results on food availability in wet and dry season. Next section refers to assessment of impact of carcass removal policy on the amount of available dead biomass for Griffon vultures. Finally, results on land cover preference and preference for certain amount of biomass by Griffon vulture are given.

3.1. Food availability maps

After food availability analysis as the output, maps of livestock distribution, carcass distribution and biomass distribution within the study area, in wet and dry season, were created. Maps of livestock and carcasses distribution in two seasons represent intermediate maps created in order to produce final maps of dead biomass distribution in wet and dry seasons. Map of livestock distribution in wet and dry season (Figure 19 and Figure 20 - page 24) show the number of cattle, goats and sheep together within municipalities of Cadiz. Livestock distribution is related to the land cover which differs among different parts of province and within municipalities. Low numbers of livestock or their absence is in areas covered by marshlands and other water bodies, built-up areas and olives and other fruits which are not suitable for livestock grazing.
Areas covered by grass, forest, shrubs and areas with mixture of trees and shrubs with crops or grass serve for extensive farming, so a high density of livestock is concentrated in these areas.

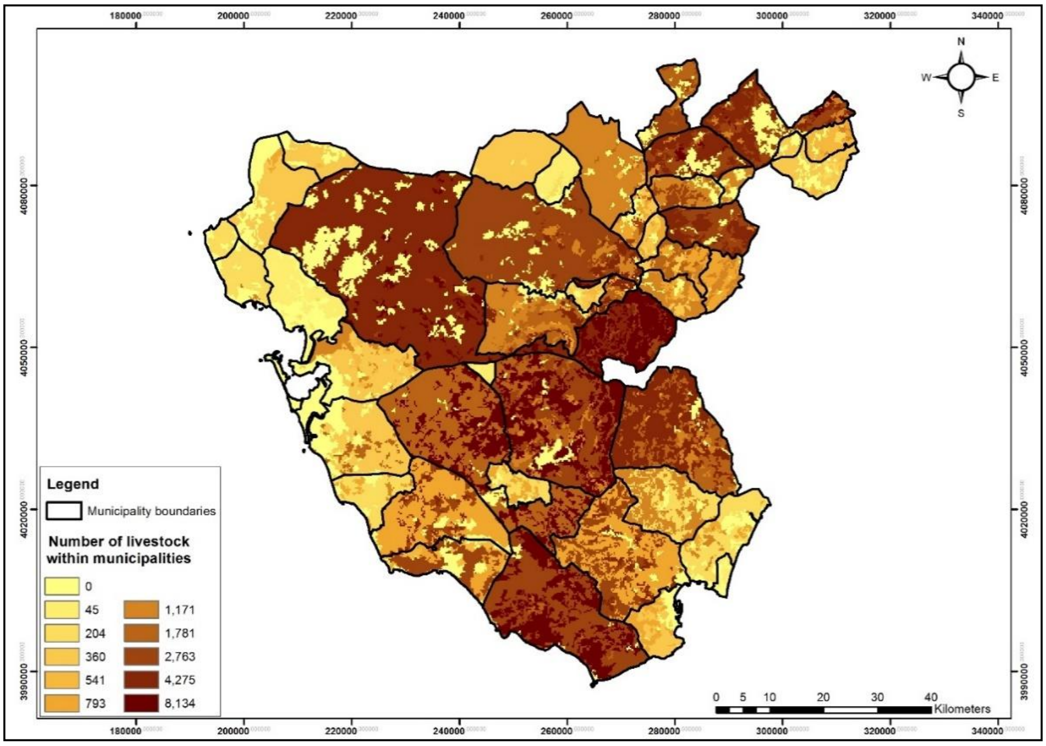

Figure 19. Number of livestock (cattle, sheep and goats) distributed within municipalities in wet season.

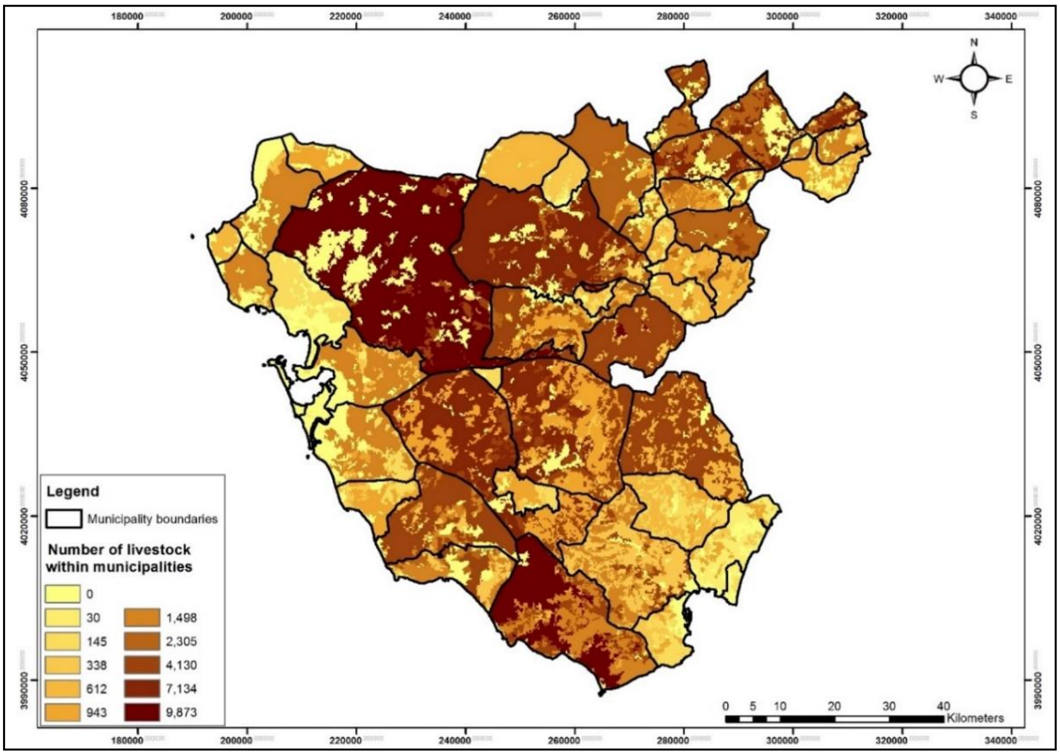

Figure 20. Number of livestock (cattle, goats and sheep) distributed within municipalities in dry season.

During dry season, livestock is similarly redistributed within the study area as compared to wet season. There is, however, more livestock present within areas covered by crops than in wet season. This is due to the fact that the percentage of usage of areas covered by crops for cattle, goats and sheep grazing is higher in dry than in wet season because of harvesting period. In dry season, livestock is less present in forests and shrub lands than in wet season. This could be the result of floods that occur in wet season in more flat areas as stated by farmers that move livestock to forests. Forests are mostly located on higher altitudes and on slopes where rainwater does not retain, thus it is suitable and safe for livestock. During the dry season, shrubs dry easily due to high temperatures and lack of rain, thus there is less food available for livestock on shrub lands.

Maps of carcass distribution in wet and dry season (Figure 21 - page 25, Figure 22 – page 26) show the number of livestock carcasses available within municipalities. Distribution of carcasses is related to the amount of livestock present within municipalities, however percentage carcass removal from the field was taken into account. Forests and shrub lands that cover mostly western and southern parts of the Province, are highly suitable for goats and sheep grazing. Number of dead goats in wet season is notably higher than in dry season. By considering these factors, it is clear why there are more carcasses in this part of study area in wet season. In northern parts of Cadiz Province where crops occupy a large surface in dry season, there are more available carcasses. This is due to the fact, as already mentioned before, that area covered by crops is used for cattle, goats and sheep grazing more during this period of the year (harvesting period), and thus more available carcasses are expected.

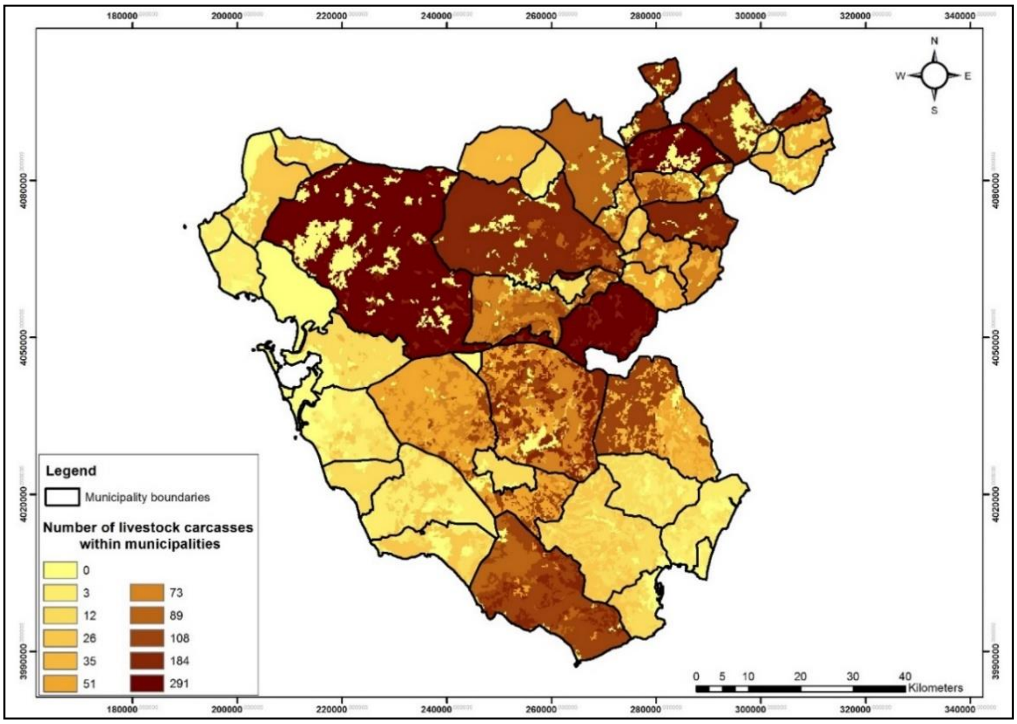

Figure 21. Number of livestock carcasses distributed within municipalities in wet season.

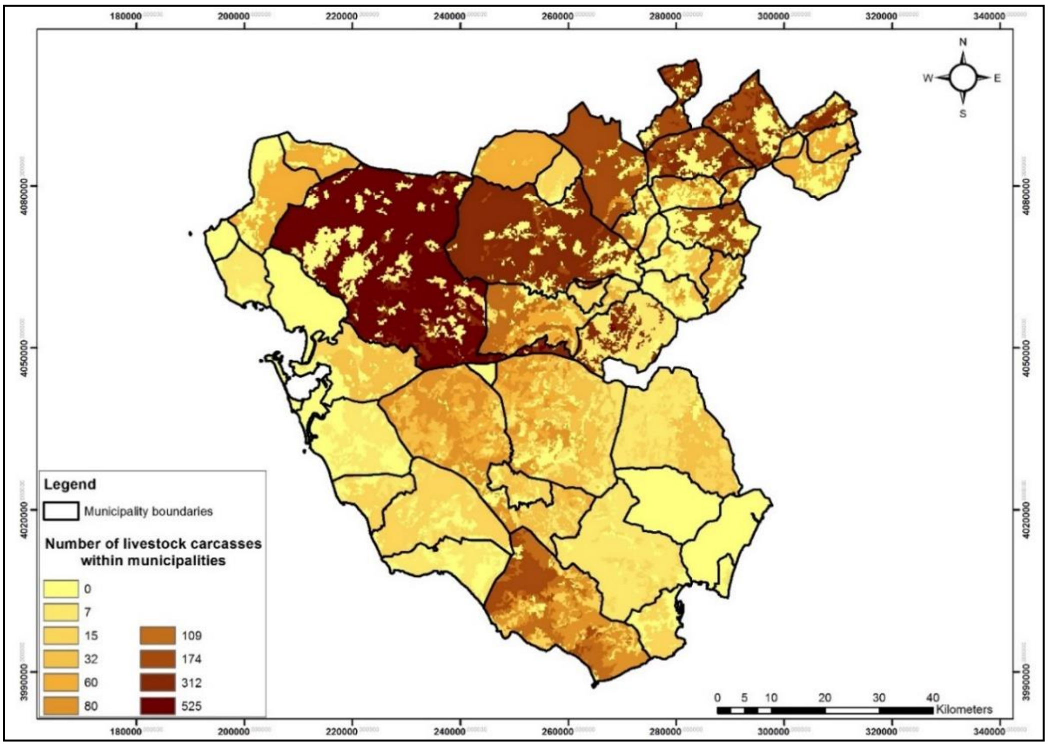

Figure 22. Number of livestock carcasses distributed within municipalities in dry season.

Map of total dead biomass distribution in wet and dry season (Figure 23 and Figure 24, page 27) is derived from carcasses distribution maps, therefore distribution of biomass coincides with spatial distribution of carcasses. These maps show the amount of dead biomass in kg within municipalities available for Griffon vultures in wet and dry season. It is important to mention that the amount of biomass is not a reflection of the amount of carcasses. Griffon vultures are adjusted to feed on soft tissues of dead animals, so bones are not part of their diet (Grubac, 2014). Therefore, only part of total carcass biomass, without bones, is considered in the research.

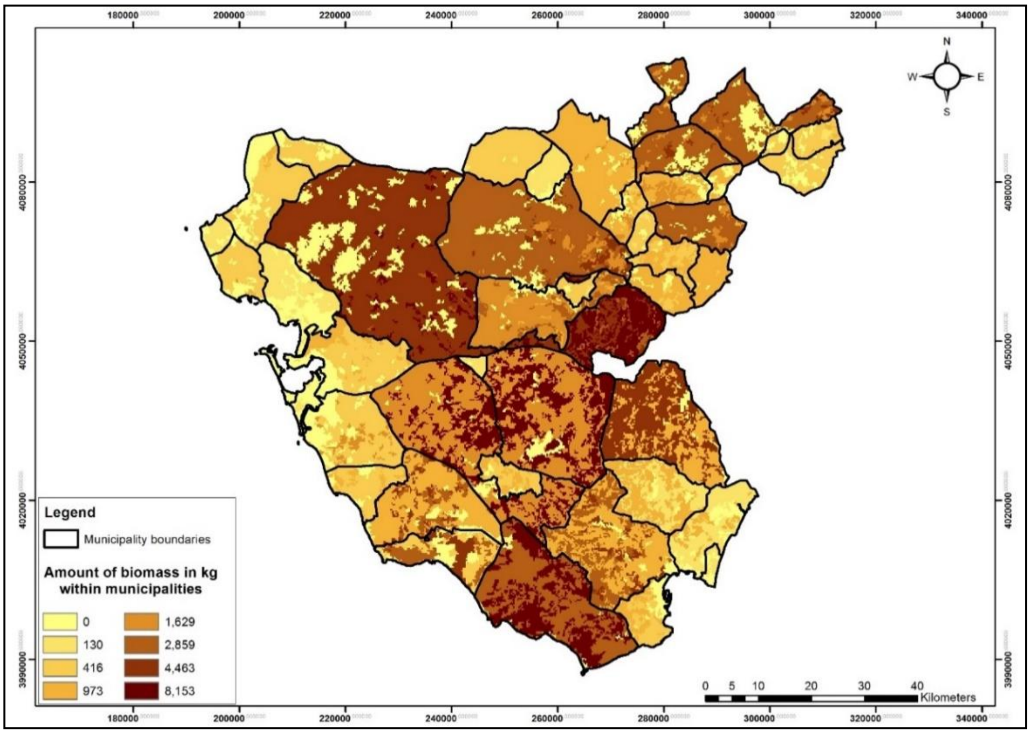

Figure 23. Amount of dead biomass in kg within municipalities available for Griffon vultures in wet season.

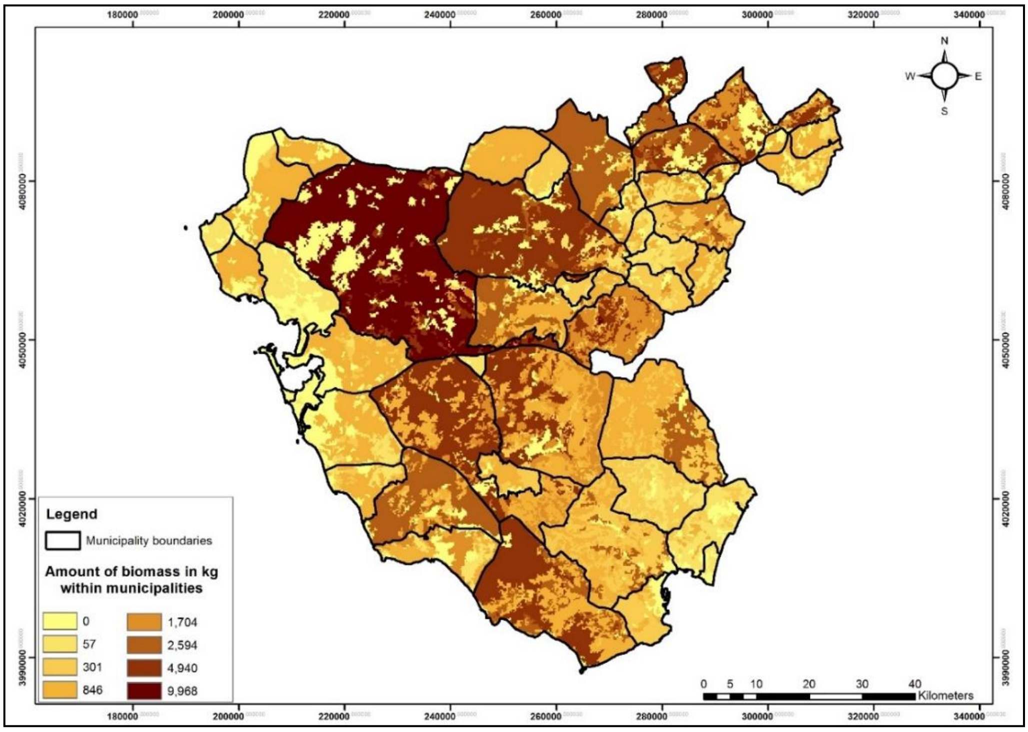

Figure 24. Amount of dead biomass in kg within municipalities available for Griffon vultures in dry season.

The results of paired 2-sample t test carried out due to comparison of amounts of total dead biomass available in wet and dry season, after carcass removal from the field, are shown in Table 6. The t stat value 4.27 is more than t critical (1.97) and this implies that there is a significant difference between the two data sets being tested. This is significant at $\alpha=0.05$ with a P value at $2.5E^{-5}$, thus the null hypothesis pertaining to this was rejected (Hypothesis 2). There is 31% (277kg) less biomass available for Griffon vultures in dry season as compared to wet season.

Table 6. Analysis of difference in total dead biomass availability between wet and dry season.

	Biomass with carcass removal wet season	***Biomass with carcass removal dry season***
Mean	895.3435 kg	618.8425 kg
Variance	2566033	1657580
Pearson Correlation	0.69771	
df	321	
t Stat	4.277066	
P(T<=t) two-tail	2.5E-05	
t Critical two-tail	1.967382	

The result of paired 2-sample t test carried out with the aim to determine whether there is a significant difference in the total amount of dead biomass without application of carcass removal from the field and the amount available after carcass removal from the field are shown in Table 7. The calculated t value is 1.99 which is more than t critical. This is significant at $\alpha=0.05$ with a P value= 0.04. The result implies that there is a significant difference in the amount of biomass available in the field before and after carcass removal, applied by farmers, thus Null hypothesis was rejected (Hypothesis 3). On average, 56% (3840kg) less of biomass is available in the field than before carcass removal from the field is applied.

Table 7. Analysis of difference in the amount of biomass available with and without application of carcass removal program.

	Biomass without carcass removal	***Biomass with carcass removal***
Mean	6858.75 kg	3018.996 kg
Variance	3.82E+09	7.38E+08
Pearson Correlation	0.999723	
df	322	
t Stat	1.993035	
P(T<=t) two-tail	0.047101	
t Critical two-tail	1.967359	

3.2. Results on analysis of relationships between Griffon vulture observations and land cover and amount of biomass

Preference for certain land cover classes by Griffon vulture that is flying in wet and dry season is presented on. Observations of Griffon vulture are presented as range of values between 0 and 1. Values closer to 1 indicate larger number of observations and more preference for certain land cover class than values closer to zero. Griffon vultures prefer flying above areas covered by grass, shrubs, forest and areas with mixture of trees and shrubs with crops or grass. Griffon vulture is also observed within built-up areas and areas under crops, but less frequently. During dry season, Griffons prefer flying above same types of land cover as in wet season.

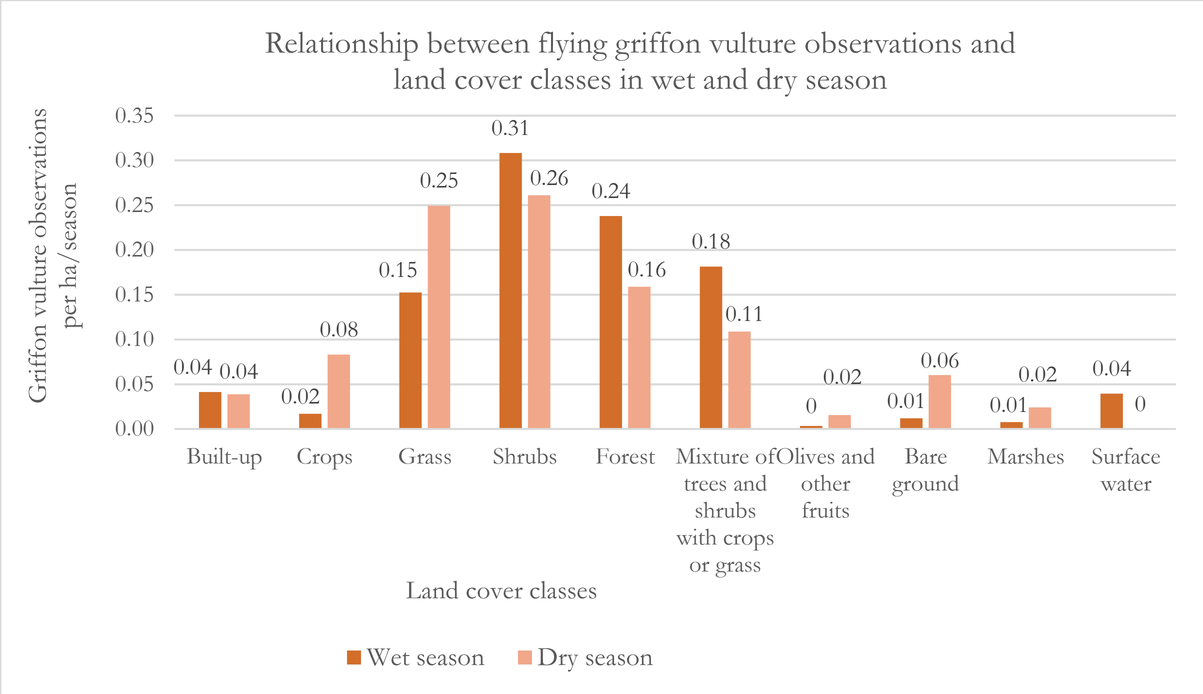

Figure 25. Relationship between flying Griffon vulture observations and land cover classes in wet and dry seasons.

"On Figure 25, values on top of each bar chart show observations of Griffon vulture per ha/season. On Figure 26 (page 30), preference for certain land cover classes by sitting Griffon vulture is shown. Griffon is mostly observed within forest, Shrubland and built-up area. It is also observed within areas covered by grass, crops and areas under mixture of trees and shrubs with crops or grass."

In order to test if there is a significant difference in land cover preference by Griffon vulture between two seasons, the Wilcoxon Signed Rank test was applied (Table 8, page 30). Differences between two groups of observations in wet and dry season were compared in order to assess if there is significant difference in frequency of observations related to land cover classes between two seasons. Test was carried out separately for sitting and flying Griffon vulture observations. Results for both set of data showed t statistic (t stat for flying data=21; t stat for sitting data=18) to be higher than critical value of 8 at $\alpha=0.05$. This implies that there is no sufficient evidence to suggest that there is a significant difference in frequency of observations between wet and dry season. Null hypothesis (Hypothesis 1) cannot be rejected, so there is no significant difference in land cover preference by flying or sitting Griffon vulture between wet and dry seasons.

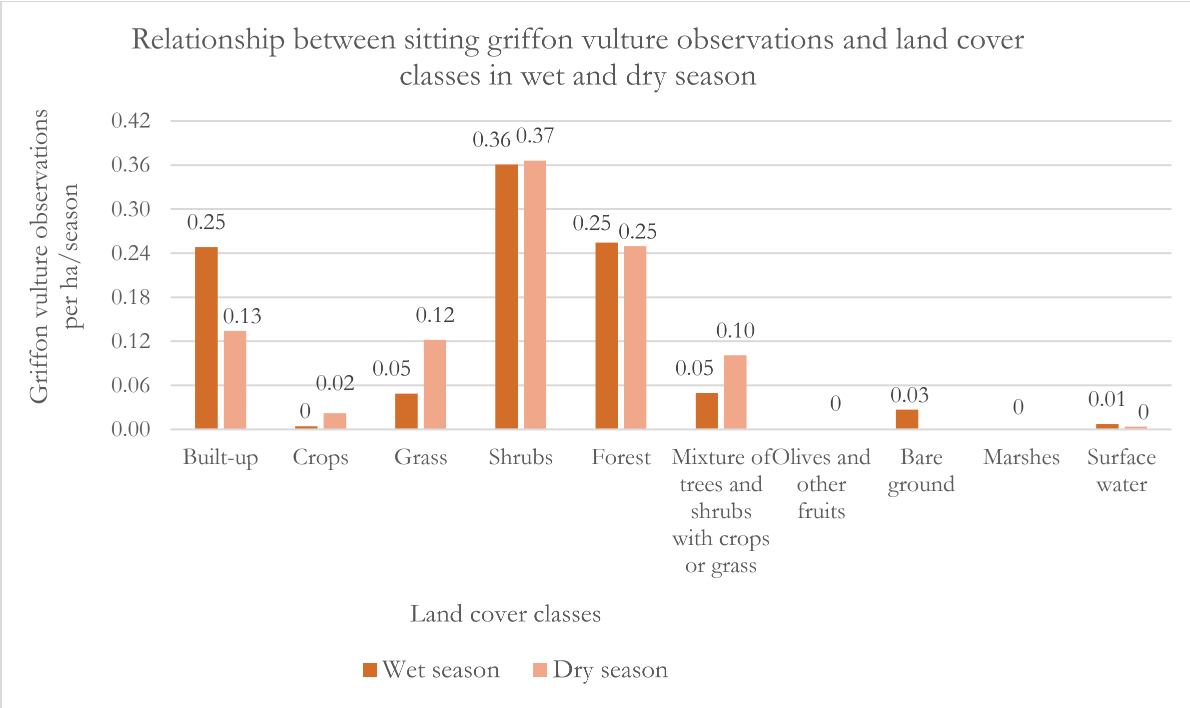

Figure 26. Relationship between sitting Griffon vulture observations and land cover classes in wet and dry seasons.

Table 8. Results for Wilcoxon signed rank test for comparing differences in observations of Griffon vulture (flying and sitting) related to land cover classes, in order to test if there is a significant difference in land cover preference by flying or sitting Griffon vulture between wet and dry season.

Observations of Griffon vulture		Critical value at α=0.05	T stat
Flying Griffon vulture in wet season	Flying Griffon vulture in dry season	8	21
Sitting Griffon vulture in wet season	Sitting Griffon vulture in dry season	8	18

Relationship between Griffon vulture observations and amount of biomass (observations per ha/season) is shown on the Figure 27 (page 31) for wet season and on the Figure 28 (page 31) for dry season. Relationship is shown for both set of observations of flying and sitting Griffon vulture.

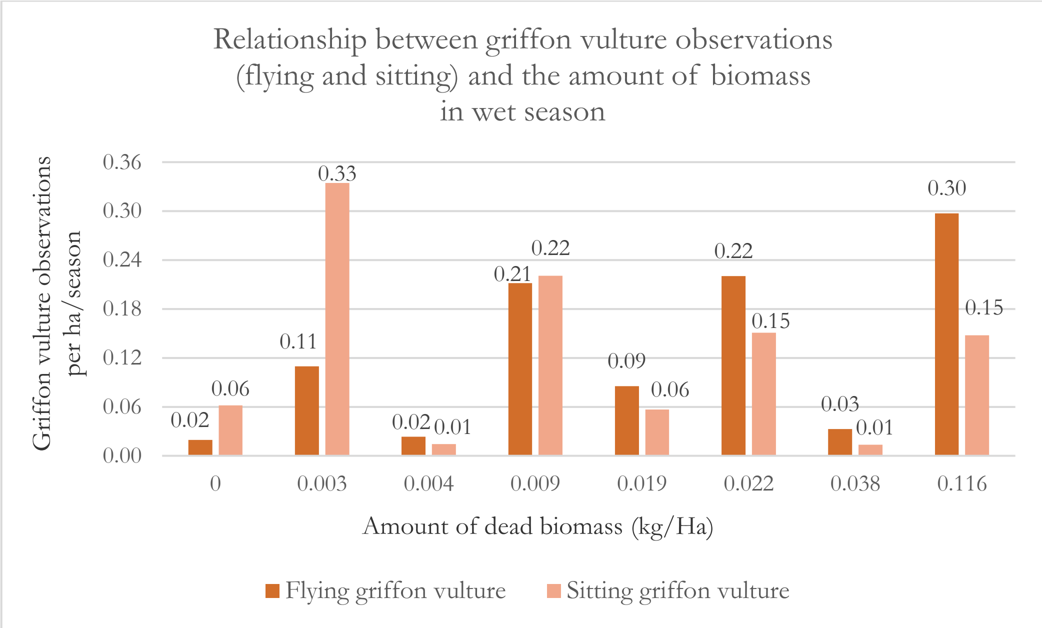

Figure 27. Relationship between Griffon vulture observations and available biomass in wet season.

"Figure 27 shows both set of observations of sitting and flying Griffon vulture. Values on top of each bar chart show observations of Griffon vulture per ha/wet season. "

Observations of Griffon vulture are shown as range of values from o to 1. Values closer to 1 indicate a larger number of observations and more preference and values closer to zero less observations, thus less preference for a specific amount of biomass. The amount of biomass as already confirmed in previous analysis differ significantly between the two seasons. It can be seen that the relationship between observations of flying and sitting Griffon vulture and the amount of dead biomass in both seasons is non-linear.

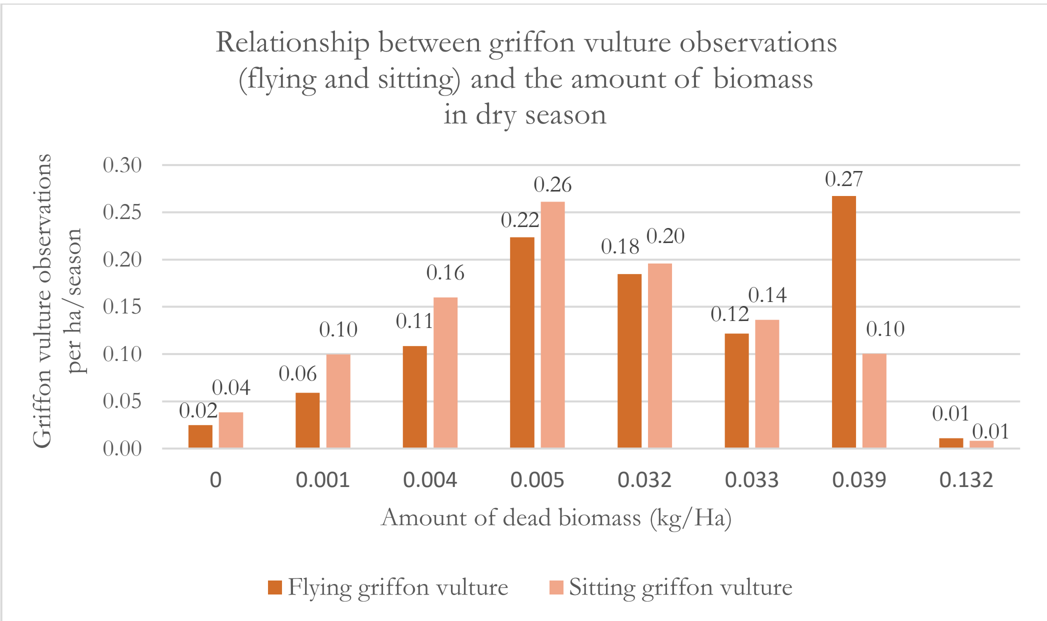

Figure 28. Relationship between Griffon vulture observations and available biomass in dry season.

"Figure 28 shows sets of observations of sitting and flying data. Values on top of each bar chart show observations of Griffon vulture per ha/dry season."

Based on observations per unit area of flying Griffon vulture, it is observed within areas with various amounts of biomass in both seasons. The observations per unit area of sitting Griffon mostly coincide with observations of flying Griffon. It can be inferred that the flying Griffon was searching for food and found a carcass on the ground and feeding on it.

4. DISCUSSION AND CONCLUSION

4.1. Discussion

Difference between the total available biomass between wet and dry season could be the result of the seasonal difference in the number of livestock present within certain land cover and the seasonal difference in mortality rate of livestock. Carcass removal policy showed as an important factor in the amount of dead biomass available in the field for Griffon vultures. One Griffon vulture has regular requirements for food, 3 times per week (Grubac, 2014). According to J. A. Donázar (1993) as cited in Grubac (2014) the average amount of meat requirement for one Griffon vulture in the wild is 500 grams daily, which makes 1.5kg per week. As regards the results on comparison of the amount of food available between two seasons, during wet season there is 277kg more of biomass available for Griffon vultures than in dry season. This amount is enough to feed eight individual Griffons in dry season. Application of carcass removal from the field leads to annual decline in the amount of dead biomass for 3840kg, which is enough to fulfil feeding capacity of 53 Griffon vulture individuals throughout the year. Thus, carcass removal policy has consequential impact on the total dead biomass available for Griffons.

The analysis of land cover preference by flying Griffon vulture showed that there is a preference for areas under grass, shrubs, forest and areas with mixture of trees and shrubs with crops or grass. This can be the result of usage of these habitats for extensive grazing, therefore Griffons are expected to fly above these areas in search for food. According to Donázar et al. (1997), shrub lands serve as an important foraging habitat for Griffon vultures. These raptors search mostly for sheep carcasses in areas covered by shrubs. According to previous analysis based on interviews, among all animals (cattle, sheep and goats) sheep are mostly taken to graze on this type of habitat. Preference for grassland, forest and areas under mixture of trees and shrubs with crops or grass could be the results of bringing livestock to graze in these areas as confirmed through interviewing farmers in Cadiz Province. Moreover, preference for grasslands and shrub lands can be explained by openness of the area as factor of ability to spot carcasses on the ground. According to Konig (1974) possibility for Griffon vultures to spot carcass on the ground depends on openness of an area. The preference for areas under crops is mostly in dry season and less in wet season, which can be associated with the harvesting period (dry season) when livestock is allowed to graze in these areas.

Differences in the number of observations among forest, shrub land and areas under mixture of trees and shrubs with crops or grass in two seasons, can be related to the differences in the amount of carcasses available between wet and dry season. In wet season there are more carcasses available in forested areas and areas covered by shrubs as compared to dry season, which might be due to seasonal difference in mortality rate especially among goats.

Furthermore, cattle are kept to graze in areas with mixture of trees and shrubs with crops or grass more than goats and sheep. Mortality rate of cattle rises in wet season as compared to dry season, so more carcasses are available in the field. The analysis also showed that flying Griffon have some preference for built-up areas. This could be the result of dumpsites or vulture restaurants, as an important source of food for Griffon vultures, occurring within these areas. According to Grubač (2005) as cited in (Grubac, 2014) Griffon vultures often feed on dumpsites. Within the classes defined on three levels of CORINE map, there was one dumpsite. Dumpsites were not taken into consideration for this research, so this class was put under built-up class. However, there is more than one dumpsite within Cadiz Province and few of them were visited during fieldwork. The presence of the vulture restaurants within built-up area is taken as an assumption, because they were not defined within CORINE classes which could imply the lack of detail of CORINE Land cover map.

Preference for forest and areas under shrubs by sitting Griffon vulture can be related to the previous discussion, so there is high possibility that Griffon vulture is feeding on carcasses within these habitats. However, another possibility is that Griffon is not observed to be within these habitats only for food, but also for resting. This study area is mountainous region and is characterized by undulate relief, and forested areas and shrubs on the slopes are very suitable places for Griffons to rest. Furthermore, occurrence within areas under grass and crops (in dry season) may be the result of feeding on carcasses. Griffon vulture is also observed within built-up area. This can confirm the previous assumption that presence of dumpsites and vulture restaurants could be the reason for Griffon to be within these areas.

According to the results related to the relationship between observations of flying and sitting Griffon vulture and the amount of dead biomass in wet and dry season, the occurrence of Griffon vultures is not related only to places with larger amount of dead biomass. This is the opposite of the suggestions given by Donázar et al. (2010) and Duriez, Herman, & Sarrazin, (2012), as cited in Moreno-Opo, Trujillano, Arredondo, González, & Margalida, (2015), that Griffon vultures select places with larger amounts of food. The areas with certain amounts of biomass where Griffon is mostly observed could be areas where feeding stations are located. According to Duriez et al.(2012) feeding stations provide food for vultures that is predictable as compared to the food in the wild which is unpredictable in space and time. Therefore, it is expected for Griffon vultures to be more observed within places where it is more likely for them to find carcasses to feed on. Furthermore, differences in frequency of occurrence might be also the result of other factors such as openness of the areas. As suggested by Konig (1974) s cited in Grubac (2014) Griffon vultures use exclusively eyesight in search for food. As already mentioned the more vegetation coverage is open the more possible is for Griffons to discover carcasses on the ground. This means that the amount of biomass is not the only factor in food searching but also vegetation coverage, so in places where carcass is discovered, regardless of the amount, Griffons are likely to be found feeding on it.

4.2. Conclusions

Extensive livestock farming showed to be a very significant activity influencing food availability for Griffon vultures. Mosaic of habitats in Cadiz Province formed by the presence of forest, areas under grass, shrubs and crops showed as an important factor in extensive livestock grazing. Beside various land cover types within the study area, human activities have a decisive influence on spatial distribution of livestock. Due to floods that occur during the wet period of the year, many farmers move their livestock to higher altitudes to graze in forested areas. Transhumance still exist in Cadiz Province, which increase the opportunity for Griffon vultures to have more available food. Harvesting takes place in dry season, so livestock is left to graze on areas under crops mostly during this period of the year.

Livestock represent potential food for Griffon vultures, thus its spatial distribution is consequential for these raptors. Seasonal difference in mortality rate of livestock, leads to significant difference in the amount of carcasses available in the field between wet and dry season.
Many farmers, conditioned by EU sanitary legislations, remove dead animals from the field for industrial disposal which influences the amount of carcasses available for Griffon vultures. During interviews, there were many complaints among farmers on the costs they are forced to spend for the services in order for carcasses to be removed from the field. Usually, livestock, especially cattle, is left to graze freely over large areas, so farmers are not able to have a constant control over the flocks. This leads to the situations when carcasses cannot be spotted by farmers, so they are left as potential food for Griffons.

Areas covered by shrubs, grass, forest, crops (mostly in dry season) and mixture of trees and shrubs with crops or grass are an important foraging habitat for Griffon vultures. Preference for these habitats by Griffon vulture, while flying or sitting, was related to the extensive livestock farming practices and seasonal difference in mortality rate of goats and cattle which can be a cause for Griffon vulture to be observed within these habitats. Openness of the area is also considered as a factor for observations of Griffon vulture within grassland and shrub land. Griffon vultures have preference for built-up areas, which was linked to the presence of dumpsites or feeding stations within these areas. Griffon vulture is not observed only within areas with larger amount of biomass. Presence of feeding stations was taken as one of the reasons why Griffon vulture is observed within areas with different amounts of biomass. Feeding stations provide Griffon vultures with food that is predictable in space and time, which bring Griffon vultures to feed on these places.

Cadiz Province, characterized by mosaic habitats and mountainous regions, offers huge potentials for extensive livestock farming practices. It is necessary to maintain mosaic habitats which are important for grazing systems and not to allow arable land to occupy this region. Finally, maintenance of extensive grazing systems and monitoring the impact of carcass removal policy contributes to the conservation of Griffon vultures in Cadiz, an important roosting, breeding and migratory area for this species.

4.3. Recommendations based on limitations within the work

By including other variables such as slope, altitude and climatic and using CORINE Land cover of 100m resolution would improve mapping the spatial distribution of livestock as well as the dead biomass within a defined study area.

Taking into consideration locations of dumpsites and feeding stations would contribute to the foraging behaviour analysis of Griffon vultures and also to the estimation of the amount of food available for them. Accessibility to telemetric data concerning more than only one Griffon vulture would improve the analysis of their behaviour. Making conclusions based on only one individual usually cannot be representative for the whole population.

This research gives an insight into the impact of carcass removal policy on the amount of available food for Griffon vultures. This can be as stimulus for further monitoring application of carcass removal among farmers, especially knowing that there is still a lack of knowledge in consequences that this policy has on the population of Griffon vultures.

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APPENDIX

Livestock census data within municipalities in Cadiz

Table 9. Livestock census data within municipalities in Cadiz province; Data was obtained from Department of Agriculture, Fisheries and Rural Development of Cádiz.

Municipalities	Number of cattle	Number of goats	Number of sheep
ALGECIRAS	1432	564	528
LOS BARRIOS	8451	1145	187
CASTELLAR	1737	353	29
JIMENA FRA.	8293	3279	539
LA LÍNEA	244	0	112
SAN ROQUE	2069	434	33
TARIFA	18964	5789	2895
CADIZ	0	0	0
CONIL	2367	370	321
CHICLANA	3237	1957	93
CHIPIONA	6	296	8
PUERTO SM	413	545	0
PUERTO REAL	1915	980	511
ROTA	3403	896	121
SAN FERNANDO	86	19	0
SANLUCAR BDA.	1526	1367	1012
JEREZ DE LA FRONTERA	12468	3227	11374
ARCOS DE LA FRONTERA	5125	6066	6797
BORNOS	208	16	383
VILLAMARTIN	695	1410	3394
SAN JOSE DEL VALLE	5492	9385	2512
TREBUJENA	632	3059	1205
ALGAR	791	606	456
ESPERA	0	70	1333
MEDINA	14968	4849	1399
ALCALA	12958	14585	1315
VEJER	9646	575	52
PATERNA	397	836	1152
BENALUP	1730	265	485
BARBATE	6814	670	29
ALCALÁ DEL VALLE	277	1724	1127
ALGODONALES	1160	11797	9100
BENAOCAZ	934	4439	1320
BOSQUE (EL)	277	1821	844
GASTOR (EL)	0	313	3857
GRAZALEMA	1314	5460	6358
OLVERA	4187	13928	6009
PRADO DEL REY	883	4852	2471
PUERTO SERRANO	539	2715	7439
SETENIL DE LAS BODEGAS	554	530	1379
TORRE ALHÁQUIME	0	1232	1105
UBRIQUE	1053	1352	1753
VILLALUENGA DEL ROSARIO	633	3119	2909
ZAHARA	950	6280	2378

Questionnaire conducted among farmers during fieldwork in Cadiz in Spanish.

Cuestionario

Facultad de Geo-información y Observación de la Tierra
Departamento de Recursos Naturales
Universidad de Twente, Enschede, Países Bajos

Este cuestionario es anónimo. Por favor, responda las preguntas con sinceridad. De esta manera, usted estará contribuyendo a avanzar en la investigación relacionada con la conservación del buitre común….La información referida a prácticas agrícolas resulta de utilidad para mejorar el estado de conservación de esta especie y puede ayudar a reducir el conflicto entre estas aves y los productores locales. Marque con un círculo la opción deseada y cuando requerido, responda debajo de la pregunta. Gracias por su cooperación

1. Qué tipo de granja es esta? Marque con un círculo la respuesta deseada?

    - Producción intensiva
    - Producción extensiva

2. Qué tipo de ganado posee? Puede marcar varias opciones. Indique además la cantidad de animales que posee.

- Vacuno

___

- Ovino

___

- Caprino

___

- Equino

___

3. Lleva a sus animales a pastar al campo? Marque con un círculo la respuesta deseada

- Si
- No

En caso afirmativo, indique en que estación (mas de una respuesta es posible)

- Invierno
- Verano
- Ambas

Puede indicar en el mapa el área donde pastan sus animales? Si no es posible para usted marcarla en el mapa, indique por favor, el nombre del area a continuación:

___

4. En qué tipo de áreas prefiere usted que sus animales pasten en cada estación? Por favor, complete las siguientes tablas. Cada tabla corresponde a una estación. Marque las opciones deseadas con una X.

INVIERNO

Tipo de ganado	Areas de cultivo	Huertas	Olivares	Bosques	Matorrales	Pastizales naturales	Pasturas
Vacuno							
Ovino							
Caprino							
Equino							

PRIMAVERA

Tipo de ganado	Areas de cultivo	Huertas	Olivares	Bosques	Matorrales	Pastizales naturales	Pasturas
Vacuno							
Ovino							
Caprino							
Equino							

VERANO

Tipo de ganado	Areas de cultivo	Huertas	Olivares	Bosques	Matorrales	Pastizales naturales	Pasturas
Vacuno							
Ovino							
Caprino							
Equino							

OTOÑO

Tipo de ganado	Areas de cultivo	Huertas	Olivares	Bosques	Matorrales	Pastizales naturales	Pasturas
Vacuno							
Ovino							
Caprino							
Equino							

5. Cuál es el peso promedio de sus animales? Por favor, complete la siguiente tabla. Si usted posee distintos tipos de ganado, indique los pesos promedio de cada tipo.

Tipo de ganado	Sexo	Peso promedio en kg
Vacuno	Hembra	
	Macho	
Ovino	Hembra	
	Macho	
Caprino	Hembra	
	Macho	
Equino	Hembra	
	Macho	

6. En promedio, cuántos animales mueren por estación? Por favor, complete la siguiente tabla.

Tipo de ganado	Cantidad de animales muertos			
	Invierno	Primavera	Verano	Otoño
Vacuno				
Ovino				
Caprino				
Equino				

7. En promedio, cuanto ganado vende usted en un año? Por favor, complete la tabla a continuación.

Tipo de ganado	Numero de animals vendidos en un año
Cattle Vacuno	
Sheep Ovino	
Goats Caprino	
Horses Equino	

8. Cómo desecha los cadáveres? Puede marcar varias opciones. Indique además la cantidad aproximada de cadáveres que usted desecha en un año.

- Los cadáveres son dejados en el campo o desechados en las cercanías
- Los cadáveres son recolectados para tratamiento industrial

Questionnaire conducted among farmers during fieldwork in Cadiz in English.

Questionnaire

Faculty of Geo-Information Science and Earth Observation
Department of Natural Resources
University of Twente, Enschede, the Netherlands

This questionnaire is anonymous. Please answer all questions sincerely. By this you will contribute to realization of research on griffon vultures and conservation of these important bird species. By estimating farming practices we will be able to make improvement in biodiversity conservation. Round off offered answers and where required add an answer below.

Thank you for your cooperation.

1. What type of farm is this? Round off the answer.

    - Intensive
    - Extensive

2. What type of livestock do you have? Multiple answers can be rounded off. Beside, write a number of animals that you have.

    - Cattle
    - Sheep
    - Goats
    - Horses

3. Do you take livestock to the field for grazing? Round off the answer.
    - Yes
    - No

If yes, during which season?
- In Winter
- In Summer
- In both (Winter and Summer)

Can you indicate on map the place where they graze?
____

4. What type of land cover do you prefer to graze your livestock on in different seasons? Please, fill in tables below. Each table is for one season of the year. Mark fields with X sign.

Table 1: WINTER

Type of animal	Arable land	Orchard plantations	Forest	Shrubland	Grassland
Cattle					
Sheep					
Goats					
Horses					

Table 2: SPRING

Type of animal	Arable land	Orchard plantations	Forest	Shrubland	Grassland
Cattle					
Sheep					
Goats					
Horses					

Table 3: SUMMER

Type of animal	Arable land	Orchard plantations	Forest	Shrubland	Grassland
Cattle					
Sheep					
Goats					
Horses					

Table 4: AUTUMN

Type of animal	Arable land	Orchard plantations	Forest	Shrubland	Grassland
Cattle					
Sheep					
Goats					
Horses					

5. What is an average weight of livestock? Please fill in table below, by writing the average weight. If you have more than one type of livestock, write down the weight for each type. The livestock is divided by sex.

Type of animal	Gender	Average weight in kg
Cattle	Cow	
	Bull	
Sheep	Ram	
	Ewe	
Goats	Buck	
	Doe	
Horses	Stallion	
	Mare	

6. On an average, what is the number of dead livestock in different seasons? Please fill in the table below by writing the number of dead livestock.

Type of animal	Number of dead animals			
	Winter	Spring	Summer	Autumn
Cattle				
Sheep				
Goats				
Horses				

7. On average, how much of livestock do you sell out per year? Please, fill in the table below.

Type of livestock	Number of livestock that is sold out in one year
Cattle	
Sheep	
Goats	
Horses	

8. How do you dispose livestock carcasses? Multiple answers can be rounded off. Beside an answer write down the number of carcasses that is disposed.

- Carcasses are left it in the field
- Carcasses are disposed near farms
- Carcasses are removed for industrial disposal