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221 00 Lund  
+46 46-222 00 00

# “No Friends but the Mountains”

## Understanding Population Mobility and Land Dynamics in Iraqi Kurdistan

Lina Eklund



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DOCTORAL DISSERTATION

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To be publically defended at Pangea, Geocentrum II, Sölvegatan 12, Lund,  
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*Faculty opponent*

Associate Professor Tobias Küemmerle

Geography Department, Humboldt-University Berlin, Germany

Organization: LUND UNIVERSITY Department of Physical Geography and Ecosystem Science, Sölvegatan 12, SE-22362, Lund, Sweden Author: Lina Eklund	Document name: DOCTORAL DISSERTATION Date of issue: Sponsoring organization
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Abstract <p>The link between population mobility and environmental change is fundamental for our understanding of how future global environmental changes will affect our societies, and also how the increased mobility will change our role in the Earth system. Climate change has been predicted as a major cause of human migration, both voluntary and forced, through for example increased storm and drought frequency, sea level rise, and reduced fresh water availability. On the other hand, contemporary migration patterns are part of processes that change the face of the Earth.</p> <p>Social, political, and natural processes have shaped the development of the Kurdistan Region of Iraq (KR-I) since the 1980's. This dissertation explores the environmental aspects of such changes by focusing on how population mobility relates to land systems in the Duhok governorate, KR-I. This dissertation takes an interdisciplinary approach by combining household survey data with information extracted from satellite images. This enables analysis of patterns at both provincial and household levels.</p> <p>The findings of this work reveal that migration patterns are mainly explained by economic drivers. The environment as a driver of migration is not emphasized in the interview responses, and only a small share of households are economically dependent on agriculture. The 2007-2009 drought was severe in terms of precipitation decrease, vegetation anomalies, and from a socio-economic perspective. The analyses, however, show no evidence of increased migration during the drought period. Migration for other reasons, such as the Anfal genocide in the late 1980's, and the subsequent reconstruction program was found to influence land use activity. In times of migration and displacement the cropland area was reduced, while it increased during resettlement initiatives.</p> <p>The final part of this dissertation consists of a methodological discussion of how scale affects analyses of the environment-migration nexus. A review of the current literature reveals that common scale-problems in this field include the mismatch between different data types, generalizations, and neglect of spatial variability.</p>	
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# “No Friends but the Mountains”

## Understanding Population Mobility and Land Dynamics in Iraqi Kurdistan

Lina Eklund



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Department of Physical Geography and Ecosystem Science

Faculty of Science, Lund University

Sölvegatan 12, 22362 Lund, Sweden

A doctoral thesis at a university in Sweden is produced either as a monograph or as a collection of papers. In the latter case the introductory part constitutes the formal thesis, which summarizes the accompanying papers already published or manuscripts at various stages (in press, submitted, or in preparation).

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KLIMATKOMPENSERAT  
PAPPER



*“Love of learning is a pleasant and universal bond since it deals with what one is and not what one has.”*

– Freya Stark

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# List of Papers

- I. Eklund L and Pilesjö P. *Migration patterns in Duhok Governorate Iraq, 2000-2010*. Open Geography, 5, 48-58 (2012).
- II. Eklund L and Seaquist J. *Meteorological, agricultural and socioeconomic drought in the Duhok Governorate, Iraqi Kurdistan*. Natural Hazards, 76, 1, 421-441 (2014).
- III. Eklund L, Persson A and Pilesjö P. *Cropland changes in times of genocide, reconstruction, and economic development in Iraqi Kurdistan*. Submitted.
- IV. Eklund L, Romankiewicz C, Brandt M, Samimi C and Doevenspeck M. *Data and methods in the environment-migration nexus: a scale perspective*. Submitted.

## Contribution to Papers

**Paper I** LE was responsible for field work, data preparation and analysis, and led the writing of the manuscript.

**Paper II** LE was responsible for field work, data preparation and analysis, and led the writing of the manuscript.

**Paper III** LE was responsible for field work, data preparation and analysis, and led the writing of the manuscript.

**Paper IV** LE led the analysis and the writing of the manuscript.

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# Abstract

The link between population mobility and environmental change is fundamental for our understanding of how future global environmental changes will affect our societies, and also how the increased mobility will change our role in the Earth system. Climate change has been predicted as a major cause of human migration, both voluntary and forced, through for example increased storm and drought frequency, sea level rise, and reduced fresh water availability. On the other hand, contemporary migration patterns are also part of processes that change the face of the Earth.

Social, political, and natural processes have shaped the societal development in Iraqi Kurdistan since the 1980's. This dissertation explores the environmental aspects of such changes by focusing on how population mobility relates to land systems in the Duhok governorate. This dissertation takes an interdisciplinary approach by combining household survey data with information extracted from satellite images. This has enabled analysis of patterns at both provincial and household levels.

The findings of this work reveal that migration patterns are mainly explained by economic drivers. The environment as a driver of migration is not emphasized in the interview responses, and only a small share of households are economically dependent on agriculture. The 2007-2009 drought was severe in terms of precipitation decrease, vegetation anomalies, and from a socio-economic perspective. The analyses, however, show no evidence of increased migration during the drought period. Migration for other reasons, such as the Anfal genocide in the late 1980's, and the subsequent reconstruction program was found to influence land use activity. In times of migration and displacement the cropland area was reduced, while it increased during resettlement initiatives.

The final part of this dissertation consists of a methodological discussion of how scale affects analyses of the environment-migration nexus. A review of the current literature reveals that common scale-problems in this field include the mismatch between different data types, generalizations, and neglect of spatial variability.



# Sammanfattning

För att få en uppfattning om hur framtida miljöförändringar kommer att påverka vårt samhälle är det viktigt att studera eventuella samband mellan migration, samhälle och miljö. Klimatförändringar väntas inom en snar framtid leda till stora befolkningsförflyttningar till följd av exempelvis ökad stormfrekvens, torka, havsnivåhöjning och vattenbrist. Migration kan å andra sidan påverka landskapets utseende och funktion.

Socio-ekonomiska, politiska och naturrelaterade processer har i hög grad påverkat samhällsutvecklingen i Irakiska Kurdistan sedan 1980-talet. Den här avhandlingen utforskar miljöaspekter av sådana förändringar genom att undersöka hur befolkningsförflyttningar förhåller sig till land-system i Duhok-provinsen. Ett tvärvetenskapligt tillvägagångssätt, som bland annat kombinerar intervju-data med information från satellitbilder, har möjliggjort analys av trender på både provins- och hushållsnivå.

Resultaten visar att migration mellan åren 2000 och 2010 huvudsakligen kan förklaras av ekonomiska faktorer. Miljöförändringar betonas inte i enkätsvaren som en orsak till migration, och endast en liten andel hushåll är ekonomiskt beroende av sin mark. Torkan mellan 2007 och 2009 var allvarlig, både med avseende på nederbörd, vegetation och från ett socio-ekonomiskt perspektiv. Analyserna visar dock inga tecken på ökad migration under eller efter torkan. Migration orsakad av konflikter, såsom Anfal-fölkömdet under sent 1980-tal och det efterföljande återbyggnadsprogrammet, har påverkat hur marken i Irakiska Kurdistan används. Under perioder av tvångsförflyttning minskade arealen som används till spannmålsproduktion, medan den ökade under återinflyttningsinitiativ.

Den sista delen av avhandlingen är en metodologisk diskussion kring hur skala i tid och rum påverkar analyser av sambandet mellan miljö och migration. En granskning av samtida litteratur visar att vanliga skal-problem inbegriper dålig matchning av data, generaliseringar och försummande av variation i tid och rum.



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# Introduction

“No friends but the mountains” is a Kurdish proverb that illustrates how the people in the region have suffered betrayal and persecution in the past. It also reveals how they traditionally have had a special relationship to their surrounding physical environment. The mountains of Kurdistan have not only protected their people in times of need, they also provide important ecosystem services, for example fresh water and fertile soils. These convenient geomorphic conditions have allowed for the cultivation of grains, fruits, nuts, almonds, and many other crops characteristic for the Middle Eastern cuisine. In the 1930’s, however, another natural resource started to become an important contributor to the economy in Iraq and in other Middle Eastern countries. The development of the oil sector generally led to a decreased dependence on agriculture and an increased urbanization. While oil revenues may provide many benefits to the population, such as employment opportunities, health care and education, it is also sometimes referred to as a resource curse (Homer-Dixon 1999, Le Billon 2001). Resource dependent economies often have low influence from the public, due to the fact that they are mainly based on non-tax incomes, and are often susceptible to political instability and conflict.

For almost a century, the Kurds have strived for independence, and been persecuted for their claims to statehood. An incident that still plays a very important role for the Kurds in Iraq is the Anfal campaign, carried out by the Iraqi government between 1987 and 1989. Targeting rural Kurdish areas that had been declared “prohibited”, the Iraqi government, led by Saddam Hussein, sought to curb the Kurdish guerilla (Peshmerga) and the people supporting them (Human Rights Watch 1993, Hardi 2011). Villages were bombed and burned, people were arrested, taken to camps, or killed, and chemical weapons were used, leaving many of the people who survived with health problems today. It also caused a rural exodus, and much of the agricultural land was abandoned, leading to a lowered agricultural activity.

The Kurdish and Iraqi economies also bears scars from the international sanctions period, when the UN imposed trade sanctions on Iraq after the war with Kuwait in 1991 ((WFP Iraq - North Coordination Office 2001, Gunter 2012, Barwari 2013). Around the same time, the Kurdish area in Iraq was sanctioned by the Iraqi government, as a response to the establishment of an autonomous region in the three northern Kurdish governorates of Duhok, Erbil and Sulaymaniyah (Kurdistan Regional Government (KRG) 2008, Gunter 2012). The sanctions caused widespread poverty

and malnutrition, so in order to remedy the situation the UN initiated the Oil-For-Food Program, in which oil were traded for food aid to the population of Iraq (including the Kurdistan Region) (Meyer and Califano 2006). This program, however well-intentioned, led to an increased dependence on food aid. A common saying in Kurdistan today is that people went from being producers to consumers.

With the U.S. invasion of Iraq in 2003 and the fall of Saddam Hussein, the Iraqi Kurds, who in 1992 had gotten an internationally accepted autonomy in the three most northern governorates of Iraq, saw a new beginning. Southern Iraq went into civil war, but the Kurdistan Region (KR-I) became a relatively stable area (Gunter 2012). The Kurdistan Regional Government (KRG) got representatives in the Iraqi parliament, and a Kurd, Jalal Talabani, was elected for president of Iraq. The oil revenues coming into Kurdistan from the Iraqi government, and the ability of the KRG to develop legal initiatives to stimulate foreign investments, have led to an economic boom in this region, bringing for example luxurious hotels, urbanization and investments in higher education to the region (Gunter 2012). The recent developments starting in 2014 with the Islamic State (IS/Daesh) taking over territory in Iraq and Syria show that Iraqi Kurdistan is still surrounded by instability.

## Objectives and Research Questions

Peoples' movements and migration patterns can reveal traces of the past, which evokes questions about the current path of Kurdistan. This dissertation uses a mix of natural science and social science data and methods to assess how the relationships between the population of Kurdistan and their surrounding environment have been affected by the region's past and present.

In order to do this the following research questions are asked:

1. **What are the main population and migration trends in the Duhok Governorate, and what are the reasons behind them? (Paper I)**

This question lays the foundation for this dissertation by investigating the 2000-2010 migration patterns and linking them to reported reasons, origin and destination areas, time of migration, and other demographic information.

2. **What are the environmental aspects of these trends?**

This question brings in the environmental aspects of migration in the study area, and leads to the following sub questions:

**What impact did the 2007-2009 drought have on agriculture and livelihoods in the Duhok Governorate? (Paper II)**

**What are the land use effects of land abandonment caused by political instability, and what are the land use effects of resettlement? (Paper III)**

**3. What are the main methodological challenges when conducting geographical research on population-environment dynamics? (Paper IV)**

This question addresses the methodological challenges that this sort of research faces, and seeks to find solutions to overcome these challenges, or to reduce their effects. An important step to become aware of such issues was through a methodological review of previous research on the environment-migration nexus, guided by the following sub-question:

**What types of scale issues are relevant for environment-migration research?**

## Dissertation Structure and Appended Papers

This dissertation starts with a brief Introduction to the history of the Kurdistan Region, and the main events that have led to the current situation. A review of the concepts and theories used within this project, and the interrelationship between them, is found in the Conceptual Background chapter. The general characteristics of the study area, the field data collections, the secondary data, and the methods of analysis used in the different papers are described in Data and Methods. Under Results and Discussion, the findings of each paper are presented together with an analysis of the results. Finally, in the chapter Conclusions, the most important findings of this work, and their relevance in a wider perspective, are summarized.

Here follows a short summary of the appended papers including brief descriptions of the data used, the methods of analysis, and the relevant findings. How the papers build upon each other is illustrated in Figure 1.

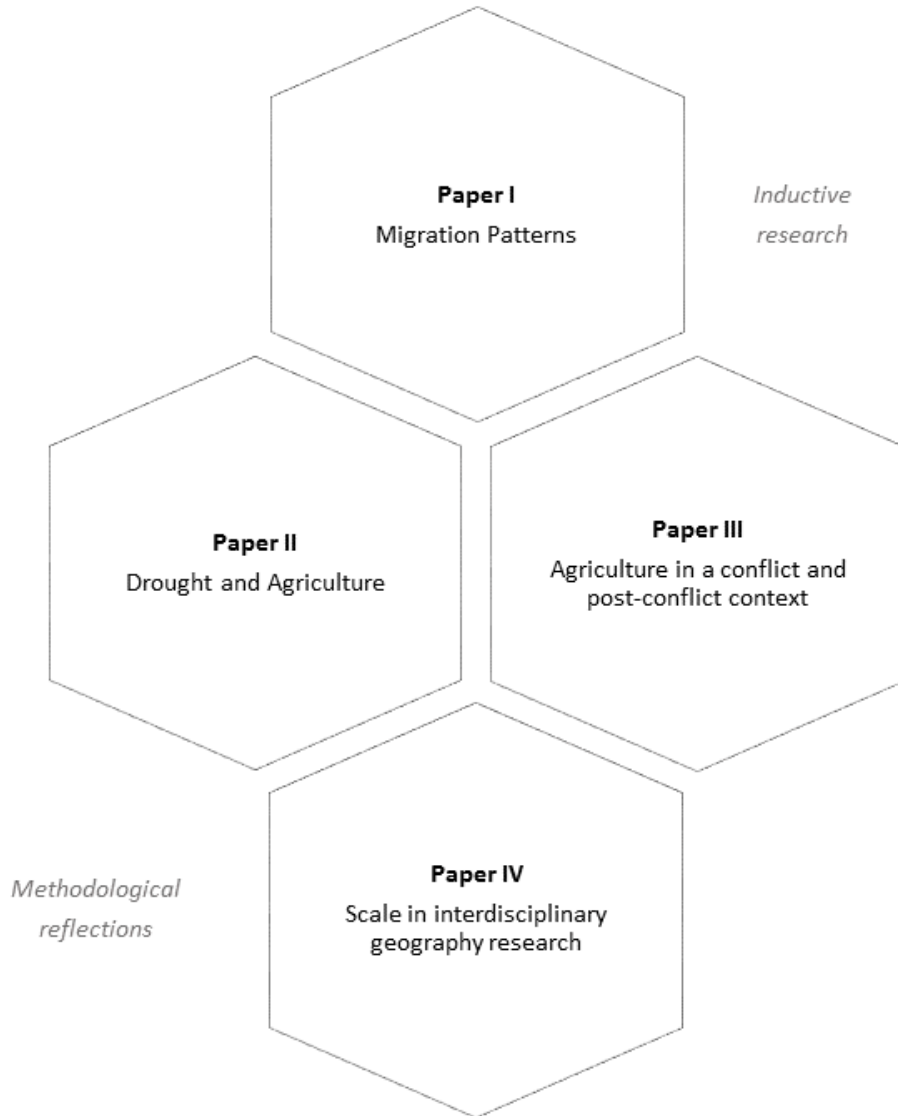
**Paper I** investigated the migration patterns between 2000 and 2010 in the Duhok Governorate, Kurdistan Region of Iraq. The data were collected through a sample survey conducted in 2011, where questions about migration experiences were directed to over 1200 randomly sampled households, in both villages and urban areas. The data were analyzed in a descriptive way, showing general migration patterns and the reported reasons and times. The results show that migration was often undertaken for economic reasons, and that security played an important role in the migration patterns. Two other important findings led to the research questions asked in **Paper II** and **Paper III**. Firstly, the finding that only a small number of migration events were reported as driven by environmental factors, despite a severe drought in 2007-2009. Secondly, an urban to rural migration pattern that exceeded the rural to urban migration flow was documented.

**Paper II** investigates the temporal and spatial characteristics of the 2007-2009 drought in the Duhok Governorate and assesses the impact on the local population. It uses data from the 2011 survey in combination with satellite based vegetation data and precipitation to understand the drought from meteorological, agricultural and socio-economic perspectives. Results reveal a severe drop in precipitation during drought years, and a large share of the area experiencing negative vegetation anomalies in 2008. People in affected villages frequently reported drought as a problem, but this perception was influenced by the dependence on rainfall for agriculture. No strong connection between drought severity and out-migration was found, which confirms the results presented in **Paper I**.

**Paper III** assesses the land cover impacts of the Anfal genocide attacks, the recovery of villages after the reconstruction program between 1991 and 2003, and the economic development since the fall of the Iraqi regime in 2003. Satellite images dating back to 1984 were used to “travel back in time” and define winter crop areas by looking at differences in greenness between pre-harvest and post-harvest dates. Results show a small decrease in winter crop area in the years after Anfal (1989-1991), confirming reports of land abandonment and negative effects on agriculture. During the late reconstruction period (1998-2002), the area saw an increase in winter crop land by 23%, indicating that the reconstruction program led to increased agricultural activity. However, the recent period (2011-2014) showed no substantial change in active winter crop land since the reconstruction period.

**Paper IV** is a methodological critique of the migration-environment literature, where scale is brought forward as an often neglected factor in both the data used and the analysis methods. Scale is divided into three parts, the data scale, model scale and reality scale. Data and model scales have two components, the smallest unit (resolution) and the extent, representing the whole area in focus. After analyzing 27 peer reviewed papers, several data and method issues emerged. The most common scale related problems were the over-reliance on coarse secondary data, the up-and downscaling of data to fit the desired analysis dimensions, and the general disregard for scale issues.

These four papers form this dissertation, where the results of **Paper I** have helped formulate the questions asked in **Paper II** and **Paper III**, and **Paper IV** is a reflection of methodology (Figure 1).



**Figure 1**

The structure of the dissertation, starting with the first paper in which questions were raised that led to the two subsequent papers and finally a paper that is based on the methodological reflections of the previous papers.



# Conceptual Background

This chapter aims to lay a foundation to the concepts that this dissertation is based on. It starts by introducing the Earth system as a way of perceiving our environment, and our role as humans on Earth. Two types of environmental change, central to this dissertation, are described. Then follows a description of migration theories and environmental change as a driver, and consequence, of migration. Finally, it introduces the concept of scale and how it affects geographical research.

## The Earth System

A good understanding of the environment in which we humans live requires viewing the Earth as a system with interacting components and processes. The Earth system consist of the atmosphere, the hydrosphere, the biosphere, the lithosphere (Strahler and Strahler 2006), and the anthroposphere (Baccini and Brunner 2012). This last “sphere” is sometimes left out from descriptions of the Earth system, but as humans have become one of the dominating forces on Earth it is an important component. The anthroposphere, including human culture, technology, and built environments, is closely connected to all of the other spheres as humans are an integral part of the Earth system. This dissertation focuses on the Land system, which encompasses all terrestrial processes and components of the Earth system, both human-related and biophysical. The understanding of Land Systems require interdisciplinary research approaches investigating the relationships and feedbacks between human societies and their biophysical environments at various scales (Rounsevell, Pedrolí et al. 2012, Verburg, Erb et al. 2013).

Drought is a recurrent climatic event that denotes a period of reduced water availability that relates to different aspects of the Land System. Four types of drought have been defined by the research community: meteorological drought (1), agricultural drought (2), hydrological drought (3), and socio-economic drought (4). The first three types focus on biophysical aspects of water availability, such as rainfall (meteorological), soil moisture/crop growth (agricultural), and water flow in rivers and aquifers (hydrological), but the fourth type reflects a situation when drought is affecting the social and economic activities of a community (Dracup, Lee et al. 1980, Heim 2002,



Panu and Sharma 2002, Ghulam, Qin et al. 2007, UNDP 2010). Drought is a relative concept that describes a situation in relation to what can be considered normal. Therefore are droughts in semi-arid areas different from droughts in e.g. rain forests, in terms of absolute values. Droughts are a serious threat to livelihood security and affect not only water availability, but also, indirectly, food security, economy, health, and sanitation, and increase the risk of other natural hazards, such as wild fires, dust storms and desertification.

Changes in Land Cover (LC) and Land Use (LU) are among the most important alterations to the Land System (Rindfuss, Walsh et al. 2004), and comprise changes to what the Earth's surface is covered with (LC) and how the land is used (LU). This includes, for example, the spreading of cities (urban expansion) and the conversion of forest to agricultural land, which also causes changes to the carbon budget and thereby contribute to anthropogenic climate change (Kalnay and Cai 2003). Other effects of these land changes, especially the decline of non-anthropogenic areas, are the reduction of ecosystem services and threats to biodiversity (Daily, Söderqvist et al. 2000, Sala, Stuart Chapin et al. 2000). Socio-economic and political processes, at scales ranging between local and global, are fundamental in explaining the drivers behind LU/LC change (Veldkamp and Lambin 2001), but should also be considered as consequences of such changes (Verburg, Erb et al. 2013).

## The Migration-Environment nexus

Migration represents a change of residence within, to, or from a certain area, for various and often multiple reasons (Black, Adger et al. 2011). The most common drivers of migration are related to economy and security, and migration has increased substantially since the 1990's with globalization as a major enabler of mobility (Castles 2002, Castles and Miller 2009).

There are several theories that are used to explain why migration takes place. One particularly influential economic theory is the *Neoclassical theory*, which attributes the individual decision to migrate to a “rational comparison of the relative costs and benefits of remaining at home or moving” (Borjas 1989, Castles and Miller 2009). This approach is also sometimes referred to as ‘push and pull theory, where some factors “push” the migrant away from their area of origin, while other factors “pull” the migrant to the area of destination. The Neoclassical theory however neglects other factors, such as government restrictions, or lack of knowledge about destination area.

*Migration systems theory* is an interdisciplinary approach that seeks to bridge the different disciplines within migration studies (Castles and Miller 2009). It focuses on the links between sending and receiving countries and argues that the migration

decision is a result of “interacting macro- and microstructures”, where macrostructures are external factors on a national or international level while microstructures are factors at the individual or migrant group level, e.g. social networks or family ties.

From a development perspective, migration can lead to economic changes in areas of origin, e.g. through remittances, but can also lead to a “brain-drain” where educated people leave a certain place (Castles and Miller 2009). From an environmental perspective, out-migration can be discussed as a factor leading to abandonment of land, whereas in-migration to a certain place may put pressure on the infrastructure of the receiving area, an issue often discussed in poor countries with a rapid urbanization rate. On the other hand, migration can also do the opposite, rejuvenating previously abandoned and unmaintained areas, or reduce pressure on infrastructure in areas of origin.

The migration research of today is increasingly concerned with migration (partly) caused by climatic or environmental changes, (also environmental migration, climate migration, or environmentally induced migration) (Dun and Gemenne 2008, Piguet 2010, Warner, Hamza et al. 2010, Black, Adger et al. 2011, Gemenne 2011, Fussell, Hunter et al. 2014). The International Panel on Climate Change (IPCC)’s 2007 report stated that one of the most important challenges posed by climate change will be the rise in migration from climate change affected areas (Solomon, Qin et al. 2007).

Environmentally induced migration can be separated into two types, migration caused by quick-onset natural disasters, such as floods and hurricanes, and migration influenced by slow-onset natural disasters, such as drought or soil degradation (International Organization for Migration (IOM) 2009). Migration driven by quick-onset disasters is often temporary, and the migrants are considered “environmental refugees”, whereas slow onset disaster driven migration is considered to be a more voluntary and potentially permanent move. A major challenge within the environment-migration research community is to isolate the environmental factor in migration to determine to what extent environmental factors influence peoples’ propensity to migrate (International Organization for Migration (IOM) 2009). An integrated view of environmental factors as one of many interacting drivers of migration was brought forward by Black, Adger et al. (2011) to capture the complexity of migration systems.

Environmental change can also become a result of migration patterns, especially changes to the land system. An important example of this are the widespread urbanization trends that lead to a “rural withdrawal” and in many cases abandonment of farm land. These urbanization trends are driven by different factors depending on the context, but economic and political changes often play an important role (see for example Kuemmerle, Müller et al. (2009), Baumann, Ozdogan et al. (2012)). Wars and violent conflicts, creating insecure environments, act as migration drivers and can therefore indirectly cause changes in land use and land cover (de Beurs and Henebry

2008, Witmer 2008, Gibson, Campbell et al. 2012, Gorsevski, Kasischke et al. 2012, Gorsevski, Geores et al. 2013, Baumann, Radeloff et al. 2014).

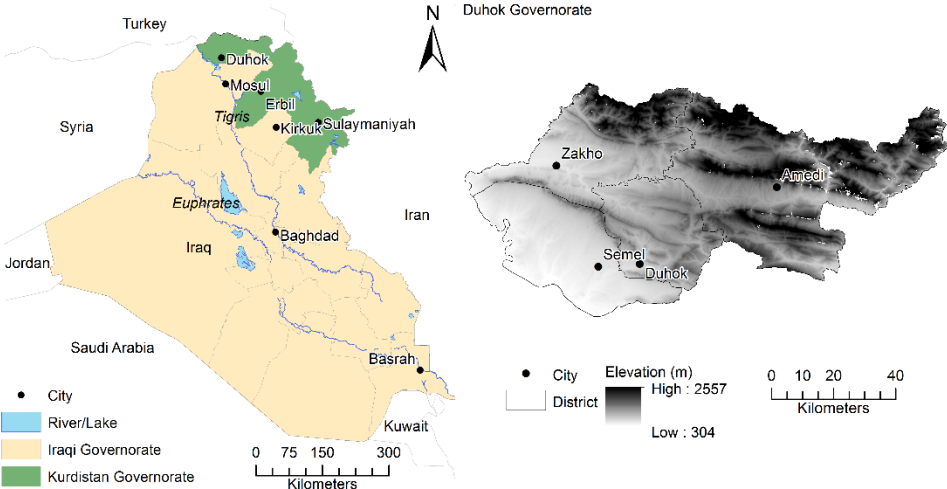
## Global vs Local: The scale concept

The concept of scale has many different meanings that vary with different research disciplines (Delaney and Leitner 1997, Atkinson and Tate 2000, Gibson, Ostrom et al. 2000, Marston 2000, Sheppard and McMaster 2008, Keshkamat, Kooiman et al. 2012). In this dissertation the definition of Gibson, Ostrom et al. (2000 p. 219) is used, which states that scale is the “spatial, temporal, quantitative, or analytical dimensions used to measure and study any phenomenon”. Scale thereby includes the finest temporal and spatial levels that the data can be broken down into, called the resolution, as well as the spatial and temporal extent covered in the analysis. An analysis of a satellite data set could therefore have the pixel size as the spatial resolution, the frequency of the data collection as the temporal resolution, the area covered by the data set as the spatial extent, and the time period for which the data are available as the temporal extent. Scale aspects are not only important to consider in the data, but also in analyses. Does the spatial and temporal resolution of the data allow you to see the patterns you are interested in? Or is the data perhaps too detailed to provide a general picture of the situation? Choosing one single scale for an analysis also means neglecting other dimensions. The Modifiable Area Unit Problem (MAUP) refers to how the units used in spatial analyses can take many different shapes and sizes, which in turn affects the statistical outcomes of the analyses (Dark and Bram 2007). An important example of where the MAUP is present is in census data, where the socially constructed units (census tracts, districts, countries) often have “no natural or meaningful geographical identity” (Openshaw 1984). Aggregating individual data into areal units might also lead to ecological fallacies, which means assigning information based on group data onto individuals. Different units of analysis will yield different correlation strengths, and coarser units decrease the variation in the data (Dark and Bram 2007). It is thus crucial to be aware of how the scale used in the data and analysis affects the results.

# Data and Methods

## Study Area

The Duhok governorate is situated in the Kurdistan Region (KR-I) in Northern Iraq that is an autonomous region in Iraq, run by the Kurdistan Regional Government (KRG). The KR-I includes the three governorates (provinces) of Duhok, Erbil and Sulaymaniyah, where the city of Erbil (in Kurdish: Hawler) is considered the capital, home to the KRG headquarters (Figure 2). The KR-I covers an area of about 40000 km<sup>2</sup>, of which Duhok has the smallest area of 6600 km<sup>2</sup> (Kurdistan Regional Government (KRG) 2014). The Duhok governorate provides an interesting biophysical and geopolitical setting, where little is known about the population-environmental dynamics taking place.



**Figure 2** Study area map with the Kurdistan governorates' location in Iraq, bordering countries, main cities and rivers of Iraq (left) and the Duhok governorate's elevation (ASTER GDEM, a product of METI and NASA), main cities and districts (right).

## Population

The population of KR-I were in 2009 approximately 4.7 million people, of which 1.2 million were living in the Duhok governorate (Kurdistan Region Statistics Office (KRSO) 2014). People residing in the three main cities of Erbil, Sulaymaniyah and Duhok made up 39% of the total population in 2009, and in the Duhok governorate 27% lived in Duhok city. These numbers are expected to have increased since 2009, but no reliable population counts exist. The name “Kurdistan” means the land of the Kurds, but it is also home to Arabs, Turkmen, Assyrians, Shabaks, Chaldeans, Yazidis and Armenians (Kurdistan Regional Government (KRG) 2014).

Kurdistan has had a mobile population since the 1970's due to different political conflicts, either between the Kurds and the Iraqi government, or between different political parties within the Kurdish region (Eklund and Pilesjö 2012). Thousands of people were displaced during a village destruction campaign in the 1970's, carried out by the Iraqi government, and the *Anfal* genocide in the late 1980's caused widespread displacement and destruction of 2000 villages (Human Rights Watch 1993, Barwari 2013). Almost 2 million Kurds fled to Iran or Turkey in March 1991 when targeted by another military campaign after Kurdish resistance had launched a rebellion against the Iraqi Government (Barwari 2013).

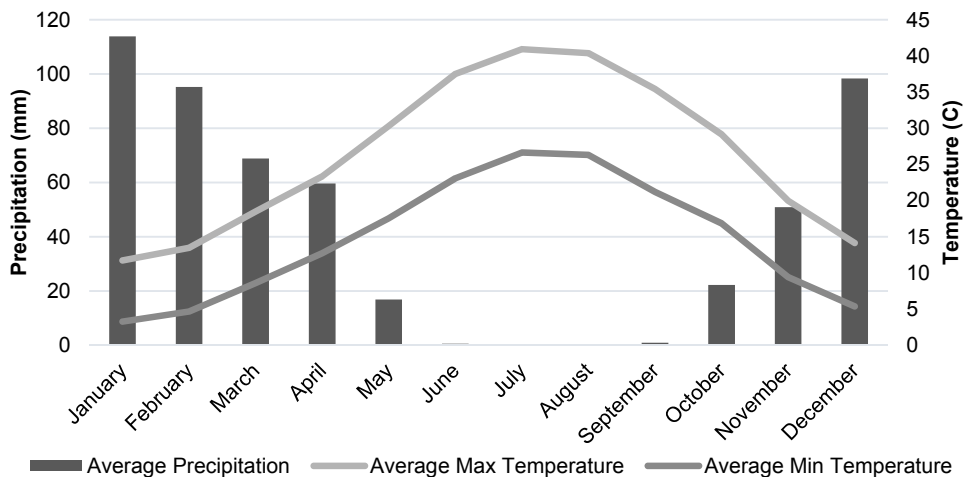
Since 2011 migration patterns in Duhok governorate have been dominated by refugees from Syria and from areas targeted by the Islamic State (IS) in 2014 and 2015 (Kurdistan Regional Government (KRG) 2012, IOM Iraq 2014).

## Physical Geography

The KR-I borders Syria in the north-west, Turkey in the north, Iran in the north east, and Iraq in the south (Figure 2). The area is home to three large water bodies, the Mosul dam, Dokan dam and Darbandikhan dam. Mosul dam, just south of Duhok governorate, is a dam on the Tigris River that runs for a short distance on the border of the Duhok governorate. Other important rivers are the Khabur, Greater Zab, Lesser Zab, Sirwan, and Awa Spi. The Zagros mountain range extends its northwestern parts across Kurdistan to the borders of Turkey where it becomes the Anti-Taurus Mountains (Held and Cotter 2006). The northern parts of Kurdistan are hence mountainous areas, with peaks of up to 3600 meters above mean sea level (Central Intelligence Agency (CIA) n.d.). The southern parts, bordering Southern Iraq, consist of plains.

The climate of Kurdistan is governed by orographic precipitation from the mountains, leading to high precipitation rates in the northern parts, and drier climate in the plains (Trigo, Gouveia et al. 2010). Precipitation is concentrated from October to May, while the hotter summer months hold little or no precipitation at all (Figure 3). The average annual precipitation ranges between 300 and 1000 mm, with inter-annual variations

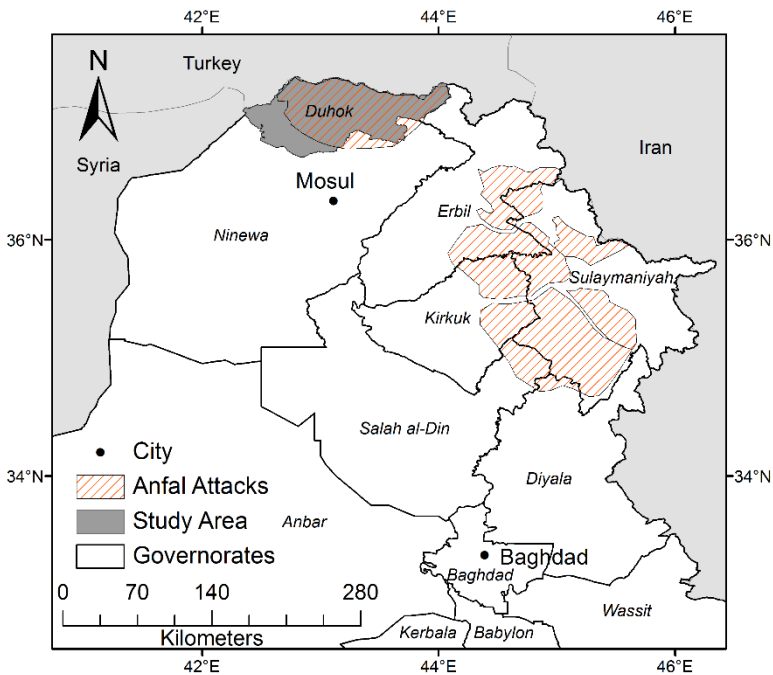
of between 100 mm and 1300 mm (Hijmans, Cameron et al. 2005, Held and Cotter 2006, UNDP 2010). The mean daily temperature for winter is around 5°C and in summer the mean temperature is around 30°C, but can rise to 50°C in the southern parts around the city of Erbil (Hijmans, Cameron et al. 2005). Drought is a recurrent climate phenomenon in the Middle East and there have been at least three severe droughts in the KR-I since mid-20th century: 1958-1961, 1998-2000 and 2007-2009 (Metz 1988, Trigo, Gouveia et al. 2010, Eklund and Seaquist 2015). During the last drought period, a precipitation decline of up to 70% was measured over Iraq (Trigo, Gouveia et al. 2010). The same drought period has been reported to cause widespread problems in Syria, especially in the north eastern governorates close to the KR-I (Ali 2010, de Châtel 2014). This included crop failures, a strongly reduced food security, and, in combination with other factors such as a reduction of state subsidies for farmers, an estimated 300000 Syrians migrated to the cities. Some would argue that the drought related migration might have played a role in the Syrian uprising in 2011 (de Châtel 2014, Kelley, Mohtadi et al. 2015). Paper II shows that despite spatial proximity and biophysical similarities between the drought struck areas in Syria and the Duhok governorate, the socio-economic effects are very different (Eklund and Seaquist 2015).



**Figure 3**  
Climate data for the Duhok Governorate derived between 2000 and 2010 (Data source: Directorate of seismology and Meteorology, Duhok)

## Agriculture

During the 1980s Iraq had about the highest food availability per capita in the Middle East (WFP Iraq - North Coordination Office 2001). Agricultural production in the three northern governorates of Kurdistan accounted for 25-30% of all food production in Iraq, due to high soil fertility and favorable climate conditions. A major event that severely affected the food productivity was the Anfal genocide campaign against the Kurds in Iraq, carried out by the Iraqi Government between 1987 and 1989, during which large tracts of agricultural land were destroyed (Figure 4), and many people were killed, imprisoned, or forcibly moved from their villages (Human Rights Watch 1993, Mubareka and Ehrlich 2010, Hardi 2011). Shortly after the Anfal campaign, Iraq invaded Kuwait, which led to international trade sanctions that prohibited the export of oil, and the import of goods considered “dual use”, for example fertilizers and material to rebuild the infrastructure that had been destroyed during the war (Gibson, Campbell et al. 2012). The development of agriculture in Iraq was hampered, and as the Kurdish Region became an autonomous region the government of Iraq imposed sanctions between Iraq and the KR-I that led to economic decline and malnutrition.



**Figure 4**  
Areas targeted by the Anfal attacks in the Kurdish areas of Iraq.

A community based village reconstruction program that provided housing to the displaced and the returnees in the KR-I was initiated by the KRG in 1991 (Barwari 2013). The purpose was also to improve access to land and water, and to rebuild people's livelihoods. Supported by various UN and NGO programs, the reconstruction program lasted until 2003 and reportedly improved the living conditions of nearly 30% of the population.

An initiative that also decreased the food production in Iraq was the Oil-for-Food Programme (OFF) that was implemented by the United Nations in 1997 and lasted until 2003 (Meyer and Califano 2006). During the OFF more than 2 million people were given free food and medical aid, with 660000 of them living in northern Iraq. People became dependent on food aid and ceased to rely on agriculture for food. According to Hardi (2011) OFF, together with lack of support in rural areas, droughts and instability, contributed to the hampering of the agricultural recovery from *Anfal*. In a survey carried out in 2001 by the Food and Agricultural Organization, 38% of all rural incomes in the Duhok governorate came from agriculture, while 62% came from non-agricultural activities (Food and Agriculture Organization of the United Nations (FAO) 2004).

Nowadays, the Kurdistan Region imports a large amount of its fruits, vegetables and poultry from nearby countries, such as Turkey and Iran (UNDP 2010). About two thirds of all tomatoes in KR-I were imported in 2010, and only water melon production exceeded the amount of imports (Kurdistan Region Statistics Office (KRSO) 2014).

Grain production in KR-I is dominated by wheat and barley, of which wheat is considered a staple food in the Iraqi diet and barley is produced mainly for animal fodder (Appropriate Agriculture International 2013). Grain fields are mostly rain fed and situated in the plains, which makes grain production susceptible to climate variations. The summer crop fields of the KR-I were in 2012-2013 dominated by pepper (16%), musk melon (16%), okra (14%) and tomato (12%), but in the Duhok governorate the most common summer crops were musk melon (48%), tomato (14%) and water melon (11%) (Kurdistan Region Statistics Office (KRSO) 2013).

## Data Collection and Preparation

The data used in this project have been collected from both secondary and first-hand sources. They include household survey data, field collected land cover data, satellite based land and atmospheric data, meteorological station data and various Geographic Information System (GIS)-data.



**Table 1**

Description of the main data used in the different papers of this dissertation

DATA	TEMPORAL EXTENT	SPATIAL RESOLUTION	SPATIAL COVERAGE	REFERENCE	PAPER
Household Survey 2011	2000-2010 retrospectively	Household	1206 households in 51 villages in the Duhok governorate	Eklund and Pilesjö (2012)	I and II
Ground Truth Points (Land cover)		Point locations	Duhok Governorate	Eklund, Persson and Pilesjö (2015)	III
MODIS EVI	2001-present	250 m	Global	USGS: United States Geological Survey (2009), Solano, Didan et al. (2010)	II
Landsat 4, 5, 7 and 8	1984-present	30 m	Duhok governorate	(United States Geological Survey 2014)	III
Meteorological station data	2000-2010	Points	2 stations, Duhok and Zakho	N/A	II
TRMM	1998-2010	0.05° (~5 km)	37°S-37°N latitudinal band	(Kummerow, Barnes et al. 1998)	II
CRU 3.2	1901-2012	0.5°	Global	Harris, Jones et al. (2013)	III
ASTER GDEM		1 arc second (~30 m)	Global	(Tachikawa, Kaku et al. 2011)	II, III

## Interviews and field collected data

A survey was conducted between July and September 2011 in 51 villages and 4 cities in the Duhok Governorate, and served as a basis for **Paper I**, but the collected data were also used in Paper II. A group of six research assistants collected data for 1206 households, using a predesigned survey with mainly open-ended questions. The questions covered household demographics, agricultural activity, environmental challenges and migration experience. Villages were randomly selected in a GIS, and within villages, households were in-situ sampled by starting from the main road,

dropping a pen and following the direction of the pen. Then every third household on the right-hand side was asked to participate. On average, each of the six research assistants conducted ten interviews per day, which resulted in 606 interviews. An additional 600 interviews were conducted in the four urban centers of the Duhok governorate. The survey for the urban households were shortened, as questions about agriculture had been removed. A similar in-situ sampling was used for the urban centers.

A follow-up survey was conducted in April 2013, in six villages that had been found interesting based on the result of the first survey. The aim was to understand the strong urban-to rural household migration pattern described in **Paper I**, and to see what role this pattern might play for the agricultural development of rural areas. The survey covered 30 households and included more detailed questions about migration, relationship to the village, and agriculture. The in-situ sampling strategy was the same as the previous survey, but the interviews were conducted with a translator. These data were only used for contextual knowledge in **Paper III**, but will be used in future studies.

During the field work in April 2013, land cover data were collected as point data. Positions were sampled using a Global Positioning System (GPS). The data were collected for the purpose of training and validating satellite based land cover assessments, and included the following classes: cropland, bare soil, built-up area, orchard, grassland, shrub and woodland. Points and sometimes photographs were collected every km on the right hand side of the road, resulting in 257 ground truth points (GTPs). Traffic safety measures, however, affected the ability to stop at all locations and therefore some points were sampled from the car and manually moved to a point between 20 and 50 meters from the road. These data were used for validation and training in **Paper III**.

## Vegetation and Land Surface Data

Enhanced Vegetation Index (EVI) data from the Moderate-resolution Imaging Spectroradiometer (MODIS) instrument were acquired from the International Research Institute's Data Library and used in **Paper II** (USGS: United States Geological Survey 2009). EVI is an index developed to monitor the vegetation of the earth based on satellite images, by looking at its reflection of near infrared light in relation to red and blue light (Equation 1):

$$EVI = G * \frac{\rho_{NIR} - \rho_{red}}{\rho_{NIR} + C_1 * \rho_{red} - C_2 * \rho_{blue} + L} \quad (1)$$

where  $G$  = gain,  $\rho_{NIR}$  = near infrared reflectance,  $\rho_{red}$  = red reflectance,  $\rho_{blue}$  = blue reflectance  $C_1 = 6$  (coefficient for aerosol resistance),  $C_2 = 7.5$  (coefficient for aerosol resistance) and  $L = 1$  (canopy background factor).

The MODIS project started collecting vegetation data in 2000 and is still providing data. It consist of 16-day composites with a spatial resolution of 250 m (Solano, Didan et al. 2010, Table 1).

The Landsat program has been collecting satellite images for over 40 years and is thereby holding the longest continuous global record of the earth's surface. The Landsat Multi-Spectral Scanner (MSS) were the first sensor to record satellite images onboard Landsat 1 through 5, but the Thematic Mapper (TM) was introduced on Landsat 4 and 5 (United States Geological Survey 2014). Landsat TM data have a resolution of 30 m for its seven spectral bands (Table 1). Onboard Landsat 7 is the Enhanced Thematic Mapper that collects a panchromatic band of 15 meters resolution, in addition to the TM's seven bands. Unfortunately the Scan Line Corrector (SLC) of Landsat 7 failed in 2003, which caused striped data gaps in all subsequent images (United States Geological Survey 2013). The latest Landsat mission, Landsat 8, were launched in 2013 and holds the Operational Land Imager (OLI) which collects data in nine spectral bands (United States Geological Survey 2014). Data from the Landsat missions 4, 5, 7 (SLC on) and 8 were used in **Paper III**.

ASTER GDEM (version 2) is a global Digital Elevation Model (DEM) product developed by the Ministry of Economy, Trade, and Industry (METI) of Japan and the United States National Aeronautics and Space Administration (NASA). It has a spatial resolution of 1 arc-second (about 30 m) and was released in October 2011. The DEM is reported to have an accuracy of 17 meters at the 95% confidence level when compared to 1800 absolute geodetic reference points in the US (Tachikawa, Kaku et al. 2011). When comparing ASTER GDEM to a 10 m national elevation grid in Japan, an average 0.7 m deviation was recorded over bare areas, and 7.4 meters over forest areas. Tachikawa, Kaku et al. (2011) thus notes that although the ASTER GDEM v. 2 has improved from its previous version, some shortcomings still exist. ASTER GDEM data were used in **Paper II** and **Paper III**.

High resolution satellite data from Quickbird (2.4 m), Worldview (1.84 m) and SPOT (2.5–10 m) data from 2002 to 2014 is provided through Google Earth. These data were used for visual interpretation of land areas in **Paper II**, and for collection of training data points in **Paper III**.

## **Meteorological data**

Station measured meteorological data for the period 2000-2011 were obtained from the Directorate of Seismology and Meteorology in Duhok, and included monthly data on precipitation (mm) and temperature (°C) from the two weather stations located in Duhok and Zakho. These data were used in the drought assessment of **Paper II**.

The Tropical Rainfall Measuring Mission (TRMM) dataset is a satellite based precipitation estimate that uses the properties of clouds to measure 3-hours precipitation at a spatial resolution of 0.25° (approximately 30 km in the study area) and covers a time period of 1998-present (Kummerow, Barnes et al. 1998, Huffman, Bolvin et al. 2007). This dataset was used in **Paper II** as a complement to the station data acquired from the Directorate of Meteorology and Seismology.

The CRU 3.2 dataset is based on climate data from a ground stations database (Harris, Jones et al. 2013). The grids have been interpolated based on station anomalies originating from this database. CRU includes data on precipitation, temperature and four other climate variables, and has a spatial resolution of 0.5°. The dataset covers data from 1901-2012. CRU is one of the datasets that is criticized in paper 4 for its coarse resolution and limitations in data used as basis for the interpolations. It is used in **Paper III** because it has the best temporal coverage.

## **Other data**

Shapefiles including administrative boundaries, villages, cities, roads and water bodies were acquired from the International Organization for Migration (IOM) and the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA). These data were mainly used for visualization, data sampling and to define areas of analysis in **Papers I-III**.

## **Methods**

This dissertation uses a mix of qualitative and quantitative methods in order to gain an integrated understanding for the population dynamics and land processes in the Duhok governorate.

## **Migration patterns in Duhok Governorate (Paper I)**

The analysis of the 2011 survey data had a mainly descriptive statistics approach in order to explore the data and summarize the main patterns. A separation between reported household migration (first hand source) and reported individual migration from the household (second hand source) was made. Reported reasons for migrating were counted and grouped into categories, such as household, female individual migration and male individual migration. A temporal dimension was added in order to see how migration flows have changed over time, and if they might be connected to certain events. The data were also grouped into urban and rural origins and destinations (e.g. rural to urban, urban to rural, rural to rural) to gain an understanding for the urban-rural dynamics of the migration patterns. Environmental changes as reported reasons for migration, and dependence on agriculture, were also included in the descriptive analysis.

## **Meteorological, agricultural and socioeconomic drought in the Duhok Governorate, Iraqi Kurdistan (Paper II)**

This study used a combination of biophysical and socioeconomic data to assess the 2007-2009 drought from multiple perspectives. Meteorological drought was assessed by looking at the temporal evolution of precipitation, based on both station data and satellite based estimates (TRMM). In this time series analysis, spatial distinctions were made between districts (for the satellite data) and point locations for the two stations.

For the assessment of agricultural drought, EVI anomalies (z-scores) were calculated for the growing period (March-June) for each year between 2001 and 2010. This gave values representing how many standard deviations the value for that year was deviating from the overall mean, where a value of more than one standard deviation above or below mean was considered an anomaly.

For the socio-economic village level assessment, buffer zones with a radius of 2 km were constructed around 50 villages, over which EVI anomalies were averaged, yielding an average EVI z-score for each village and year. The EVI anomalies for the worst drought year were then used in a Spearman rank correlation, with data on the number of people in the village who had reported drought, frost, agricultural activity, agricultural income, and irrigation. For a more descriptive analysis, the three worst affected villages during the drought year were compared to the three least affected villages. Three median villages were also included to represent the situation for the villages in between. The temporal evolution of EVI for the nine villages were discussed together with the survey responses from the villages, including estimated out-migration.

## **Cropland changes in times of genocide, reconstruction, and economic development in Iraqi Kurdistan (Paper III)**

This study uses multiple Landsat scenes between 1984 and 2014 to calculate Normalized Difference Vegetation Index (NDVI) composites for four periods:

- A. Pre-Anfal (1984-1987)
- B. Post-Anfal (1989-1991)
- C. Reconstruction (1998-2002)
- D. Present (2011-2014)

The differences in NDVI between spring and summer were calculated for each period to detect areas that had been harvested in early June, i.e. winter crops. One representative image per period were used for multi-resolution segmentation, in order to enable an object based analysis instead of a pixel-wise classification (Darwish, Leukert et al. 2003, Trimble 2012). Google Earth based training data (Quickbird (2.4 m), Worldview (1.84 m) and SPOT (2.5-10 m)) were used in combination with GTPs to help determine a threshold value for winter crops, based on mean NDVI difference and ASTER based mean slope data for the segments (ASTER 2011). The threshold value was set to an NDVI difference larger than, or equal to, 0.30291 and a slope smaller than 7.625 degrees. The results were validated for all periods using a visual interpretation of the Landsat data (Periods A-C) or GTPs (Period D) and the influence of precipitation (CRU 3.2) was discussed after comparing the results with precipitation data.

## **Data and methods in the environment-migration nexus: a scale perspective (Paper IV)**

This paper is a literature review of scale related challenges in Environment-Migration research. It is based on 27 peer reviewed case studies that uses qualitative or quantitative methods to understand the relationship between environment and migration. This study is framed by the scale issues defined by Openshaw and Taylor (1979), Atkinson and Tate (2000), Dark and Bram (2007) and Sheppard and McMaster (2008) who talk about the Modifiable Area Unit Problem and rescaling techniques. These two issues, and their sub-problems, are discussed with examples of data collection and methods of analysis in environment-migration research.

## Limitations concerning data and methods

Collection of secondary data in the Middle East can be a major challenge in terms of quality (i.e. reliability, aggregation level and comparability), availability (e.g. access, language and cost), and how “up to date” the data is (Hvidt 1996). Political instability, lack of resources and sometimes political motives are examples of factors that have contributed to the lack of reliable statistics in this area. Therefore, a combination of different datasets has been used in this dissertation, in order to increase the reliability of the analyses.

### *Population Data*

One of the main data problems is the lack of detailed and continuous population data, as population enumeration is a strongly politicized issue in Iraq. Demographic information were used to allocate power to the Arab majority in 1963, when the Ba‘th government forcibly displaced non-Arab inhabitants of the oil-rich Kirkuk governorate, and resettled it with Arab people from southern Iraq (O’Leary 2002). The last nationwide Iraqi census was conducted in 1987. For many people in the Kurdish areas participation in the census meant being forcibly relocated to camps or killed, as a large part of the rural area had been declared “prohibited” (Hardi 2011). People who did not participate in the census lost their Iraqi citizenship and were therefore in risk of getting “destroyed” in the *Anfal* genocide. In 1997, the Iraqi census included all but the three Kurdish governorates, and the results of this census were therefore not useful for this study.

The Kirkuk status referendum and the Article 140 of the Iraqi Constitution from 2005 have been impeding the census that was planned for 2007. The Kirkuk status referendum is part of a popular vote where a decision will be made on whether some Kurdish majority regions of Iraq will become part of the KR-I. Article 140, however, states that this referendum cannot be carried out until two measures have been taken, normalization and census. Normalization means assisting the return and/or compensating the people who were displaced from and to Kirkuk during the “Arabization policy”, and the census data would then be used to decide which areas can be considered Kurdish. The Kirkuk Status referendum was supposed to resolve the issue of Kirkuk by the end of 2007, but has since been delayed. A population enumeration was conducted in the Kurdistan region in 2009, but although the data have been acquired, little information about the methods for data collection is provided. The only use of this data have therefore been to provide approximate population size of the Duhok governorate, the KR-I and the urban-rural population difference.

### *Meteorological data*

Finding reliable data with good coverage on precipitation and temperature has been a major challenge, which is reflected in the use of many different precipitation data sources in this dissertation. Data from only two meteorological stations with no exact location information and with only ten years of data recorded, were not sufficient for studying precipitation anomalies for either Paper II or Paper III. A better temporal and/or spatial coverage was found with TRMM and CRU data, but these datasets have their limitations, such as coarse resolution (both) and a low density of stations to base the interpolation on (CRU) (see Eklund, Romankiewicz et al. (forthcoming)).

### *Survey data*

Household surveys and interviews are common ways to collect socio-economic information, but several limitations apply. The design of the interview sheet determines what information will be collected and how questions are asked. The first survey was conducted early on in the project, and due to time and economic constraints, only a small test survey was done before the real data collection started. This meant that some questions and their responses were vague and too general to be used. Another issue relates to translation and interpretation. The questionnaires were in English and the survey was conducted by English students, but the interviews were conducted in Kurdish (and sometimes Arabic), and then the responses were translated back to English. In this process of translation, meanings could be lost and there is risk of misunderstandings between the researcher and the interviewer, as well as between the interviewer and the interviewee, that is difficult to eliminate. To reduce the risk of misunderstandings, a longer training period with the field assistants would be necessary. From a gender perspective, the survey had the limitation that it was directed towards the household head, which in most cases were male. This issue might have led to a different response than if women had been targeted in the survey. The fact that all field assistants conducting the interviews were male could also play a role in the results of the surveys. During the second field work the whole family, including women, men and children, would often sit down and respond to the questions. In hindsight, there are many questions that could have been asked differently, and questions that could have been added to the questionnaires, but overall the first survey provided a solid foundation to build upon.





# Results and Discussion

## Migration patterns in Duhok Governorate, Iraq, 2000-2010 (Paper I)

This study recorded 1033 migration events for the 1206 households included in the survey. 520 of these migration events represented temporary relocations from urban centers to rural areas during a short period in spring of 2003, when Iraq was invaded by a coalition led by the United States. This temporary relocation was reportedly a security measure, and shows that an important response to insecurity is relocation. This type of migration was considered a separate category, and was therefore excluded from the rest of the analysis. Economy was determined as the main driver of migration, both for household and individual migration. The concept of “economy” is wide so migration for economic reasons might be everything from job opportunities to cheaper housing. Family and marriage related migration is also common among both males, females and whole households, showing the importance of family in the Kurdish/Iraqi culture. This type of migration may include for example an individual’s move after getting married, or a household who move to be closer to the rest of the family. Nearly 70% of the females who have migrated have done so for family/marriage reasons. Security as a reason for migration was reported in household migrations, but not in individual’s migration decisions. Many of these security motivated migrations happened between 2002 and 2008, and were mostly households moving from Baghdad and Mosul to both cities and villages in the Duhok governorate. Environmental degradation as a reason behind migration was found to be low and was explained by the low reliance on agriculture in the area. Overall, only 20% of the rural households were involved in agriculture, and only 13% were economically dependent on agriculture. Household migration directed from urban to rural areas (36.7% of the household migration events) was found more common than households migrating from rural to urban areas (20.2%). This result contradicted reports of rural-urban migration, and indicated that there were economic incentives for moving to rural villages. This trend was only true for households, as the individuals’ migration patterns were directed from rural to urban areas (14.6%), and abroad (67.3%).

## Meteorological, agricultural and socioeconomic drought in the Duhok Governorate, Iraqi Kurdistan (Paper II)

This study supported previous reports of a severe drought between 2007 and 2009, where a decrease of nearly 50% in precipitation was recorded in the Duhok governorate. This drop in precipitation was also reflected by strong negative vegetation anomalies in 2008. For that year, 66.2 % of the governorate showed negative ( $>-1$  standard deviation) or strong negative ( $<-2$  standard deviations) vegetation anomalies. For the years 2007 and 2009, however, there were no substantial anomalies, which means that agricultural drought only occurred during the year 2008, while meteorological drought occurred between 2007 and 2009. Negative vegetation anomalies were also found for the year 2003, which was a year of very high precipitation. This is explained by an abnormally late snow melt in spring, which affected the aggregated NDVI negatively for that year.

The socio-economic drought assessment showed that 46 out of the 50 villages included in the study had experienced negative vegetation conditions (of  $>1$  standard deviation) during the drought year of 2008. The reporting of drought as a problem coincided to some degree with negative vegetation anomalies ( $\rho = -0.39$ ), but more importantly with agricultural activity of the village inhabitants ( $\rho = 0.42$ ). The analysis of the three worst affected, the three least affected and the three median villages showed that the median villages had nearly as large negative anomalies as the worst affected villages. The reporting of drought as a problem was as just as high in the median villages as the worst affected villages, while the least affected villages had no reporting of drought as a problem. Two of the least drought affected villages had instead reported frost as a problem, which corresponds well with those villages' vegetation anomalies in 2003.

This means that surveys can be useful in drought assessments, especially in agricultural areas where people are more susceptible to droughts. The findings show that diversification of income sources, due to decades of insecurity, have led to a reduced drought vulnerability in many households, and that no association between drought severity and out-migration from villages could be confirmed.

## Cropland changes in times of genocide, reconstruction, and economic development in Iraqi Kurdistan (Paper III)

This study provides insights to the reports of an agricultural decline in the Duhok governorate in connection with the *Anfal* genocide (Table 2). This genocide was carried out by the Iraqi government against the population living in the Kurdish part of Iraq, and led to widespread land abandonment as people fled or were forcibly moved, imprisoned or even killed. Despite these reports the Duhok governorate only saw a 7.5% decrease in active winter cropland area in the years after *Anfal*. The study, however, reveals a 23% increase in cropland during the reconstruction period (Table 2), when land was restored and villages rebuilt through a community involved governmental program. During this period, Iraq was sanctioned and importing agricultural inputs such as fertilizer or infrastructure materials was prohibited, which may have explained the extensification of land. Since that period, the winter cropland area has increased very little by 2.6% in 2011-2014 (Table 2), a period of increased urbanization and economic development.

**Table 2**

The area of winter crop within the Duhok governorate throughout the four periods.

	Pre Anfal (1984-1987)	Post-Anfal (1989-1991)	Reconstruction (1998-2002)	Present (2011-2014)
Active cropland	1053 km <sup>2</sup>	974 km <sup>2</sup>	1197 km <sup>2</sup>	1228 km <sup>2</sup>
Other	5526 km <sup>2</sup>	5605km <sup>2</sup>	5382 km <sup>2</sup>	5351km <sup>2</sup>
Sum	6579 km <sup>2</sup>	6579 km <sup>2</sup>	6579 km <sup>2</sup>	6579 km <sup>2</sup>

The findings also show that 661 km<sup>2</sup> (10% of the Duhok governorate area) had been cultivated with winter crops consecutively through the four periods, and that 115 km<sup>2</sup> (1.8%) were cultivated in all periods but the post-*Anfal* period, indicating land abandonment due to *Anfal* and recovery during the reconstruction period. Another 125 km<sup>2</sup> (1.9%) had been taken into cultivation after *Anfal* and onwards, which could imply displacement of agricultural activity. An expansion of 114 km<sup>2</sup> (1.8%) cropland onto land previously not used for winter crops was seen between the reconstruction period and the present period. These changes show that despite net decreases and increases at a provincial scale, different changes can be seen at a more detailed scale, showing the complexity of the relationship between socio-economic and political changes, and land dynamics.

The classification accuracy calculations for the present period showed an overall accuracy of between 87.6 and 96.3%, and a Kappa-value of 0.615-0.859. The influence of precipitation on the analysis were considered low.

## Data and methods in the environment-migration nexus: a scale perspective (Paper IV)

This review of case studies show several data and methodology related issues in the environment-migration literature. Scale refers to the dimensions (e.g. spatial and temporal) used to study and analyze a phenomenon (Gibson, Ostrom et al. 2000), and depending on what dimensions are chosen, the observation will be different. Focusing on a large area (extent) with a coarse resolution might not show the same result as when covering only 10% of that area but with a more detailed resolution. Keshkamat, Kooiman et al. (2012) differentiate between reality scale, model scale and data scale. They explain that while reality is made up of different interconnected processes at all scales imaginable, researchers need to use model scales for the processes they want to study. Data, however, is often connected at a different scale and therefore a data scale needs to be considered. The Modifiable Area Unit Problem (MAUP) is a key issue that refers to how the units used in spatial analyses can take many different shapes and sizes, which affects the statistical outcomes of correlation analyses. An example of this is the use of administrative boundaries to separate areas in the analysis, instead of basing the division on e.g. watersheds or grids. This study examines the data and analyses used in 27 case studies of the environment-migration nexus, with regard to scale.

Environmental data, used in environment-migration research, are often quantitative and from secondary sources, either satellite based (vegetation and precipitation data) or interpolated from a historical rain gauge stations database (precipitation). Most satellite and precipitation data have global coverage with a coarse spatial resolution of between 250 m (MODIS) and 2.5° (~250 km, Global Precipitation and Climatology Project (GPCP)). Data with coarse resolutions will not show variations in e.g. precipitation or vegetation greenness that are smaller than the pixel size. So for example a 250 by 250 km pixel can have strong internal variations in precipitation, which will not be seen in the data. Another issue is that many of the global precipitation datasets are interpolated based on a stations database that in some areas have very few stations represented.

Migration and socio-economic data are extracted mainly from census data (secondary) or from sample surveys. In both cases, the migration measured is dependent upon the definition of relevant boundaries, where for example a move within a sub-district might not be recorded when focusing on districts. Furthermore, census data often come aggregated to administrative levels, which makes a more detailed analysis impossible.

There is also a temporal aspect of census data, since censuses take place on a ten year basis, and much of the migration patterns between censuses are missed. Sample surveys, on the other hand, are often only carried out once and migration histories are gathered retrospectively. The issue with sample surveys is the comparability and representativeness between surveys. While a study might be representative for a certain community, it might be difficult to compare it to another community where a different survey has been carried out.

In this review we find that very few of the case studies acknowledge scale as a potential cause of uncertainty, although there are several scale issues present in the data and methods used. In the analyses of the migration-environment nexus, the main scale issue was the mismatch of scale between different datasets and types. Data from different sources needed, therefore, to be rescaled to the desired resolution by for example averaging or aggregation. This upscaling of data leads to generalizations that neglect the internal variability within the unit of analysis, and such a modification should therefore be carefully motivated and discussed. The review also identified the use of “multi-level” approaches, which in theory is a good idea, but in many of the cases only used data from different scales and conducted the analysis at one scale.



# Conclusions

This dissertation is a study of how people are interacting with their biophysical environment in Iraqi Kurdistan. It shows how the Earth surface is changed, not only by climate and environmental factors, but also by socio-economic and political factors. The study thereby identifies human activities as central components in the Earth system, in the context of Iraqi Kurdistan. Furthermore this study provides important insights to the role of conflicts and political instability in migration and population mobility, and how the history of insecurity has potentially reduced the rural population's vulnerability or susceptibility to drought.

Population mobility in Iraqi Kurdistan is generally not an outcome of environmental issues, but rather driven by socio-economic and political factors. Urban areas are attracting people with economic and educational opportunities, but the mapping of the 2000-2010 migration patterns also revealed a strong return migration from urban to rural areas. In the history of Iraqi Kurdistan, the Anfal genocide and the Oil for Food Programme have been presented as important impediments to the agricultural development of the region. This study, however, reveals that the Anfal genocide did not cause any substantial reduction in winter cropland activity. It also shows that winter cropland area actually increased during the late part of the Oil for Food programme, that also coincided with a village reconstruction program aimed at rebuilding villages that had been destroyed in the Anfal campaign. The results of this work also show how satellite data can be used in quantitative assessments of past periods and thus bring new insights to socio-economic and political events and their effects on the landscape.

An essential finding in this dissertation is the importance of studying population-environment dynamics in the context of political and economic history. It has also become clear how vital the issue of scale is in research combining population and environment. The spatial and temporal dimensions of the data often determine the scale at which the analysis takes place, which in turn affect the ability to identify and explain patterns. This work uses different analytical dimensions to study people and land in the Duhok governorate, from village to province level. Local case studies are important compliments to global or regional assessments, with their ability to provide more detailed information to the overall assessment. There is always a tradeoff between detail and generalizability in research, but by working with multiple dimensions, this issue is reduced.



Future studies of the population-environment dynamics in Iraqi Kurdistan can build upon this research by further investigate some of the findings that could not be addressed in the scope of this dissertation. When mapping migration patterns, a strong urban to rural trend was found that brings up the question about urban-rural dynamics and the need for more focus on rural development. Furthermore, the cropland areas that were abandoned during certain periods, or the land that was converted to cropland in the most recent period, constitute “hot-spots” where both qualitative and quantitative analyses would provide interesting additions to our knowledge about agriculture in the area.

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# Appended Papers



