CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Tropical AgriSciences

Study programme: Tropical Forestry and Agroforestry

Farmers' use and preferences of trees in Kurdistan region of Iraq

MASTER'S THESIS

Prague 2018

Author:

Ragheb Mohammad, BSc.

Supervisor:

Doc. Ing. Bohdan Lojka, Ph.D.

Declaration

I hereby declare that I have done this thesis entitled “Farmers’ use and preferences of trees in Kurdistan region of Iraq”, independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to citation rules of the FTA.

In Prague, April 27, 2018

…..…….……

Ragheb Mohammad

Acknowledgements

First and foremost, I would like to thank God. You gave me the power to believe in my passion and pursue my dreams, the Almighty!

Secondly, I would like to express my very great appreciation to my supervisor doc. Ing. Bohdan Lojka, Ph.D. to his encouraging, helping, patience, and supporting during my diploma thesis writing.

To my lovely and dear mother, I am very grateful and proud because you are my mother but sadly and I am so sorry I could not see you even before your death, you left me even before to see you for the last time. I am asking the God to forgive you, and to grant you highest place in the paradise. You taught me how to respect, patience, and deal with people. You taught me the right way in my life. God bless you my dear mother. My dear Mom, I will never forget you, you will be in my heart forever!

To my dear father, brothers, and sisters thank you for everything to your encouraging, supporting, helping, and raise my spirits during my study. I am very proud to have such a lovely family in my life. God bless you all!

I would like to express my love, my pride, and my respect for my unique family for their supporting and patience during my study. I love you my lovely wife and my beloved sons Anas and Amir. I missed you a lot my lovely family, with all my heart thank you!

Also, I would like to express my appreciation to my best academic colleagues Mr. Hardy Awlla, Mr. Halmat Saber, and Mr. Dilzar Zerar at Salahaddin University – Erbil to your helping, patience, and supporting during the data collection in Erbil.

I would like to thank my colleague Niga Rezgar for her helping, supporting, and encouraging during my diploma thesis writing, thank you!

My big thanks to Anna Manourova, Ph.D. student, to her helping and supporting during my diploma thesis writing, thank you!

I would like to express my special appreciation and thanks to the Ministry of Education, Youth and Sports for support and funding scholarships, thank you!

MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY

Abstract

Trees play an important role in virtually all the natural ecosystems. Most of the trees have multiple uses, and they offer a range of valuable products such as fruits and service roles such as windbreaks, to the rural farmers and local people. The study aimed to identify the most important use of tree species by the farmers in Iraqi Kurdistan along with their preferences among the species as well as to evaluate the abundance of species. The methodology was based on the studies developed by World Agroforestry Centre (ICRAF) and International Service for National Agricultural Research (ISNAR) with appropriate modifications to the study conditions. The fieldwork was carried out in Erbil province of Iraqi Kurdistan from August until October 2017 in both lowland and highland areas. Altogether, 62 respondents were interviewed by semi-structured questionnaires and 46 tree species were identified in both regions. The results showed that fruit trees (grapes – *Vitis vinifera,* olives - *Olea europaea*, pomegranate - *Punica granatum*, figs - *Ficus carica*, and apricots - *Prunus armeniaca*) are used extensively in both regions. Farmers relied mainly on fruit trees of various species due to high market profits and income generation. Besides that, farmers were generally focused on windbreaks as a service role in the lowlands. Regarding the species preferences, olives had a significantly high priority among the farmers in the lowlands, while the pomegranates were higher preferred in the highlands. Our study suggests, further development of agroforestry systems in Erbil could be an important factor in mitigating effects of climate change, especially in the case of increasing temperature. Better tree pruning and spacing may reduce the heat and thus save both fruit harvest quality and quantity. In the future, more studies should be conducted on farmers tree preferences and market value chains.

Keywords: agroforestry, Erbil province, Iraqi Kurdistan, lowlands vs. highlands, sustainable development, tree priority, use of the tree

Table of contents

List of tables

List of figures

List of abbreviations

AAI Appropriate Agriculture International (Japan)

FAO Food and Agricultural Organization

GPS Global Positing System

ICRAF World Agroforestry Centre

IPCC Intergovernmental Panel on Climate Change

ISNAR International Service for National Agricultural Research

MPTs Multipurpose trees

NCCI NGO Coordination Committee of Iraq

1. Introduction

Trees play a crucial role in most terrestrial ecosystems. They give an extensive range of outputs and facilities to rural and urban population. Combining trees with other vegetation is an old agriculture practices known as agroforestry (ICRAF 2018). The term "agroforestry species" usually refers to woody species also called “multipurpose trees” or “multipurpose trees and shrubs” (MPTs). Trees give food for human consumption, fodder for livestock, timber as a building material, poles and stakes for other crops, fuelwood, resins, gums, medicines, mulch, and green manure. Important woody perennial groups in agroforestry systems include fruit trees, fodder trees, and fuelwood species, but the term MPTs covers all these (Nair 1993). Besides production role, MPTs very often have essential service role. They can serve for runoff and erosion control, reduce wind speed, be used for fencing and demarcation of boundaries, promote nutrient cycling and efficient nutrient use (Raven 1991).

In the agroforestry context, multipurpose trees are defined as trees and shrubs which are intentionally managed and kept for more than one preferred use, product, and service; the retention or planting of these trees is usually economically but also sometimes ecologically interested. Simply said, the term “multipurpose” indicates the use of tree for more than one service or production function in an agroforestry system (Wood & Burley 1991). Cultivation of various MPTs not just enhance the agricultural production but also contributes to its sustainability (Franzel et al. 1996).

Farm productivity in tropics and sub-tropics could be increased through upgrading of agroforestry in conjunction with domestication of native tree species. World Agroforestry Centre (ICRAF) is helping to expand agroforestry practices throughout the world, e.g. focusing on multi-strata agroforestry, planting of legume tree species to improve soil conditions or, planting of fruit and timber trees to diversify on farm productivity (Lojka & Preininger 2006). In agricultural practices, trees have a potential to increase crop yields by nitrogen fixation, to improve soil organic matter or nutrient cycling and, also to participate in soil conservation (Young 1997).

In Kurdistan region, the fruit production is a significant agricultural activity. Trees are cultivated mostly on slopes in the mountain areas. In Erbil province, the most frequently grown fruit tree is apple (*Malus pumila*). Other species extensively planted are for example walnut (*Juglans regia*), apricot (*Prunus armeniaca*), pomegranate (*Punica*

granatum), peach (*Prunus persica*) and grape (*Vitis vinifera*). Moreover, farmers are not only cultivating trees for fruits but also for other productive uses, such as for fodder and fuelwood (oak - *Quercus infectoria*), jam (fig - *Ficus carica*), oil (olive - *Olea europaea*), and timber (poplar - *Populus nigra*) (AAI 2013). Besides, farmers are planting various species for their service roles such as windbreaks (eucalyptus – *Eucalyptus camaldulensis*), fencing (leyland cypress - *Cupressus* × *leylandii*), shading (mulberry - *Morus alba*), aesthetic (albizzia - *Albizzia lebbeck*), and air cleaning (cypress - *Cupressus sempervirens*).

Therefore, the main purpose of the study was to identify the most important tree species, their uses and preferences among small-scale farmers around the Erbil city in Kurdistan region of Iraq. Also, the ranking of priority tree species recorded in the field observation by farmers and their current abundance were also assessed.

2. Literature review

2.1. Study area

2.1.1. Geography and climate description

Erbil province situated in a transition zone in North of Iraq and the capital of the Kurdistan Region. The zone characterised by Mediterranean and arid climatic features (Hameed 2013). It falls between latitudes 36°11′28″ N and longitudes 44°0′33″ E. The lowlands have a sub-tropical climate condition. However, the high altitudes make the winters very cold (Khalid 2014). In the lowland, the elevation is around 300 – 550 m a.s.l. but, the highlands are above 550 m a.s.l. Erbil covers an area of 15,074 km^2 (NCCI 2015).

The highest average temperature is 40 °C in July, while the lowest average temperature is 9 °C in January (Figure 1). The highest average rainfall is 77.4 mm with 20 rainy days in March, while the lowest and driest month is July (Figure 2). The arable lands are estimated around 6,262 km^2, whereas only 4,039 km^2 were under cultivation in 2006, mostly because of the declining amount of rainfall in the area (Heshmati 2009).

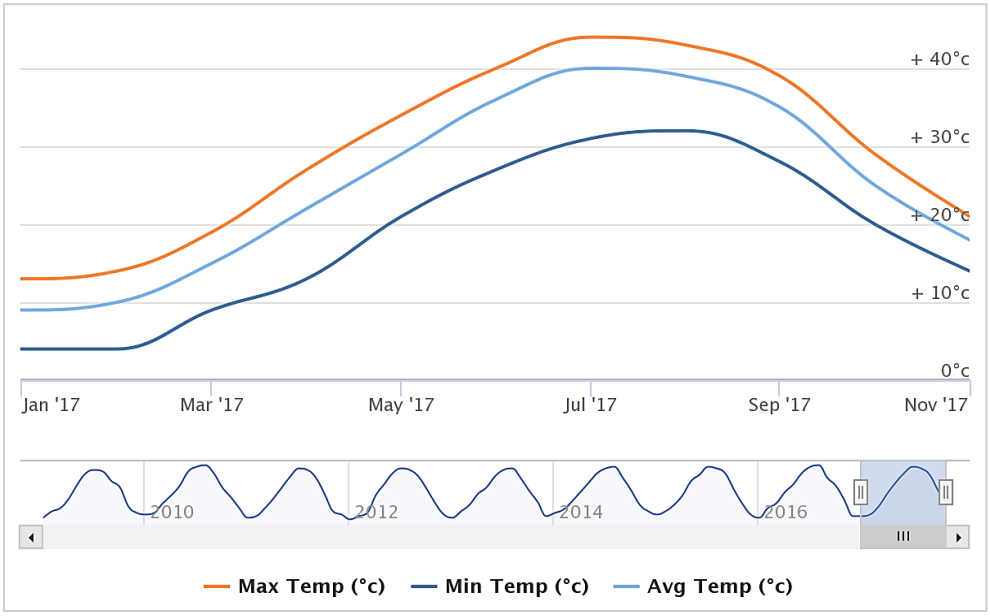


Figure 1. Average, maximum, and minimum monthly temperatures of Erbil province. Source: (World Weather 2017).

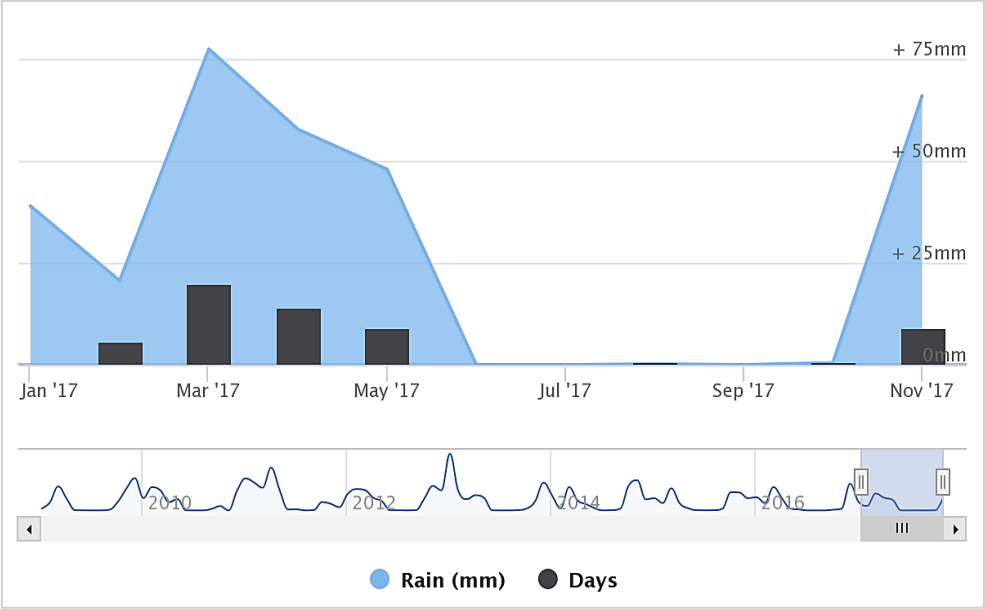


Figure 2. Average rainfall amount (mm) and rainy days over the year of Erbil province. Source: (World Weather 2017).

According to the most recent assessment, sustained emissions of greenhouse gases will cause further warming, and it is almost certain that there will be more frequent hot temperature extremes over most land areas during the next 50 years (IPCC 2014). Local governments should aim towards implementing green sustainable development policies and climate change strategies to reduce vegetation loss the associated effects such as climate change and biodiversity loss (Hussein 2017).

In the Middle East, soils could be relatively fertile. Nevertheless, there is a huge problem with soil erosion. Deficiency of some elements such as nitrogen and phosphorus are now prevalent after many centuries of trading of nutrients and crop products in cereal (Loss et al. 2015).

In Iraq, the grade of soil development decreases from northern part to southern part of country characterised by differences in physical, morphological, mineralogical and chemical properties. The soils are classified as Aridisols 62.2 %, Entisols 16.2 %, Inceptisols 12.6 %, Mollisols 3.8 %, Vertisols 1.2 %, and 4 % for others (Muhaimeed et al. 2014). The mountain soils of the northern region of Iraq are wide-ranging: Brown, Red, Chestnut forest soils, Lithosols, Regosols, and Alluvial soils. They merely skeletal, where rock outcrops occur. Gypsum is often common in the brown and red soils of the lowlands and foothills (Jaradat 2003).

In the Kurdistan region, soils are characterised by high lime content, low organic matter and alkaline pH. Due to climate change, use of organic fertilisers and chemical materials higher than agronomy ratios, where this change led to drought in last two decades (Buringh 1960).

Figure 3. Geographical map of Kurdistan region of Iraq.
Source: http://www.interopp.org/img_srmap/sr_iz_1999.jpg.

2.1.2. History

In the 1920's, the agriculture sector was a primary economic income for the individuals of ancient Mesopotamia in Iraq. In 1977, Iraq was self-sufficient in crops especially cereals such as wheat (*Triticum aestivum*) and barley (*Hordeum vulgare*), whereas agricultural imports reached 22 % of total imports of the country.

In the early 1980's, the most fruit crop was date palm in Iraq. Around 30 million date palms were planted in the whole country, however this number had nowadays significantly decreased. In 1990, Iraq was one of the main countries in the food availability due to the large capacity imports of foods. Recently, however, Iraq has converted from net food exporter to food importer. This was motivated by many factors, such as, increasing population industrialisation, farmers migration from villages to urban cities, increase in living standard, and reduction of soil productivity, especially in the southern region.

In 1999, the total cereals output was estimated at 1.6 million tons per year. Recently most of farming in the country involves planting and harvesting a one type crop per year such as maize (*Zea mays*). The winter crops in the rainfed areas, mainly cereals such as wheat (*Triticum aestivum*), are planted in the fall season and collected in late spring or early summer during the year. While in the summer, the crops predominated in the irrigated areas of central and southern Iraq (Jaradat 2003).

Regarding the Kurdistan region, located in the North of Iraq, the area has a rich history in the agricultural sector. In Chermu (Jarmo) Village remains of wheat and barley had been discovered for more than 10,000 years ago (USAID 2008). In Kurdish areas, most of the crops were cultivated since 9,000 years ago. Farming of fruit trees was harshly influenced by long years of war: Iran - Iraq War (1980 – 1988) and Anfal Campaign War (1986 – 1989). During the times of war, farms were ignored, not managed, and farmers came to their villages just for collecting of walnuts. Farmers were obligated to work temporary in the army for additional income and in this way, they have supported their livelihoods (AAI 2013).

The economy of Kurdistan has been traditionally always based on agriculture. Since 1992, more than half of population was living in rural regions and involved in agriculture. However, the secondary subsistence based on animal husbandry e.g. sheep, goats, and sparse cereal production wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), rye

(*Secale cereale*), and along with cash crops such as tobacco (*Nicotiana tabacum*) and sugar beet (*Beta vulgaris*) was typical for most of the Kurds. Only 24 % of the 40 % of arable land in Kurdistan was under tillage (O'Shea 2004).

For the future, farmers in Kurdistan region need to know the extent and exact site of the best land for food, fibre, and forage production. Such knowledge contributes to the development of modern, technologically advanced agricultural practices (USAID 2008).

2.1.3. Population and socio-economic characteristics

Iraq has an estimated population of 39.34 million. Almost 76 % of Iraq's population is made up of the dominant ethnic group, the Iraqi or mesopotamian arabs. Other major ethnic groups include the Kurds 17 %, Turkmen 3 %, Assyrians 2 %, and Persians 2 % (WPR 2018). In Iraqi Kurdistan, the population of Kurds has an estimated around 5.2 million in the three governorates: Erbil, Duhok, and Sulaymaniyah. The total area of Iraqi Kurdistan is estimated around 40,643 km^2 (KRG 2018). Erbil province has a population nearly 1,530,722 inhabitants, Kurd people main ethic. However, other minor populations such as Assyrians, Turkmen and Arabs also live there (NCCI 2015).

Total agricultural employment in Iraq has been estimated around 20.4 % for both man and woman (World bank 2017). The total area which has been used for agricultural production is about 8 million hectares which is almost 67 % of the arable area. However, due to certain limitations such as soil salinity, drought, shortage of irrigation water in summer, fallowing and the unstable political situation it is estimated that the average area actually cropped each year ranges from 3 to 4 million hectares (FAO 2018). Agricultural development has been shown to be an essential operator of poverty reduction and job creation, especially among the rural population (Breisinger et al. 2011; Diao et al. 2007; World Bank 2008). Also, agriculture could serve as a dynamic contributor to the economy of the Kurdistan Region and is considered as a second most important economic sector after petroleum. In Kurdistan region, approximately 35 % of the population depended on agriculture as their source of sustenance in 2003. However, by 2012 the number declined to 9 %. Erbil province has 5.3 % of employed people in the agriculture sector; moreover, agricultural employment was estimated for quite a low percentage for both men 6.8 % and women 8.9 % (Mazid 2015).

2.1.4. Land use and agriculture

In Iraq. the whole area is nearly 44 million ha but 12 million ha (27 %) of the total area potentially appropriate for agricultural production (Omer 2011). There are four main agro-ecological zones: desert, steppe, mountain forest, and alpine. In Kurdistan region, we can find mountain forest and alpine zone plants with a low amount of rainfall. This has an essential role for creation of short-lived herbaceous plants. Overcutting and overgrazing processes in Zagros mountains have decreased some of Iraqi Kurdistan's oak forests to bushland, also other stand trees such as maple (*Acer* spp.), hawthorn (*Crataegus azarolus*), and pistachio (*Pistacia khinjuk*). Besides, alpine zone plants can withstand higher elevations and survive harsh weather conditions (Jaradat 2003). Iraqi areas are mainly divided into two zones: the first is rain-fed northern winter grain production and the second is an irrigated zone in the South centre. This region focuses mainly on cultivation of fruits, vegetables, crops, and cereals (Schnepf 2003).

Agriculture sector contributes significantly to the production of Iraq. The two most important crops in the country are wheat and barley, estimating together for approximately half of the country's total cultivated cereals area such as wheat (*Triticum aestivum*) 31.4 % and barley (*Hordeum vulgare*) 15.7 %. However, fruits and vegetables make up 15.2 % of the whole land planted and about one-third of farmed land to other crops (Table 1) (FAO 2013).

Table 1. The yields of main crops, fruits, and vegetables in Iraq.

Crop/fruit/vegetable	**Area harvested (hectares)**	**Total area harvested (%)**
Cereals	2,015,790	52.7
Wheat	1,200,000	31.4
Barley	6,000,000	15.7
Fruits and vegetables	581,070	15.2
Other crops	1,224,766	32
Total	**3,821,626**	**100**

Source: Adapted from (FAO 2013).

In Kurdistan region, the most staple crops are wheat and barley. Two thirds of farmers have sown their seeds during the first and second week of November every year. Erbil contributes nearly by 83 % for wheat production, 7 % for barley production, and 10 % for other crops such as chickpeas (*Cicer arietinum*) and lentils (*Lens culinaris*). Approximately 52 % of farmers in Kurdistan region harvest their wheat in the region

during the first and second week of June (Mazid 2015). There is still enough of arable land in Kurdistan region available to the farmers. Major limitations for crop cultivation are: inadequate use of the water source, dispersed use of fertilisers, bad quality of seeds, and lack of appropriate machinery. Also, rural poverty and civil war led to decrease of youth workers (O'Shea 2004).

In Erbil, open field vegetables are common, the region has a dry climate with visible temperature gap between day and night. The cultivation of the vegetables is mostly from May to November. Another locally important crop is tomato (*Solanum lycopersicum*) in summer season the production of Erbil reaches around 38.9 % of the total Iraqi production, folloewd by watermelon - *Citrullus lanatus* (19.4 %), cucumber - *Cucumis sativus* (15.9 %), sunflower - *Helianthus annuus* (13.7 %), eggplant - *Solanum melongena* (12.1 %) (Ismael & Ngah 2011). Fruit trees are also considered as profitable crop for local farmers, mainly species are planted in lowlands (olives - *Olea europaea*, grapes - *Vitis vinifera*, and mulberries - *Morus alba*) prevail, while in the highlands (apples - *Malus pumila*, pomegranates - *Punica granatum*, walnuts - *Juglans regia*, apricots - *Prunus armeniaca*, and cherries - *Prunus avium*). On the other hand, some of the tree species used for service role such as windbreaks, shading, and environment cleaning (eucalyptus - *Eucalyptus camaldulensis*, cypress – *Cupressus sempervirens*, and pine – *Pinus brutia*). Chemical fertilisers are applied after blossoming and irrigation is usually used between March and November, farmers mostly use well water, whereas in Duhok province located Northern Kurdistan, especially in hilly areas, farmers use old irrigation channels along the steep slopes (AAI 2013).

Livestock production is the second most important after agriculture sector in rural zones of Iraq, and to some extent for urban neighbourhoods as well (RFSAN 2017). Livestock production is significant component in both rainfed zone - North region and irrigated zone - South region (RFSAN 2016). Rangeland or steppe which supplies essential feed sources for sheep and goats comprise about 50 % of the whole area of Iraq. Moreover, overgrazing has a significant role in the land degradation of Iraqi rangelands, and this is leading to decrease of vegetation cover (Jaradat 2003). Animal husbandry is major source of income and food especially for female-headed households in Iraqi Kurdistan (FAO 2017). Cereals' remains after harvesting are often grazed by sheep and goats in Kurdistan region. They serve as valuable stock fodder over summer and autumn

when limited or no green feed is available (Loss et al. 2015). Grazing of livestock is common in Erbil but is more spread in the north where hillside grazing by sheep and goats prevails. Despite that, beef meat is the most traditional source of dietary protein for most people (Schnepf 2003).

Forest cover in Iraq comprises three main oak forests located in northern Iraq (Kurdistan region) in mountainous areas, the species are (*Quercus aegilops, Quercus infectoria,* and *Quercus libani*), besides those species can be found another forest cover of evergreen species *Pinus halepensis* var. *brutia*. While Riverian forest species growing throughout the mountains for example Juniper- *Juniperus oxycedrus* and pistachio - *Pistacia mutica*. Several scientists are concerned genetic resources of Kurdistan forest trees were not sufficiently collected and surveyed (Jaradat 2003). Moreover, forested areas in Iraqi Kurdistan are sub-tropical 100 %, public ownership 100 %. Total forest area is around 825,000 hectares (1.9 %), also involving around 20 native tree species such as (oak - *Quercus infectoria,* almond - *Prunus dulcis,* and hawthorn - *Craetagus azarolus*) (Table 2) (FAO 2015).

Table 2. The recent Iraqi forest cover areas, the breakdown of the forest types, and conservation forest areas (2015).

Iraq Forest Cover		
Total Land Area (ha)	43,432,000	
Total Forest Area (ha)	825,000	
Percent Forest Cover (%)	1.9 %	
Another wooded land (ha)	259,000	
Percent another wooded land (%)	0.6 %	
Other land (ha)	42,348,000	
Inland water (ha)	92,000	
The Breakdown of Iraq Forest Types		
Primary forest (ha | %)	-	-
Modified natural (ha | %)	810,000	98.2 %
Semi-natural (ha | %)	-	-
Production plantation (ha | %)	15,000	1.8 %
Conservation of biodiversity (ha | %)	165,000	20 %

Source: Adapted from (FAO 2015).

2.1.5. Use of trees in the region

In tropics and sub tropics, farmers are growing indigenous trees and shrubs for their economic profits such as fruits, wood, firewood, vinegar and juice, mainly trees in sub-tropical areas such as pomegranate – *Punica granatum*, apricot – *Prunus armeniaca*, and

cherries – *Prunus avium*, while mostly farmers are dependent on the annual crops such as wheat for their livelihoods (Batish et al. 2007). One of ways for sustainable agriculture is to produce crops in between the trees. Crops are grown between the rows of trees to protect soil from erosion, provide nitrogen, and produce economically reliable product to improve the yield from the trees. In the Middle East, orchards are a standard component of landscapes. Farms are established in lands with precipitous slopes where cropping is nearly not possible and there is a high risk of soil erosion. One of the solutions for agriculture in those areas can be in planting trees together with other crops (Loss et al. 2015).

Main uses of wood in Iraq between 1961 and 2001 were: fuelwood, industrial round wood and wood for paper production (Ministry of Environment 2010). The cutting rotation of trees is between (8 - 10) years for fast growing trees such as poplar (*Populus nigra*). Nowadays, the wood is usually used for fuelwoods, charcoals, buildings, the supply of foliage (Khalid & Bararasul 2015). Cultivation of trees on farm provides several benefits from both timber and non-timber products (Michon & de Foresta 1996; Simons & Leakey 2004). Trees have also a variety of ecosystem services such as carbon sequestration (Jose 2009). Moreover, including climate mitigation through carbon sequestration (Nair et al. 2009). Alley cropping is common practice by farmers in Erbil especially in arid zones South-East of Kurdistan region. Trees in arid zones should be able to prune thoroughly but it should not be from evergreen species such as *Eucalyptus* spp. because the species need more water but *Carissa edulis* is an excellent response to pruning process, and *Punica granatum* has a high biomass production and even deep root system in the soil (Johansson 2012).

2.2. Concept and definition of agroforestry

Agroforestry is one of the oldest agricultural practises used worldwide. (Lojka & Preininger 2006). Definition according to the Lundgren and Raintree (1983) says it is: “A collective name for land-use systems and technologies where woody perennials (trees, shrubs, palms, and bamboos) are deliberately used on the same land-management parts as crops and animals, in some form of spatial arrangement or temporal sequence. In agroforestry systems, we can find both ecological and economic interactions between the different components” (Lundgren & Raintree 1983).

While the definition according to ICRAF (1993) is: “A collective name for land-use systems and practices in which woody perennials deliberately integrated with crops and animals on the same land management part. The integration can also be in a spatial mixture or a temporal sequence. There are normally both ecological and economic interactions between the woody and the non-woody components in agroforestry” (ICRAF 1993).

Another agroforestry definition is according to Leakey (1997): “A dynamic ecologically based natural resources management system that driversifies and sustain production for increased social, economic and environmintal benefits through the integration of trees in farmland and rangeland”.

Altogether definitions suggest that the agroforestry usually includes two or more species of plants or both plants and animals with at least one species considered as woody perennial. The simplest version says that agroforestry is growing trees on farms. The agroforestry systems are always more complicated compared to monocultures both ecologically and economically (Leakey 1997).

2.3. Multipurpose tree species

All the tree species could be multipurpose trees, while some of them are more multipurpose than other species. Multipurpose trees in agroforestry systems are defined as trees and shrubs which have more than one preferred use product and/or service; retention or cultivation of these trees is usually economically but also sometimes ecologically motivated in a multiple harvest land use system (Nair 1993).

The shade is one of a service function for human and livestock purposes, also decreasing in wind speed, fencing and weeds control. Primary function of service in agroforestry is soil management role, erosion control and conservation, soil fertility enhancement, microclimate enhancements and boundaries demarcation (Young 1997). The extensive range of agroforestry practices is involved in the protection of trees, cultivation, regeneration or management in agricultural lands with annual crops plantation, wildlife, humans and livestock as well. Product and service of trees considered as a major function in our life. Typical product function is nuts, fruit, oils, gums, beverages, resins, latex, flavours, leaves for nutrition and food, fodder for livestock, timber, biomass and fuelwood for energy production, and medicines as a therapy for

diseases. Service function is: bee habitats for pollination, carbon capture, shelter from wind and sun, host to edible insects, modifying micro-climates, nitrogen fixation, increased soil carbon, erosion control, groundwater recharge and better regulation of water (Table 3) (ICRAF 2018).

Table 3. The multipurpose species functions and their uses, such as ecological, service, production, cultural and economic functions.

Ecological function	**Service function**	
Soil improvement	Reduction in wind speed	Animal / Plant Habitats
Control of runoff and erosion	Microclimate improvements	Flood / Runoff Control
Maintenance of soil organic matter and physical properties	Air Purification	Weed / Disease Control
Matter and physical properties	Shade	Marine Animal Food
Promote nutrient cycling and efficient nutrient use	Water Pollution Control	Wild Animal Food
Control of weeds, pest and diseases	Fencing and demarcation of boundaries	Improvement of the hydrological cycle
Mulch and green manure	Maintenance of biodiversity	Forest Protection
Productivity function	**Cultural function**	**Economic function**
Timber (commercial)	Cages / Roosts	Prop or Nurse Plants
Timber (subsistence)	Parcelization / Wrapping	Staple foods
Fuelwood	Abrasives	Supplementary Foods
Illumination / Torches	Fertility Control	Emergency Foods
Rubber	Insulation	Fodder
Resins and gums	Decoration	Fruits for different uses
Tools	Body Ornamentation	Preservatives
Weapons Hunting	Cordage / Lashing	Oils
Containers	Glues / Adhesives	Beverages
Woodcarving	Caulking	Insect Repellents
Handicrafts	Fibre / Fabric	Scents / Perfumes
Fishing Equipment	Commercial Products	Deodorants
Weaving / Plaiting	Export Products	Dyes
Toys	Ritual Exchange	Medicines
Musical Instruments	Secret Meeting Sites	Poisons
Tannin	Recreation	Poles and stakes

Source: Adapted from (Thaman & Clarke 1987; Thaman et al. 2000; Young 1997).

2.3.1. Tree Products

Fuelwood, fodder and timber trees

Fuelwood collecting for the heating purpose is often mentioned as a factor that contributes to the devastation of tropical and sub-tropical forests, also, to the land degeneration (Mercer & Soussan 1992). However, some of the woody species have

specified as fuelwood crops such as poplar (*Populus euphratica*) and eucalyptus (*eucalyptus camaldulensis*) to provide wood for cooking, heating and lighting (Nair 1993). People in Iraqi Kurdistan use forests to produce charcoal and firewood. Favourite species for those purposes are: pomegranate (*Punica granatum*), oak (*Quercus aegilops*), willow (*Salix alba*), and poplar (*Populus nigra*). In past years, there had been massive cutting of trees in the highlands to provide wood stuff and charcoal to city markets in the lowlands (Chapman 1948). Fodder trees serve as source of feed for livestock and also sometimes used as mulch (Franzel & Scherr 2002). One of the highest quality fodder tree is for example leucaena (*Leucaena leucocephala*) (Brewbaker 1985). In Iraq, fodder trees are used for livestock feeding for sheep and goats (Schnepf 2003). Typical feed coming from tree species in Kurdistan region are leaves of pomegranates (*P. granatum*) and num-num (*Carissa edulis*) (Johansson 2012). Also galls and acorns are collected from oak (*Quercus infectoria*). The acorns are used mainly throughout winter season when the ground is covered with thick snow (Khalid & Bararasul 2015).

Production of timber is considered as a major activity of Iraqi forest management started. Palm trees (*Phoenix dactylifera*) was used for construction purposes, while the leaves were used for house thatching. Poplar (*P. nigra*) and oaks (*Quercus infectoria*, *Q. aegilops*) are used in Kurdistan region for many purposes such as building roofs, construction, and timber (Poyck 1962).

Fruit trees

Fruit trees can be generally defined as one of the most important agroforestry species (Lojka & Preininger 2006). Iraqi Kurdistan is a vibrant centre of diversity for several "stone fruit trees" such as apricots (*Prunus armeniaca*) and peaches (*Prunus persica*), both wild and domesticated (FAO 2007). Fruit cultivation is a major activity for farmers in the sloping mountainous areas and is high widespread in Kurdistan region. Some examples of fruit trees that are broadly grown in the high slopes: apples (*Malus pumila*), walnuts (*Juglans regia*), pomegranates (*Punica granatum*), and grapes (*Vitis vinifera*) (AAI 2013). In southern Kurdistan, a special tree *Pistacia atlantica* subsp. *kurdica* tree is grown for various purposes. Both ripe and unripe fruits are used as condiment to make many different meals, Kurdish chewing gum, and dried fruits to make bead (Ahmed 2017). Fruit industry sector in Kurdistan region has not reached excellent quality until now that could compete with imported products because of weak distribution of product

system. Despite the fact that the area has favourable ecological conditions for fruit farming (AAI 2013).

Medicinal trees

Medicinal plants play an important role for rural people coming from developing countries, who do not have access to additional health facilities. Also, sale of medicinal products can be crucial for farmers' income (Levingston & Zamora 1983). Those products include both fresh and dried products oils, juices and various extracts (Elevitch & Wilkinson 2000). Medicinal plants in Iraq have more than 400 species. Mainly there are women who have the knowledge of natural medicines (Jaradat 2003). A tree traditionally used in Kurdistan for healing purposes is again *Pistacia atlantica* subsp. *kurdica* also known as Kurdish gum. The gum is exudate from the trunk of the tree and used for mouth clearing, relieving of abdominal pain, strengthening, reducing stress, improving memory, against cough, and asthma problems. The gum mixed with soap mad from the pistachio oil used to cure wounds. Altogether, the tree has an essential role in Kurdish ethnomedicine and is also economically valuable (Table 4) (Ahmad & Askari 2015).

Table 4. List of the medicinal plants of the folk pharmacopoeias of The Ziarat and Charbagh in Semnan province of Iran.

English name, scientific name	**Part (s) used**	**Uses in the local popular medicine**
Pomegranate *Punica granatum*	Fruit	Tapeworm infestation, laxative, purgative, estrogens, and diarrhea
Oak *Quercus infectoria*	Bark, Gall	Hemorrhoid, diarrhea, dysentery, nasal polyps, and eczema astringent
Fig *Ficus carica*	Fruit, Latex, Sap	Laxative, constipation, pain, inflammation, tumors, dry cough, while sap: To heal sore, intestinal depurative, and insect bites
Mulberry *Morus alba*	Leaves, Twigs, Fruit	Expectorant, cough, catarrh, fever, sore throats, headache, dizziness, tonic, toothache, laxative, diabetic, and insomnia
Hawthorn *Crataegus monogyna*	Aerial parts, Fruit	Cardio tonic, dilate blood vessel, relaxant, antioxidant, heart remedy, and blood pressure
Grape *Vitis vinifera*	Leaves, Fruit	Astringent, anti-inflammatory, diarrhea, heavy menstrual bleeding, uterine hemorrhage, and vaginal discharge
Apple *Malus domestica*	Fruit	Laxative, dysmenorrhea, sore throat bronchitis, and intestinal depurative
Olive *Olea europaea*	Leaves, Fruit	Diabetics, aphtha, and stomach-aches

Source: Adapted from (Jalali et al. 2009).

2.3.2. Service role of trees

Shade trees

The canopy type together with spacing between trees are important factors in farm management. Some trees have broad canopies and it's better shading than trees with vertical canopies. Usually, dense shade is decreasing the moisture loss and defending soil from frosts during winter, but light shade is critical for seedbeds and farms as well (Wood & Burley 1991). In Iraq, date palms (*Phoenix dactylifera*) were usually grown for shade purposes for protection the smaller fruit trees such as citruses; orange (*Citrus sinensis*), and lime (*Citrus aurantifolia*) (Davies 1957). Another shade tree species in Kurdistan region are (eucalyptus - *Eucalyptus camaldulensis,* horsetail - *Casuarina equisetifolia,* poplar - *Populus nigra,* cypress - *Cupressus sempervirens,* pine - *Pinus brutia,* mulberry - *Morus alba,* chinaberry - *Melia azedarach* and locust - *Robinia pseudoacacia*).

Windbreak trees

Windbreaks are defined as a tight stripe of trees, shrubs and grasses planted to protect homes, canals, fields, and other zones from the intense wind and blowing sand. Shelterbelts are defined as a group of trees or spots aroun the farm. Wind is considered as the main reason for soil moisture loss and erosion. Windbreaks can therefore sustainably increase the agricultural production (Van Eimern 1964) Tree species used as windbreaks are for example horsetail (*Casuarina* spp.), eucalyptus (*Eucalyptus* spp.), and pine (*Pinus* spp.). As trees grow and modify their forms, it is important to combine many tree species to get different grow levels, sizes and shapes in many lines (Figure 4) (Nair 1993).

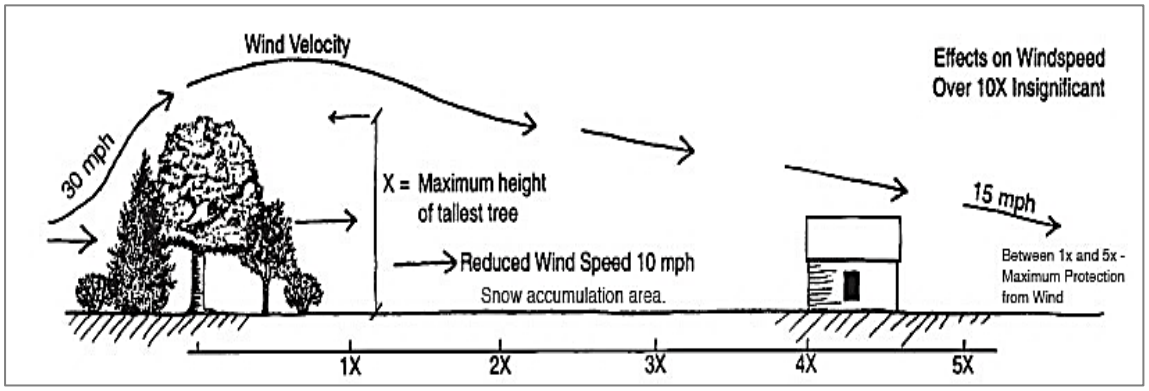


Figure 4. Windbreaks role in the farm.
Source: http://spokaneconservation.blogspot.cz/2012/03/wind-it-can-cause-more-problems-than.html.

Soil improvement and nitrogen fixation trees

The improvement of soil fertility dependents on type of soil, climatic condition in the region, tree pruning and adding of litter (Batish et al. 2007). Important is the role of trees against soil erosion. The farmers practised for a long term in cultivating trees on their farms, and these for control of soil erosion in many ways, this includes both direct use of trees for erosion reduction and additionally to improve physical structures of the soils. Efficient soil maintenance contributes to the water infiltration into the soil and decreases water runoff on the soil surface. The improvement of land has a direct connection to moisture retention of the ground, and many of these effects related to the trees. In the soil, the content of organic matter, lead to improves the capacity of water-holding in the land. For example (pine – *Pinus brutia* and cypress – *Cupressus sempervirens*) (Tengnäs 1994).

Nitrogen fixation is an essential distinctive of many leguminous plants, both of Mimosoides and Papilionoids cover more than 90 %, while Caesalpinioids comprise 34 %. The herbaceous legumes exploited as productive crops in agriculture system through growing nitrogen-fixing species in the farms (Nair 1993). Nitrogen fixation trees are spread in tropical and sub-tropical agroforestry systems, however trees not only able to fix nitrogen, but can also improve soil physical and chemical, and biological properties through adding large below and above ground organic matter, also releasing and recycling nutrients (Jose 2009). Farmers should give more attention to fast-growing species with predictions of financial return in early period as much as possible. Some examples (leucaena - *leucaena leucocephala*, acacia – *Acacia cyanophylla*, and albizzia – *Albizzia lebbeck*). In the semi-arid areas, *Faidherbia albida* had been a status of being a soil improver, and initially for increasing crop yields under its deciduous canopy. Also, this shows that the water-holding for soil, its capacity rises under *F. albida* in contrast with nearby locations empty of such trees (Felker 1978). Planting legume species which use nitrogen from the air to produce compounds which enrich the soil by their root nodulation in the soil (Pye-Smith 2009). In agrosilvopastoral systems, the fertiliser application also could be useful evidence to be reasonable economically, if joint with ideal use of manure and perennials woody legumes for improvement of soil. Agroforestry practice also could be maintainable for excellent soil improvement by breeding process and bacteria of high production multipurpose species and livestock (Von Maydell 1987).

Several groups of leguminous species with types of bacteria *Rhizobium* or *Bradyrhizobium* and these contain several used multipurpose trees as mentioned above in the most extensively way (Nair 1993). Some of the species that could have the facility to nitrogen fixing in the soil, these species could not always be effective for their nitrogen fixation. However, one of the pre-required for nitrogen-fixing efficient is the lowest phosphorus rates in the soil. So, even if the species of nitrogen-fixing planted, this could be insignificant, because of low rates of phosphorus in the soil. The plant itself for their growth uses most of the nitrogen which fixed through the roots. Also, if the roots die, the nitrogen becomes free in the soil, and it can be used again by other crop plants (Tengnäs 1994).

2.4. Farmers' tree preferences

Priority setting of the trees in agricultural research has received considerable attention over the last decade, especially concerning the possible methods that can be applied (Alston et al. 1995; Contant & Bottomley 1988; Von Oppen & Ryan 1985). The challenge of priority setting is to design a procedure that combines simplicity, transparency, participation and analytical rigour, to confirm that the right choices are made (Akinnifes et al. 2004). The priority-setting process, therefore, involves collecting a broad set of data on many species at the earlier stages, and more detailed information on a limited number of species at later stages. The process involves several steps: (i) team building and planning; (ii) assessment of client needs; (iii) assessment of species used by clients; (iv) ranking of products; (v) identification of a limited number; (vi) valuation and ranking of priority species; (vii) final choice. In the initial stages, information is collected from the user groups of MPT species and the principal uses of the MPTs themselves. This information is used to reduce the number of species under consideration. By the fifth step, "Identification of priority species", only a few species remain. In the final stages, information is collected about these species to make the final decision on setting priorities among them. This is not only useful for species preference, it can also help to improve relationship between institutions and build a spirit of cooperation (Franzel et al. 1996).

3. Objectives of the thesis

The main objective of the study was to identify the most important tree species used by farmers in small-scale farms around the Erbil city in Kurdistan region of Iraq. The focus was also to identify their use, abundance on farms and preference of species among farmers.

The specific objectives were as following:

(i) To find out important tree species used by the farmers in small-scale farms in the area.
(ii) To identify priority tree species by ranking them according to farmers' preferences in the area.
(iii) To evaluate the abundance of tree species as well as silvicultural management.

Our research questions were following:

(i) What are the most tree species used by farmers, and which parts of the trees are the most utilized?
(ii) What are the differences between tree species planted in the lowlands and highlands?
(iii) What is the priority species used by farmers according to their preferences in their farms?
(iv) What is the abundance of trees planted in the lowland and highland farms?
(v) Is there any agroforestry implementation or silvicultural practices of trees?

4. Materials and methods

4.1. Study site

The data were collected in seven sites. Four districts Qushtapa, Khabat, Shamamik, and Bahirka (South and South-West of Erbil city) were considered as a lowland region, and three districts Pirmam, Korre, and Shaqlawa (North-East of Erbil city) were considered as a highland region. The lowland locations surveyed in the first rounds, the highland sites surveyed in the second rounds (Figure 5).

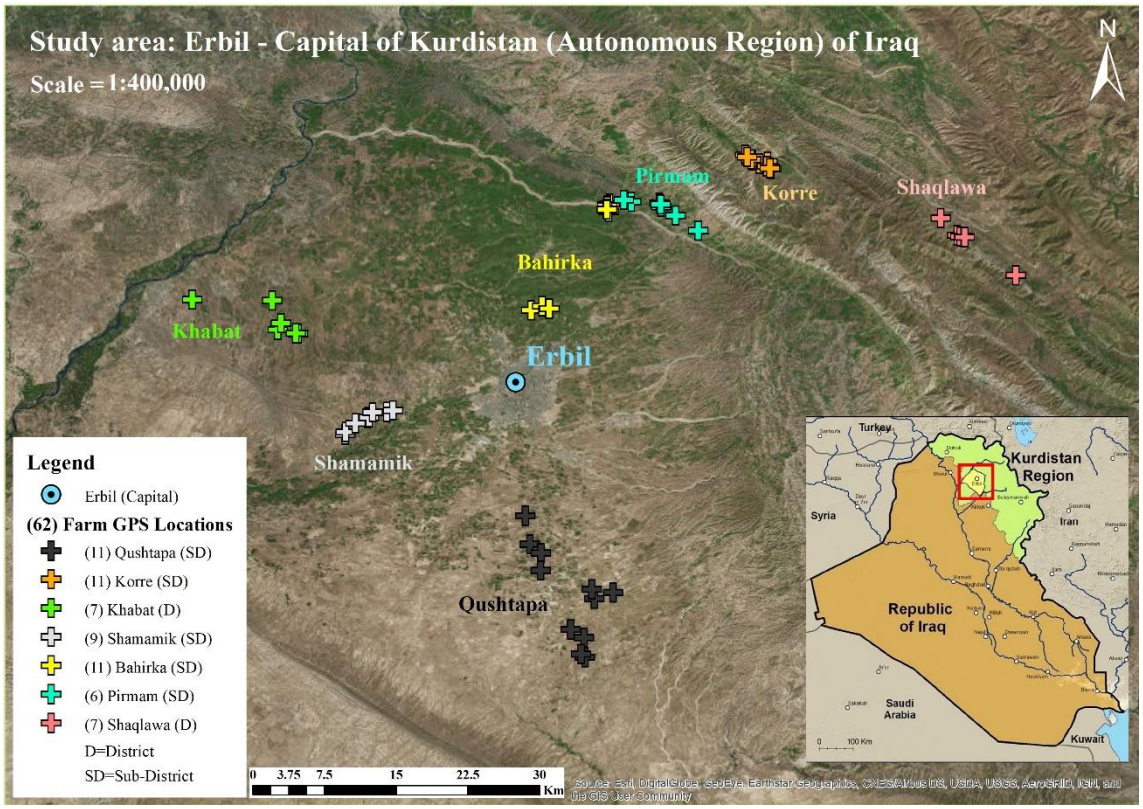


Figure 5. Study site, Erbil city – Kurdistan region of Iraq, adapted from ArcGIS software.

The first location was Qushtapa sub-district containing 52 villages, but for our survey, we selected only six of them. The villages are situated in the lowlands, 21 km far from the Erbil and lies between latitudes 36° 0' 2" N and longitudes 44° 1' 57" E, with elevation nearly 390 m a.s.l. Population size is approximately 14,635 inhabitants with around 3,361 farmers, whereas 485 of them work as horticultural farmers, with 85,046 hectares of arable lands (Amin et al. 2014).

The second location was Khabat district. Located in the lowland area north-west direction and about 33 km far from Erbil city. It falls between latitudes 36° 16' 20" N and longitudes 43° 40' 24" E, with elevation nearly 287 m a.s.l. The arable land covers about

22,257 hectares. The population is 17,067 inhabitants, containing 1,556 farmers, 856 of them working as horticultural farmers (Amin et al. 2014).

The third location was Shamamik sub-district, located in the west and about 20 km far from Erbil. It is also considered as lowlands, with an elevation about 337 m a.s.l. It falls between latitudes 36° 1' 17" N and longitudes 43° 55' 3" E.

The fourth location was Bahirka sub-district, situated in north-east of Erbil within the lowlands area. It lies between latitudes 36° 18' 57" N and longitudes 44° 2' 6" E, with elevation nearly 464 m a.s.l. Population size is about 10,750 inhabitants, with 265 working as farmers and 12 specializing in horticulture. Arable land areas reach 36,823 hectares there. The number of farmers is 265 farmers, but 12 of them working as horticultural farmers on the site (Amin et al. 2014).

The fifth location was Pirmam sub-district, situated in north-east of Erbil with a highlands topography and elevation reaching nearly 1,104 m a.s.l. It falls between latitudes 36° 23' 9" N and longitudes 44° 11' 46" E. The Population size is nearly 26,647 individuals. The number of farmers reaches 1,920 farmers, 578 of them work as horticultural farmers. Arable lands are about 39,217 hectares (Amin et al. 2014).

The sixth location was Korre sub-district, located in the highlands area north-eastward of Erbil and 37 km far from it. It falls between latitudes 36° 24' 0.1" N and longitudes 44° 14' 20" E, with elevation around 786 m a.s.l. The area has nearly 7,000 inhabitants with 200 farmers, while 100 of them work as horticultural farmers. Moreover, the arable land areas reach around 7,852 hectares (Amin et al. 2014).

The seventh location was Shaqlawa district which it covers 34 villages, but we selected only four of them. The is located north-eastward of Erbil in highlands with elevation about 946 m a.s.l. It falls between latitudes 36° 24' 25" N and longitudes 44° 18' 57" E. Population size is 10,182 individuals with 1,986 farmers and 1,952 of them work as horticultural farmers. The arable lands were estimated around 50,025 hectares (Amin et al. 2014).

We divided the farmers into two different agro-ecological zones according to the elevation to lowland and highland farms. Four locations Qushtapa, Khabat, Shamamik, and Bahirka were considered as lowlands, with altitudes of farms less than 550 m at sea

level, whereas three other locations of Korre, Pirmam, and Shaqlawa were considered as highlands, with altitudes of farms higher than 550 m at sea level (Figure 6).

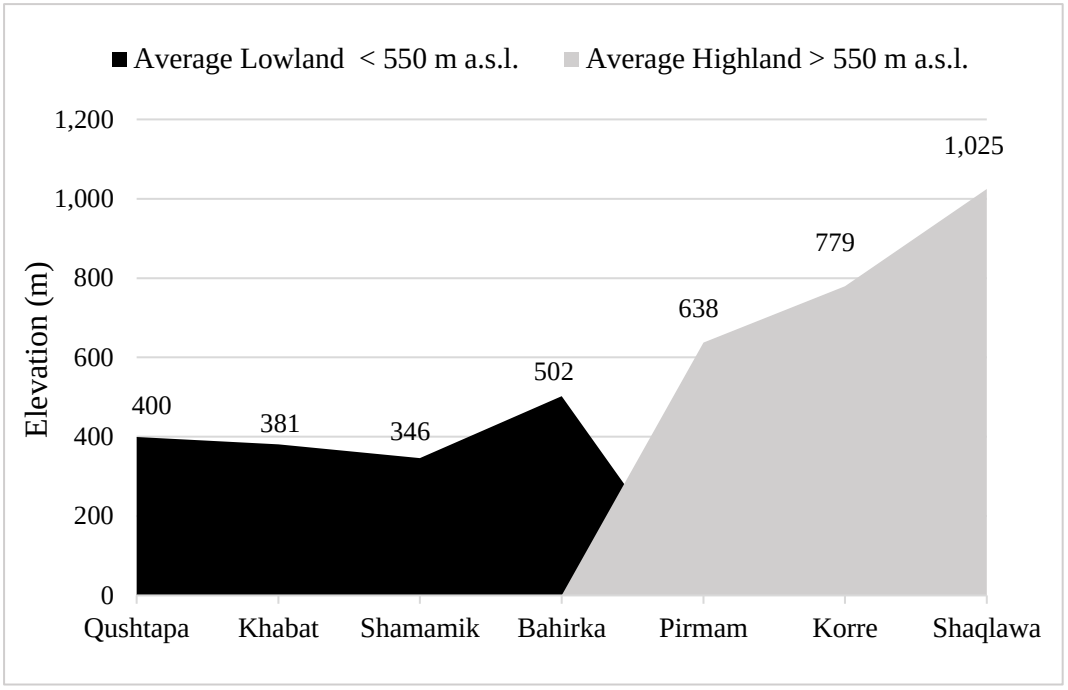


Figure 6. The average elevation of seven locations for lowlands and highlands.
Source: Adapted from Microsoft Excel Spreadsheet Software.

There is a slight difference in temperatures, the highest average temperature and lowest average rainfall in the lowlands belong to Qushtapa; it was 20.5 °C and 495 mm per year, respectively. While in the highlands the lowest average temperature was 16.9 °C belongs to Pirmam and highest average rainfall was 881 mm in Shaqlawa. Moreover, the difference in average temperature and annual rainfall is 3.6 °C and 386 mm per year between lowlands and highlands. Therefore, the tree species grown in the highlands are expected to be different from tree species grown in lowlands (Table 5).

Table 5. The seven farms' locations according to lowlands vs. highlands.

Agro-ecological region	Location (SD/D)	Village	Number of farms	Climate Class.	Ave. Temp. °C	Ave. Rain. (mm/y)
Lowlands	Qushtapa SD	Kucha Biyas, Small Murtka, Qushtapa, Dolabakra, Hemzakor, and Kardis	11	Csa	20.5	495
	Khabat D	Goraban, Girdarash, and Jadida	7	Csa	20.3	567
	Shamamik SD	Qarya Taq, Ben Beriz, and Swery	9	Csa	20.4	510
	Bahirka SD	Kark, Zarza, and Qala Murtka	11	Csa	19.7	638
Total			**38**			
Highlands	Pirmam SD	Shinawa, Khorkhawa, and Sayukan	6	Csa	18.3	809
	Korre SD	Berizh, Gorasher, Jorash, and Mawan	11	Csa	16.9	823
	Shaqlawa D	Akuban, Punjinah, and Dawra	7	Csa	17.4	881
Total			**24**			

Locations SD refers to Sub-district and D refers to District. Köppen Geiger climate classification is Csa it means (Hot - Summer Mediterranean Climate) (Kottek et al. 2006). Class.: Classification. Ave. Temp.: Average temperature °C per year. Ave. Rain.: Average rainfall mm per year.

Source: (Climate Data 2012).

4.2. Data collection

The data were collected since August till October 2017 in the seven above mentioned locations using semi-structured questionnaire (Appendix 1). “Semi-structured interview is defined as an oral interchange where one-person (the interviewer) efforts to contrive information from another person (the interviewee) by asking open-ended questions. While, unlike structured interviews, this conversational manner offers applicants a chance to discover issues considered as important” (Yengoh & Brogaard 2014). The materials used included: questionnaire form, camera, and GPS device for recording the coordinates of farms (Appendix 2).

The methodology was based or developed by ICRAF and ISNAR “Choosing the right trees – Setting Priorities for Multipurpose Tree Improvement” (Franzel et al. 1996) and was also inspired by (Huml 2011), who carried out comparable research on tree species preferences in Peru, Ucayali region. Before starting to interview the farmers, questionnaires were translated into the Kurdish language, with appropriate changes to the study conditions and the area. The survey began from morning to before sunset in several rounds throughout three months.

Altogether 62 farmers were interviewed in the several rounds, 38 form lowland, with 11 coming from Qushtapa, 7 from Khabat, 9 from Shamamik, and 11 from Bahirka. Then 24 farmers were questioned in highland areas, 11 from Korre, 6 from Pirmam, and 7 from Shaqlawa (Table 5). The questionnaire was divided into four parts. The first part involved socio-demographic data. In the second part, we tried to identify the tree species uses and preferences and focused also on tree species that are not present on the farms, but farmers would like to grow them. Third part involved detailed description of the uses of each species for example: do you plant the species for commercial or subsistence purposes? what are the worst problems in establishing this species? The fourth part represented field observation for species that were grown by farmers on their farms: an abundance of trees, counting and recording all trees species on their farms, also agroforestry systems and silvicultural practices that are carried out (Appendix 1).

4.3. Data evaluation

The data evaluation was done in Excel spreadsheet. Firstly, all names of tree species recorded; scientific name, common name, and local name for each tree species. Also

including origin, life form, use of the parts according to the specific codes for each tree species, the species occurrence, and frequency of each tree species were recorded and evaluated. By two formulas, the tree species frequency and salience index were calculated (Smith 1993):

(i) Frequency (%) = number of tree species in all farms for the region / total number of farms of the same region * 100

The formula used to evaluate the tree species for each region (lowlands vs. highlands) separately.

(ii) Free-list salience index of an item (%) = sum of the item's percentile ranks / total number of lists * 100

Free-list index formula used to evaluate the average of tree percentile in both regions.

To know the tree species name, we requested the Ministry of Agriculture, also with the help of the employees from the Salahaddin University - Erbil, to cooperate us and identify all tree species that were found in the study area.

Secondly, farmers listed up all trees which grew on their farms, each species received one point, together for all farms. The farmers were required to list up all the tree species grown, within their compounds. Then, we discussed ways of species use, for example, fruit, fodder, windbreaks separately for each region lowlands vs. highlands.

Thirdly, farmers selected and ranked the ten most preferred tree species, from 1 to 10 points, the first with the highest priority received 10 points. The evaluation was carried out separately for lowland and highland regions, and this value led us to identify each species priority.

Fourthly, the farmers listed up all the not grown species on their farms that they would like to plant. Again, the species got one point and after that the points have scored and summed for each region separately.

Finally, regarding the field observation, all tree species were summed and evaluated individually and separately for each region (lowlands vs. highlands).

4.4. Limitations of the thesis

Firstly, to find the locations of farmers were tough and was needed guidelines from the Ministry of Agriculture because the farmers were not in their farms all days, I needed

to call them by phone before several days. Thus, the survey was not easy to find farmers for interviewing.

Secondly, there was not a botanical expert in the field observations; I needed someone to help me as a horticultural expert during the fieldwork. Therefore, pictures and voucher specimens were shown to my experts in the Salahaddin University – Erbil for identification. Also, some of the farmers did not have a sufficient experience and knowledge regarding their farms, especially the new farmers.

5. Results

5.1. Farmers' socio-demographic description

The farmers owned different sizes of lands in both regions. In lowlands, the size of lands of most farmers was greater than in highlands. Moreover, some part of their compounds were usually planted with crops such as wheat, barley and maize. Typically, the farmers incomes were relatively high compared to highland region. In highlands, the size of farms was smaller than in the lowlands and farmers owned less free lands. Also, the number of households in the lowland was higher than in the highland (139 and 66 respectively). The average age of farmers in lowlands was 52 year, while in highlands was just 43 year. In lowlands, the average work duration of farmers on their farms was 12 years, in highlands it was 17 years. The majority of farmers were workers (illiterate) in both regions, while some of the farmers had studied until primary or high education level (Appendix 3).

5.2. Species frequency in the region

In total, farmers listed up a use of 46 tree species, while 40 (lowlands) and 39 (highlands) were found in both regions, seven of them were noted only in lowlands and six only in highlands (Table 6). We found out that native species were planted more frequently than introduced species in both regions (27 vs. 19, respectively). Deciduous species were more common than evergreen species in both regions (30 vs. 16, respectively). The most utilized species which had more than one use in both regions were for example olives (*Olea europaea*), poplars (*Populus nigra*), chinaberries (*Melia azedarach*), and grapes (*Vitis vinifera*).

Regarding the species frequency, in lowlands, eucalyptus (*Eucalyptus camaldulensis*) has scored the highest with 97 %, followed by olives, pomegranates, grapes, and figs (89 %, 87 %, 84 % and 76 % respectively). In the highlands, figs (*Ficus carica*) were the most frequent species with 88 %, followed by pomegranate, apricot, peach, and grape (84 %, 80 %, 76 % and 76 % respectively). In both regions, pomegranates (*Punica granatum*) were the most frequent species with 87 %, followed by figs and grapes in same frequency 81 %. The data suggests that other tree species has a fewer frequency in both regions.

Table 6. All tree species listed by farmers, their names, origin, life form, main uses and frequency (%) in both regions (lowlands vs. highlands).

Scientific name	English name	Local name	Origin	Life form	Use	Lowland or Highland	Frequency (%)		
							L (38)	H (24)	LH (62)
Ailanthus glandulosa	Heaven tree	Zmana Mel	I	D	A	L	3	0	2
Albizzia lebbeck	Albizzia	Albizia	I	D	A	L	3	0	2
Callistemon viminalis	Bottle brush	Flcha	I	E	A, B, D	L, H	11	4	8
Casuarina equisetifolia	Horsetail	Kazwarina	I	E	A, B, N	L	5	0	3
Citrus aurantifolia	Lime	Lemo	N	E	F	L, H	5	8	7
Citrus sinensis	Orange	Burtuqal	N	E	F, I	L, H	24	16	21
Citrus × paradisi	Grapefruit	Sendy	N	E	F	L, H	3	0	2
Craetagus azarolus	Hawthorn	Gewzh	N	D	F	H	0	8	3
Cupressus sem. var. *horizantalis*	Cypress horizantalis	Saru	I	E	A, B, L, N	L, H	11	4	8
Cupressus sem. var. *verticalis*	Cypress verticalis	Saru	I	E	A, B, N	L, H	43	4	27
Cupressus × leylandii	Cypress leyland	Saru	I	E	A, B, N	L, H	5	0	3
Diospyros kaki	Persimmon	Kaki	I	D	F	L, H	3	16	8
Eriobotrya japonica	Loquat	Yenki Dunya	I	D	F	L, H	22	20	21
Eucalyptus camaldulensis	Eucalyptus	Qalamtuz	I	E	B, L, N, O	L, H	97	16	65
Ficus carica	Fig	Hanjir	N	D	C, F, H	L, H	76	88	81
Fraxinus rotundifolia	Ash	Bnawi	N	D	A, O	L, H	3	4	3
Juglans regia	Walnut	Gwez	N	D	A, B, F, O	L, H	14	64	34
Malus pumila	Apple	Sew	N	D	F, H	L, H	11	64	32
Melia azedarach	Chinaberry	Tasbeh	I	D	A, B, G, L, O	L, H	27	4	18
Morus alba	Mulberry (white)	Tu	I	D	A, F, L, N	L, H	57	44	52
Morus nigra	Mulberry (black)	Shatu	I	D	F	L, H	14	16	15
Olea europaea	Olive	Zaetun	I	E	F, K, M	L, H	89	20	61
Phoenix dactylifera	Date palm	Khurma	N	E	F	L	5	0	3
Pinus brutia	Pine	Kazhi	N	E	A, B, N	L, H	24	12	19

Table 6. Continued

Scientific name	English name	Local name	Origin	Life form	Use	Lowland or Highland	Frequency (%)		
							L (38)	H (24)	LH (62)
Pistacia khinjuk Stocks	Pistachio (stocks)	Qazwan	N	D	C, F	L, H	0	4	2
Pistacia vera	Pistachio	Festiq	I	D	F	L, H	5	12	8
Platanus orientalis	Sycamore	Sura Chnar	N	D	A, O	H	0	4	2
Populus nigra	Poplar (black)	Aspindar	N	D	A, B, G, L, N, O	L, H	16	48	29
Prunus armeniaca	Apricot	Zardalu	N	D	C, F, H	L, H	49	80	61
Prunus avium	Cherry	Gelas	N	D	F	H	0	24	10
Prunus domestica	Plum	Alu	N	D	F	L, H	8	24	15
Prunus domestica cultivars	Prune	Halozha	I	D	C, F	L	3	0	2
Prunus dulcis	Almond	Bawi	N	D	C, F, N	L, H	14	24	18
Prunus persica	Peach	Khokh	N	D	F	L, H	41	76	55
Pseudo negundo	Chaste tree	Kefrok	N	D	A	L	3	0	2
Punica granatum	Pomegranate	Hanar	N	D	D, E, F, G, I, M	L, H	87	84	87
Pyrus communis	Pear	Harme	N	D	F, G, H	L, H	41	52	45
Pyrus syrica	Pear (Syrian)	Harme Suri	N	D	F	L, H	0	4	2
Quercus aegilops	Oak (brantii)	Barue Bare	N	E	E, F, G, L, O	H	0	20	8
Quercus infectoria	Oak (infectoria)	Barue Mazi	N	E	E, G, O	H	0	12	5
Rhus coriaria	Sumac	Sumaq	N	D	F	H	0	8	3
Robinia pseudoacacia	Locust	Aqaqia	I	E	A	L, H	3	4	3
Salix alba	Willow (white)	Bee	N	D	A, L, O	L, H	0	24	10
Salix babylonica	Weeping willow	Shorabi	I	D	A	L, H	3	0	2
Vitis vinifera	Grape	Tre	N	D	C, E, F, I, J	L, H	84	76	81
Washingtonia filifera	Fan palm	Washintonia	I	E	A	L	16	0	11

Origin: N=Native species; I=Introduced species. Life form: E=Evergreen species: D=Deciduous species. Use: A=Aesthetics; B=Air cleaning; C=Dried fruits; D=Fencing; E=Fodder; F=Fruits; G=Fuelwood; H=Jam; I=Juice; J=Leaves; K=Oil; L=Shading; M=Vinegar; N=Windbreaks; O=Wood. Frequency (%): L=Lowland; H=highland; LH= Lowland & Highland. (38) total lowland farms; (24) total highland farms; (62) total lowland & highland farms.

5.3. Use of the species

Use of trees for fruit production was mostly cited in both lowlands and highlands, just slightly different between both regions, their scores were 245 and 205 respectively. The wood was the second most significant use after fruits in highlands, whereas the oil was the most significant after fruits in the lowlands. There was not a significant use of oil trees in the highlands. Other uses achieved least points and their scores were equally present almost in lowlands and highlands. There was an equal use of jam and juice with 20 scores for both, with the same use of trees for fuelwood 11 and fodder 12 in the highlands. There was only one cited use of the trees for fuelwood and fodder in the lowlands (Figure 7).

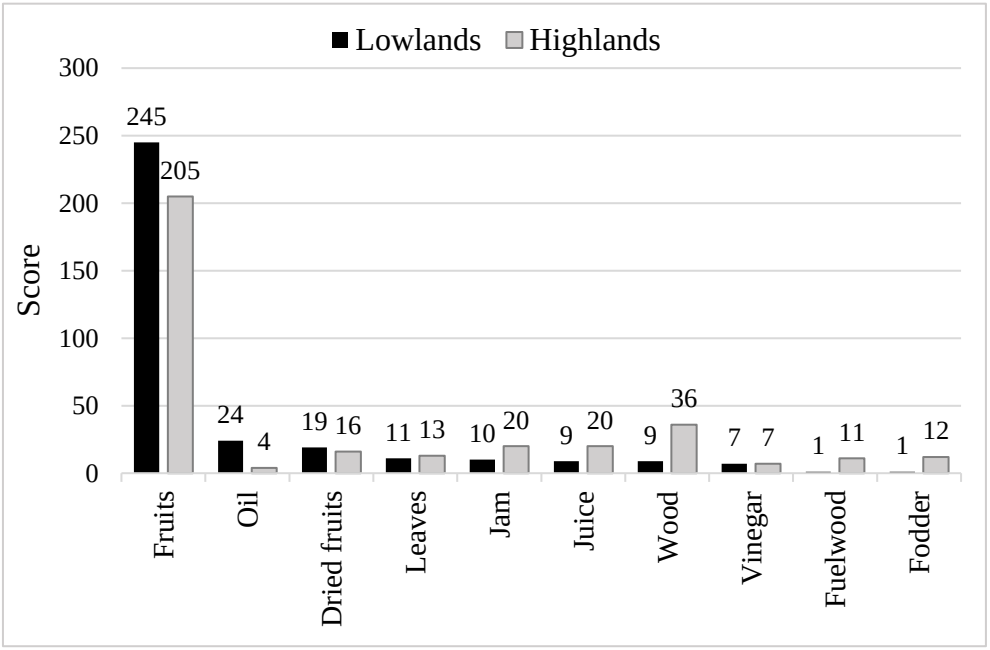


Figure 7. The main product use of tree species in lowlands vs. highlands.

The service role of tree uses in the lowlands was cited much higher than in the highlands (175 vs. 58, respectively). We found that windbreaks were the most cited use with score of 67 points in the lowlands. There were substantial uses of air clean 38 and shading 34 in the lowlands compared to highlands. There was an equal of aesthetic uses in lowlands 35 and highlands 33. Fencing was significant just in highlands with score of 4 compared to lowlands with just 1 point (Figure 8).

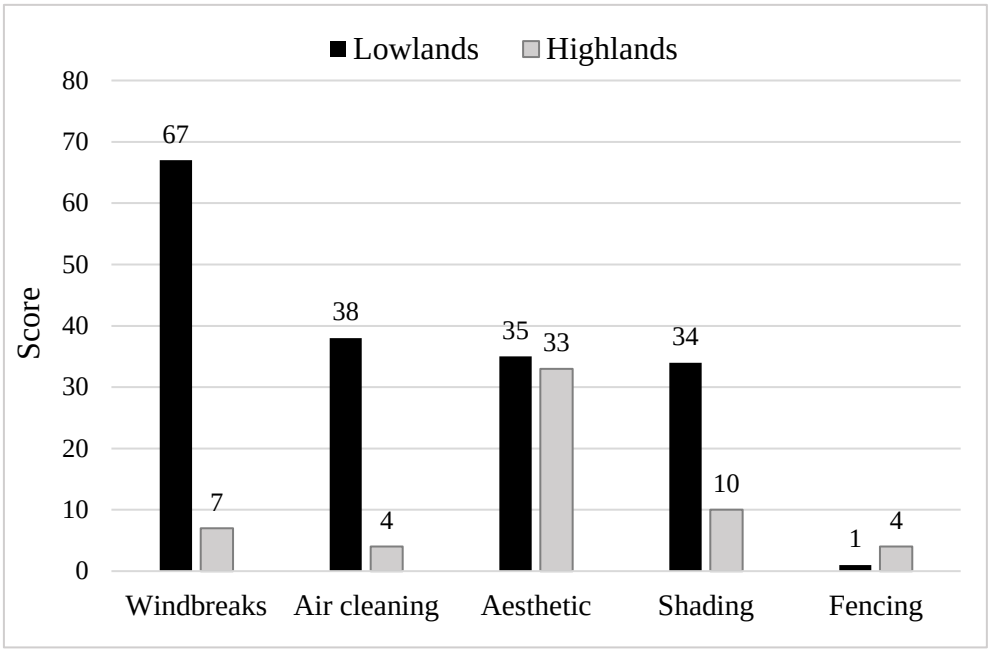


Figure 8. The main service role of tree species in lowlands vs. highlands.

5.4. Farmers' preferences and species occurrence

We found different preferences for tree species while comparing the planted tree species on farms in both regions (Table 7). In lowlands, olives were most preferred species (scored 276 points) and most used by farmers 94 % (Appendix 4), followed by pomegranate, grape, and fig (253, 237, and 230 respectively) but figs were quite highly used on the farms 76 % compared to grapes 69 %. Eucalyptus was most preferred species (scored 135 points) but received less used on the farms 27 %. Apricot was less preferred 134 but was highly planted 73 %. While orange and chinaberry have scored fewer priorities (26 and 21 respectively) but orange was highly used on the farms 58 %.

In the highlands, we found that the most preferred species was pomegranate (scored 209 points) and it was also the most planted by farmers on their farms with 95 % (Appendix 5), the second most preferred was fig with score of 182 points but less used on the farms 71 %, compared to apples scored 112 but were highly planted on the farms 77 %, followed by apricot, peach, and grape (123, 109, and 107 respectively). Oaks and almonds were less preferred by the farmers (scored 18) but highly used on their farms 46 %. The most contrasting results is that the olive received the top priority in the lowland list but in the highland list, it got the tenth priority. On the other hand, pomegranate has obtained the top priority in the highland list and got the second priority in the lowland list.

Table 7. Farmers' preferences scores and salience index (%) of tree species in lowlands and highlands.

English name	Lowlands				Total score	Salience index (Ave. %)	English name	Highlands			Total score	Salience index (Ave. %)
	Qushtapa	Khabat	Shamamik	Bahirka				Pirmam	Korre	Shaqlawa		
Olive	108	50	37	81	**276**	**94**	Pomegranate	45	101	63	**209**	**95**
Pomegranate	57	53	63	80	**253**	**82**	Fig	54	68	60	**182**	**71**
Grape	82	40	47	68	**237**	**69**	Apricot	29	60	34	**123**	**66**
Fig	49	37	60	84	**230**	**76**	Apple	13	90	9	**112**	**77**
Eucalyptus	51	31	27	26	**135**	**27**	Peach	35	42	32	**109**	**55**
Apricot	31	21	38	44	**134**	**73**	Grape	14	58	35	**107**	**70**
Mulberry	26	18	28	27	**99**	**46**	Pear	18	27	31	**76**	**50**
Pear	40	0	24	30	**94**	**66**	Walnut	3	30	19	**52**	**55**
Peach	0	17	45	22	**84**	**66**	Cherry	0	24	19	**43**	**58**
Cypress	17	11	6	5	**39**	**21**	Olive	33	6	0	**39**	**71**
Loquat	4	0	12	15	**31**	**55**	Plum	15	10	0	**25**	**38**
Almond	7	0	0	21	**28**	**54**	Loquat	16	0	8	**24**	**31**
Pine	23	5	0	0	**28**	**29**	Mulberry	2	15	4	**21**	**58**
Orange	0	0	11	15	**26**	**58**	Almond	7	0	11	**18**	**46**
Chinaberry	6	3	11	1	**21**	**29**	Oak	0	0	18	**18**	**46**

The most (15) important tree species were selected for each region. Data divided into four locations in lowland vs. three locations in highland. Each number in the table represent the total scores for all the farmers preferred species for each location in the study area. Total preferred species scores for both regions (in descending approach from most important species to least important species). Salience index (average percentage) of most used tree species in both regions (Smith 1993).

5.5. Other species preferred by farmers

Tree species that would farmers like to grow on their farms in both lowlands and highlands are represented in Figure 9. In the lowlands, the preferred species was cited much higher than in the highlands. The most preferred species in the lowlands was apricot (scored 16 points), followed by peach, loquat, *Citrus* spp., and almond (14, 13, 11 and 10 respectively). In the highlands, the most cited species was *Citrus* spp., (scored 12 points), followed by loquat, cherry, peach, and almond (10, 7, 6 and 6 respectively). Similarly, it seemed farmers increasingly desired to plant trees of the same species in lowlands and highlands, especially citruses and loquat that were highly cited in both regions. Farmers would not grow species such as chinaberry, date palm, acacia, fan palm or pine in the highlands, also they would not grow oak, prune and willow in the lowlands.

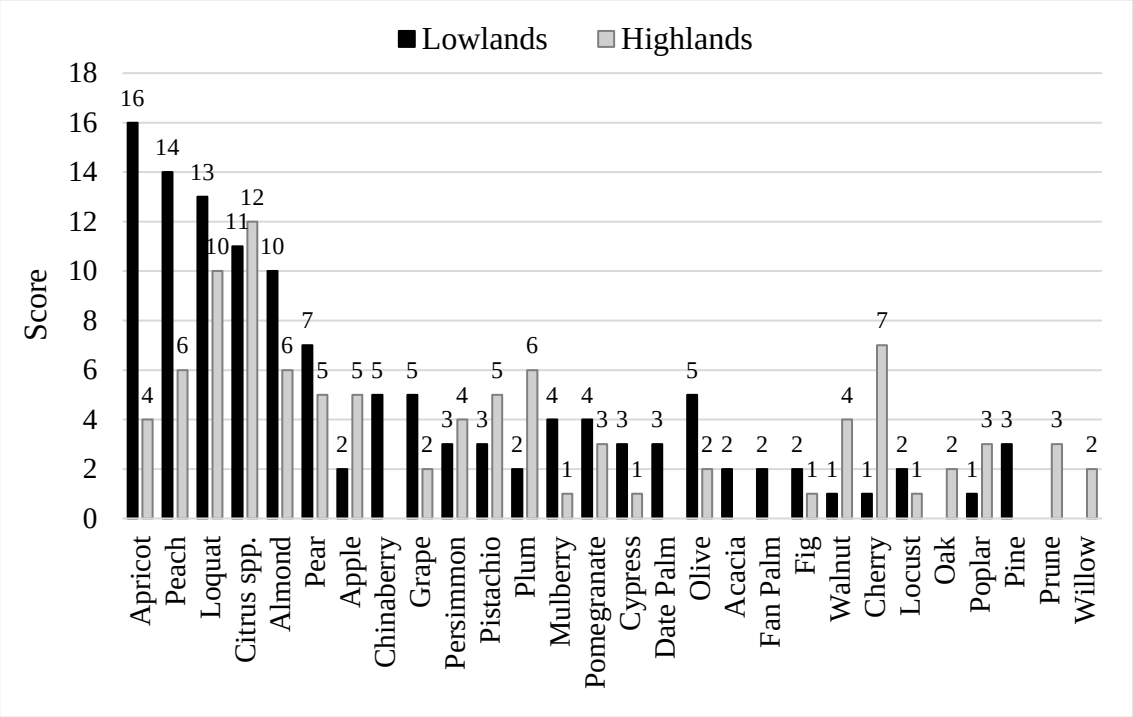


Figure 9. Tree species that would farmers like to grow on their farms (lowlands vs. highlands).

5.6. Tree species abundance

In total, trees abundance in lowlands were cited much higher than in the highlands (50,689 vs. 12,935) (Table 8). Grapes were the most planted woody species in both regions, much higher in the lowlands 16,617 (32.78 %) than in the highlands 2,424 (18.74 %). In the lowlands, olives were the second most planted species 15,166 (29.92 %) but in

highlands were less planted 655 (5.06 %), followed by pomegranates 5,161 (10.18 %), eucalyptus 4,153 (8.19 %), apricot 2,347 (4.63 %), fig 2,276 (4.49 %), and pear 1,580 (3.12 %). In highlands, pomegranates were most planted 1,842 (14.24 %), followed by eucalyptus 1,271 (9.83 %), oaks 1,152 (8.91 %), and hawthorn 1,002 (7.75 %). Other species were less planted compared to above mentioned species, willow was only planted twice in lowlands but much more in highlands 385 (2.98 %), only three trees of sycamore was planted in the highlands.

5.7. Description of the most important tree species

We found that farmers had a significant focus on the valuable tree species due to their commercial profits, for example, olives, pomegranates, grapes, and figs. The other preferred species were mixed for both purposes commercial and self-subsistence such as eucalyptus, mulberries, and oaks. The data show that farmers had many problems that affected their trees on their farms, for example lack of water and high temperature were the most common problems. Regarding the traits of trees, farmers had highly significant focus on the taste of fruits. Olives are most used for their oils and pomegranates for their fruits and juices. The findings confirm that farmers depend on the quality of fruits because of their commercial profits in the markets. There was a significant difference in trees planting between both regions (Table 9).

The pests and diseases are major problems for trees. Stem borer beetles and sunburn of top leaves were the most significant factors mentioned by the farmers. The stem borer beetles were considered highly dangerous insects on “stone fruit trees” such as apricots, peaches, cherries and plums. Consequently, control of that insect was very hard and need more experience, for instance, for instance cutting of the infected branches during the pruning process and using pesticides. The infected branches should be burned far away from the farm.

Another most frequent problem is the rising temperature significantly effecting the trees in lowlands in past several years (Figure 10). The expert farmers tried to make their trees into “umbrella shape” by pruning processes, to avoid high temperatures. As a result, they got better fruits in both quality and quantity as well (Figure 11). Because of rising temperature, the tops of tree branches became weak and they are more vulnerable to pests and diseases.

Figure 10. Pomegranate shrub is directly exposed to the high sunlight and high distance between trees (left photo). Undesirable fruit for the market (right photo).
Source: Author's personal photo documentation 2017.

Figure 11. Pomegranate shrub well managed into "umbrella shape" near to the soil with a high capacity of fruits for both quality and quantity.
Source: Author's personal photo documentation 2017.

There were significant differences in source of planting materials that farmers used for various tree species. The most frequented sources were seedlings, cuttings, or there were wildings species. Grafting nowadays seems to be the most important because is easier and faster compared to other methods with the same quality of mother fruit tree. There trees were usually not propagated by seeds.

Our results found that agroforestry systems were highly practised in both regions (lowlands and highlands): silvoarable (trees with crops or boundary trees with fruit trees) and agrosilvopastoral (trees, crops and livestock). Also, forest farming system of trees in the highlands was very common and found naturally with the wild or native species such as oak, hawthorn, and wild almond. Homegardens were also a common agroforestry practise in the region.

Table 8. Tree species abundance in both regions (lowlands vs. highlands).

English name	Lowland				Total individuals	Percentage (%)	English name	Highland			Total individuals	Percentage (%)
	Qushtapa	Khabat	Shamamik	Bahirka				Pirmam	Korre	Shaqlawa		
Grape	6,481	620	3,751	5,765	16,617	32.78	Grape	221	736	1,467	2,424	18.74
Olive	6,579	4,070	1,700	2,817	15,166	29.92	Pomegranate	176	769	897	1,842	14.24
Pomegranate	749	380	1,121	2,911	5,161	10.18	Eucalyptus	1,271	0	0	1,271	9.83
Eucalyptus	869	1,237	1,484	563	4,153	8.19	Oak (brantii)	0	0	1,152	1,152	8.91
Apricot	572	288	311	1,176	2,347	4.63	Hawthorn	0	0	1,002	1,002	7.75
Fig	700	73	208	1,295	2,276	4.49	Almond	10	0	719	729	5.64
Pear	1,073	0	176	331	1,580	3.12	Fig	302	169	220	691	5.34
Cypress	343	157	130	177	807	1.59	Apple	48	597	16	661	5.11
Peach	0	77	230	67	374	0.74	Olive	653	2	0	655	5.06
Citrus spp.	0	0	230	143	373	0.74	Apricot	274	165	36	475	3.67
Mulberry	97	40	69	100	306	0.60	Willow	110	271	4	385	2.98
Almond	190	0	0	103	293	0.58	Poplar	2	203	62	267	2.06
Pine	215	26	0	20	261	0.51	Sumac	0	0	255	255	1.97
Loquat	100	0	37	107	244	0.48	Peach	81	102	53	236	1.82
Poplar	19	8	30	145	202	0.40	Pear	36	42	116	194	1.50
Chinaberry	54	25	44	15	138	0.27	Walnut	37	63	60	160	1.24
Apple	0	0	55	15	70	0.14	Mulberry	60	33	32	125	0.97
Plum	0	7	0	49	56	0.11	Citrus spp.	59	41	0	100	0.77
Fan Palm	26	0	0	26	52	0.10	Pine	21	41	0	62	0.48
Prune	0	0	50	0	50	0.10	Plum	22	27	0	49	0.38
Pistachio	0	16	18	0	34	0.07	Loquat	35	3	2	40	0.31
Horsetail	0	22	4	0	26	0.05	Cherry	0	9	30	39	0.30
Bottle Brush	0	0	11	13	24	0.05	Cypress	28	0	1	29	0.22
Walnut	0	0	1	19	20	0.04	Ash	25	0	0	25	0.19
Date Palm	0	0	18	0	18	0.04	Oak (infec.)	0	0	24	24	0.19
Locust	0	0	0	18	18	0.04	Persimmon	8	1	5	14	0.11
Persimmon	7	0	0	0	7	0.01	Chinaberry	0	0	8	8	0.06
Albizzia	0	0	0	4	4	0.01	Pistachio	3	0	5	8	0.06
Ash	0	0	0	4	4	0.01	Bottle Brush	5	0	0	5	0.04
Chaste tree	0	0	0	3	3	0.01	Locust	0	0	5	5	0.04
Heaven Tree	0	0	0	3	3	0.01	Sycamore	0	0	3	3	0.02
Willow	0	0	0	2	2	0.00						
Sum					**50,689**	**100.00**					**12,935**	**100.00**

Table 9. Specific descriptions of the most preferred tree species in both regions (lowlands and highlands).

English name	Commercial or subsistence?	The worst problems?	The most important trait for you and why?	Where/how do you grow this species?	Pests and diseases?	Harvest time and Season?	Source of planting material?	Agroforestry system
Olive (*Olea europaea*)	Com.	Lack of labours, water, pruning needs skill, weeding, freezing season	Food, oil and resistance: more profits (high yield), usually black fruit olive for oil extraction but yellow fruit olive for food, strong resistance to high temperature	Orchard plantation usually distances between trees in systematic arrangement (7 × 5) m or (5 × 5) m - best soil: sandy rocky soil (good drainage) and open areas with air - rarely planted as boundary or scattered in the farm - the best time for irrigation at evening - required manure and fertilising	Stem borer beetle (branches and stem) - spiders (damage fertile buds) - back die (fungi) from top to base	Oct. – Nov. (autumn)	Seedling, cutting, grafting	Silvoarable system, Agrosilvopastoral system, Homegardens
Pomegranate (*Punica granatum*)	Com.	Lack of water, high temperature, weeding, and lack of labours	Taste and size: high marketable (weight) and its quite expensive	Row planting (2 or 3 or 4 or 5) m - group or mixed planting or scattered or boundary as fencing trees - soil: clay-sandy with manure, fertilising in (Dec. - Jan.) - pruning and grafting process in (Jan. - Feb.)	Fruit: cracks, sunburn, decay, worms (white fly moth) - aphids (leaves and branches)	Sept. – Oct. (autumn)	Seedling, cutting, grafting	Silvoarable system, Agrosilvopastoral system, Homegardens
Grape (*Vitis vinifera*)	Com.	Lack of labours, high temperature, electricity, lack of water, weeding	Taste and yield: more profits from the yield and its normal price	Alley planting between trees, homegardens, boundary of farm, row planting (1 or 2 or 3) m - Pruning, grafting, and cuttings in (Jan. - Feb.) - fertilising in different time of the year - soil: moderate clay-sandy	Red spider (leaves) - wasps and ants (fruits) - sunburn leaves - hawk moth insect (leaves) - birds (fruits) - dusts	Jun. – Jul. (summer)	Seedling, cutting, grafting	Silvoarable system, Agrosilvopastoral system, Homegardens
Fig (*Ficus carica*)	Com.	Required more water than other species, high temperature, lack of water, and weeding	Taste: very desirable fruits in the markets and its expensive	Boundary, group, mixed, scattered planting or row planting (4 or 5) m, distance between trees - grafting, pruning, cuttings, and air layering in (Jan. - Feb.)	White butterfly moth worms (fruits) - spider, dusts, sunburn leaves - stem borer beetle - ants	Jul. – Aug. (summer)	Seedling, cutting, grafting, air layering	Silvoarable system, Agrosilvopastoral system, Homegardens
Eucalyptus (*Eucalyptus camaldulensis*)	Both	Drought, lack of water, irrigation, and their seeds are toxic to neighbour fruit trees	Resistance and fast-growing: high temperature and often lack of water	Row planting (2 or 3 or 4 or 5) m - group or mixed planting or scattered or boundary as fencing trees - soil: clay-sandy with manure, fertilising in (Dec. - Jan.) - pruning and grafting process in (Jan. - Feb.)	Bark beetles - nematode worms (roots)	wood (8 - 15) years	Seedling, seeds	Silvoarable system, Agrosilvopastoral system, Homegardens

Table 9. Continued

English name	Commercial or subsistence	The worst problems?	The most important trait for you and why?	Where/how do you grow this species?	Pests and diseases?	Harvest time and Season?	Source of planting material?	Agroforestry system
Apricot (*Prunus armeniaca*)	Com.	Tree must be grafted, high temperature, lack of water, pests, lack of labours	Taste: desirable fruit by the people in the markets and its normal price	Scattered or mixed planting or row planting distance between trees (5 or 6) m in the farm - fertilising and grafting in (Jan. - Feb.) or before spring for better fruit yield - Spraying pesticides has done in three stages firstly, in winter, secondly after flowering, thirdly at fruit stage.	Stem borer beetles, very dangerous and common insect, attacks the top of fertile branches and continues till the base of the tree	May – Jun. (summer)	Seedling, seeds, grafting, cutting	Silvoarable system, Agrosilvopastoral system, Homegardens
Apple (*Malus pumila**)***	Com.	Lack of water, weeding, irrigation, high temperature, and exploit area at planting the tree	Taste: preferable fruit in the markets and higher demand by the people and normal price	Mixed or scattered planting trees or row planting (5 m) distance between trees - fertilising and manure are applied before spring season - it good grow in sandy-clay soil with good drainage	Colding moth worms (fruits) - aphids - wasps (fruits)	Sept. – Oct. (autumn)	Seedling, grafting, air layering	Silvoarable system, Agrosilvopastoral system, Homegardens
Peach (*Prunus persica*)	Com.	High temperature, weeding, lack of water, irrigation, drought, and tree should be grafted	Taste: preferable fruit in the markets, high demand and quite expensive	Orchard or mixed or scattered planting trees or row planting (3 or 4) m - grafting, pruning is applied in (Jan. - Feb.) - fertilising or manure added to soil before spring season - sandy-clay soil with good drainage	Stem borer beetles (branches and main stem) very dangerous and common insect	Jun. – Jul. (summer)	Seedling, cutting, seeds	Silvoarable system, Agrosilvopastoral system, Homegardens
Mulberry (*Morus alba*)	Both	High temperature, lack of water, seedlings should be grafted, drought, and electricity	Taste and large crown: low and short period yield but it's expensive in the markets - the tree shade crown used for farmers' rest	Boundary of homegardens or scattered planting or row planting (5 m or 6 m) distance between trees	Wasps and ants (fruits) - sunburn and dusts (leaves) - nematode worms (roots)	Apr. - May (spring)	Seedling, grafting	Silvoarable system, Agrosilvopastoral system, Homegardens
Pear (*Pyrus communis*)	Both	Lack of water, electricity, pests, tree needs grafting, irrigation, and needs fertilising	Taste: preferable fruit in the markets, high demand and quite expensive	Row planting (4 m or 5 m) distance between trees or scattered or mixed planting - fertilising and pruning are needed	Stem borer insect - sunburn leaves - worms (fruits)	Jun. – Jul. (summer)	Seedling, grafting, seeds	Silvoarable system, Agrosilvopastoral system, Homegardens

Table 9. Continued

English name	Commercial or subsistence	The worst problems?	The most important trait for you and why?	Where/how do you grow this species?	Pests and diseases?	Harvest time and Season?	Source of planting material?	Agroforestry system
Walnut (*Juglans regia*)	Both	High temperature	Resistance and taste: keep for long time and its expensive	Boundary trees planting or scattered or row planting (5 m) distance between trees - not suitable for dry lands, needs wet soil and air - prefer planting individually not mixed - grafting process for better fruit yield	sunburn leaves - decay (fruits)	Nov. – Dec. (autumn)	Seedling, seeds, grafting	Silvoarable system, Agrosilvopastoral system, Homegardens
Cypress (*Cupressus sempervirens*)	Subs.	Drought, lack of water, irrigation, max. high temperature, and dusts	Resistance: for winds and high temperature and evergreen tree	Boundary planting in the farm or scattered or in group planting - tolerates different types of soils	Nematode worms (roots) - stem borer beetles	wood (15 - 30) years	Seedling, seeds	Silvoarable system, Agrosilvopastoral system, Homegardens
Cherry (*Prunus avium*)	Both	High temperature, lack of water, and irrigation	Taste: very desirable fruits in the markets and quite expensive	Mixed or scattered or row planting trees (4 m or 5 m) distance between trees - fertilising and pruning are required	Stem borer beetles (branches and stem) - worms (fruits)	May – Jun. (summer)	Seedling, grafting	Silvoarable system, Homegardens
Loquat (*Eriobotrya japonica*)	Both	High temperature, lack of water, direct sun-light, long distances between trees	Taste: marketable fruit and quite expensive	Orchard style: row planting (3 m or 4 m or 5 m) distance between trees or scattered in the farm - loquat needs shade for better grow and fruit yield - fruit yield from grafted loquat is faster and better than loquat planted by seeds	Wasps and ants (fruits) - sunburn and dusts (leaves)	Mar. – Apr. (spring)	Seedling, seeds, grafting	Silvoarable system, Agrosilvopastoral system, Homegardens
Almond **(***Prunus dulcis*)	Both	High temperature in summer and almond usually does not prefer too much water (wild)	Resistance and taste: long period storage and its expensive in the markets	Forest farming: naturally growth (scattered) or planted in row (5 m) distance between trees or scattered or boundary planting	Stem borer beetles (branches and stem) - sunburn leaves	May – Jun. (summer)	Naturally, Seedling, seeds	Silvoarable system, Agrosilvopastoral system, Homegardens
Oak **(***Quercus aegilops*)	Both	High temperature, pests, sun-burn leaves	Resistance: acorns are storage for long time and used as food or fodder	Forest farming: naturally growth and scattered distribution of trees	Stem borer and bark beetles - leaf caterpillar insects	Oct. – Nov. (autumn)	Naturally, seedling, seeds	Silvoarable system, Forest farming

6. Discussion

Our study was first of its kind in the Erbil province of Iraqi Kurdistan, there was no particular study on the use and preferences of tree species in the study area. During our survey, we tried to figure out the farmers' use of trees as well as the most preferred tree species among the small-scale farmers, with the assessment of trees abundance in lowland and highland regions. Consequently, we divided our study area into two agro-ecological regions: lowlands (less than 550 m a.s.l.), and the highlands (more than 550 m a.s.l.) toward mountainous regions. In general, farmers were highly focused on the cultivation of native fruit trees more than exotic ones in both regions. They claim that native trees are more convenient to be grown in the rough climate in both regions and they had more knowledge and experience in their management. Our focus in this chapter will be on fruit trees as products and windbreak trees as service role in the farm. Moreover, we will discuss why farmers were highly dependent on fruit trees and what was the main problems that farmers were forced to cultivate those trees on their farms in both regions (lowlands vs. highlands). Also, I would like to explain the tree species abundance and trees management on their farms, with further clarification on climate change influences in the area.

6.1. Farmers' use and preferences of tree species

Our results revealed that farmers cultivated fruit trees more than other uses of trees such as woods, fodders, and fuelwoods. The farmers' income and profits are indeed depended on the fruit tree farming, and economically, fruit farming brings high earnings in both regions. We observed that farmers had many problems with increasing temperatures especially in summer season in past several years, this led to many problems for the farmers in the area such as poor fruit quality and quantity. Other problems that could be connected to this climate changes are frequent droughts, lack of water availability, low groundwater level, high evaporation, and proliferation of weeds. According to AAI (2013), fruit farming is a major activity among the farmers both in the sloping mountainous areas and lowland areas in Kurdistan region. Fruit orchards are a common land-use system of tree growing in Erbil, especially olive orchards. Loss et al. (2015) mentioned that, orchard planting style of fruit trees are most important in Erbil province and generally in Kurdistan, production of various fruits is practised in medium to high rainfall areas, while olives and nuts such as almonds mainly in arid regions.

Besides fruit production of the trees, farmers had valuated the service role such as the used trees as windbreaks, where mostly eucalyptus (*Eucalyptus camaldulensis*), cypress (*Cupressus sempervirens*), and pine (*Pinus brutia*) are planted on the field boundaries, especially in lowland region. While other tree products are less important for the farmers because recently products such as fodder, fuelwood, and wood, farmers are close to the city, some of them imported from the neighbouring countries. Also, there are strict rules by the government for tree cutting to save forest biodiversity in the region, and the most important is the availability of gas instead of wood. Farmers have cultivated windbreak trees for several issues: to protect their farms from strong winds, dust, and hot winds in the summer season and provide shading to farms. Eucalyptus is considered one of the most important species on the farm because of its resistance to high temperatures. According to various studies, windbreaks are one of the main agroforestry systems in arid environments, with clear service role on farms (Brandle et al. 2004; Schroth & Sinclair 2003). Farmers also mentioned cypress as important windbreak tree, moreover, windbreaks are planted to improve local microclimate and used in agriculture of many countries as environmentally efficient boundaries (Ben Salem & Van Nao 1981). Windbreaks are also important for protection of soil, fruit trees, orchards in orchards and crops in arid areas (Sheikh 1988).

Farmers were highly cultivating of fruit trees in the lowlands and highlands. It is evident that farmers depended on fruit trees for commercial profits and for their livelihoods as well. Farmers highly cultivated olives in the lowlands more than any other species, while in highland olives were not much cited by farmers. The reason is olives had tolerance to the high temperatures that almost reaches 45 - 50 °C mostly in the summer between July to August. Various studies revealed that olives were very resistant to drought, lack of water, had thick and hard leaves, and can survive without water or irrigation for several days in the summer (Bacelar et al. 2007; Connor & Fereres 2010; Gullo & Salleo 1988). Olives are able to withstand a wide range of environmental stresses due to a variety of physiological and morphological adaptations. The leaves of olive can bear very low water potentials and sustain their full rehydration capacity even after losing almost 40 % of their water content (Rhizopoulou et al. 1991). Because of that, the high temperature problems that were cited in our survey were very critical for the farmers. As researchers, we must understand the climate changes (global warming) to sustain, develop, and follow the agroforestry practices in the region and farm management as well.

We should also reveal which tree species have high resistance to high temperature to be planted in the lowland region especially.

In the highlands, the results showed that pomegranate is significantly preferred and used among the farmers on their farms. The reason is that the fruits were highly desirable in the markets and more profitable due to fruit quality, size, and juice. Another point is the pomegranate grows better in the mountainous climate condition with more rainfall and even the quality of fruits was more satisfactory than in lowland pomegranate fruits. The study of Khoshbakht & Hammer (2006) reported that pomegranates were widely cultivated in the homegardens and forests in Savadkouh region of Iran which had the same climate condition as our study area, warm in summers and cold in winters, with mean annual rainfall of 1,700 mm.

Our results also showed that farmers did not mention any medicinal uses of trees in the study area. We can see several reasons behind that. Firstly, farmers were very near the city, this means they do not need to use their trees as medicinal sources because there is a lot of pharmacies' stores and shops that are accessible. Secondly, farmers do not have much experience about the medical uses of trees, or they do not have a desire to use them. However, the tradition of medical applications of trees is still active and available in the remote villages in the highlands, where farmers always keep their traditional uses of trees as medicine. The studies showed that that the wealth of medicinal trees and plant knowledge among the people of Iraq and Kurdistan region is based on hundreds of years of observations, belief, and historically is a rich therapeutic country (Al-douri 2000; Alsamarkandi 1985; Khalil 1979). Another study reported that *Pistacia atlantica* subsp. *kurdica* plays a vital role in the economy of residents and Kurdish ethnomedicine (Ahmed 2017). This plant may be a valuable starting point interesting not only for pharmaceutical businesses, to become a natural alternative method for better wellness and health.

6.2. Species abundance and management

We found that number of trees planted in the lowlands were several times much higher than in highlands. Grapes were highly planted in both regions, followed by olives in lowlands and pomegranates in highlands. The reason is farmers owned small lands in the highlands compared to the lowlands. Mainly because of two reasons: firstly, because of difficult transportation in mountainous areas during the fruit harvesting season including the marketing (selling process) and most of the farmers used the transport by themselves.

Secondly, it was costlier compared to lowland regions that transportation process was more accessible to the markets. This shows that farmers had much free lands in lowlands that were suitable for trees planting without high barriers or slopes, while in highlands, the most of areas were less suitable for fruit trees cultivation because of the steep slopes and rocky soils.

Most of the species were found in different agroforestry systems such as homegardens with mixed fruit trees and boundary trees, this was a common practise in both lowlands and highlands. In lowlands, silvoarable systems, planting trees together with crops, are popular along with orchards or rows of fruit trees surrounded by boundary trees. Agrosilvopastoral system combining trees, crops and animals, was a common practise in both lowlands and highlands. Forest farming was a common practise in highlands. Olives, pomegranates, figs, and grapes were found in homegardens, silvoarable and agrosilvopastoral systems. Also, pomegranate trees were found in the forest farming system with wild trees such as oaks, hawthorns and almonds in the highlands. Seedlings are the most frequent source of planting materials in both regions and farmers usually buy them from private nurseries or government. Seeds are less used because are costlier and slower compared to seedlings.

Main tree management practises are pruning and weeding, in case of vegetative propagation, farmers used mainly grafting or air layering. Pruning is done in winter season between January to February, while grafting is done in early spring before the growth of buds. Olives generally need less pruning because they are evergreen species of along age, also are growing better in sandy rocky soils. However, pomegranates and figs need a lot of pruning to get better fruits. Weeding is another very common agriculture practise, usually done in spring season. Chemical fertilising is applied according to the needs of particular species. Animal manure is applied in the winter season for mature trees and restricted for young seedlings or small trees because it can burn them. Process of weeding is also very common, is usually done in spring season.

Eucalyptus, cypress, and pine were highly used for boundary trees on the farms because of high resistance to drought and high temperatures. In highlands, most of the fruit trees were planted in mixed arrangement, group or scattered. In lowlands, the most fruit trees were a part orchards, rows or trees intercropped with crops, e.g. olive trees with chickpea. For better farm management, farmers have to improve their trees' shape for

better fruit incomes in both quality and quantity. It will be better if the farmers reduce the distance between their trees mainly in the lowlands because of the high temperatures during summers. Farmers also should keep their trees' crown in low height, especially pomegranates and figs due to the high temperatures that negatively effects the fruits of trees.

6.3. Species differences and climate change effects.

Our results found that some of the tree species were planted only in the lowland farms for their various uses such as date palm - *Phoenix dactylifera*, fan palm - *Washingtonia filifera*, albizzia - *Albizzia lebbeck*, chaste tree - *Pseudo negundo*, heaven tree - *Ailanthus glandulosa*, and horsetail - *Casuarina equisetifolia*. Inversely some of the species were found only in the highland farms such as cherry - *Prunus avium*, oak - *Quercus aegilops* & *Quercus infectoria*, hawthorn - *Craetagus azarolus*, sumac - *Rhus coriaria*, pistachio - *Pistacia khinjuk*, and sycamore - *Platanus orientalis*. However, there were some species planted in both regions such as walnut - *Juglans regia*, pistachio - *Pistacia vera*, almond - *Prunus dulcis*, apple - *Malus pumila*, and plum - *Prunus domestica*, but those trees were growing better in highlands on slopes farming because they require wet soils and cold weather. Besides, some of those trees were naturally found in the wild or had been planted by the farmers on their farms such as oaks, almonds, sumac, and hawthorns.

Our results showed that high temperatures were one of the most problems in the region, especially in lowlands. The quality and quantity of fruits in lowlands were very poor because trees cannot tolerate high temperatures and hot winds in summers. Although most tree uses were for the fruits, this does not mean that farmers harvested good fruits in quality and quantity. In highlands, farmers they had problems with pests, lack of water, and selling issues. In lowlands, the problems were riskier than we expected, the problem was in high temperatures. Even the olives that had good tolerance to the harsh climate suffered, but generally was better compared to other species in high temperature resistance. According to the studies on the climate changes, researchers found that global warming influences various climate regions and high elevation regions especially (Diaz & Bradley 1997; Dixon et al. 2003; Pepin & Norris 2005; Pepin & Lundquist 2008; Qin et al. 2009; Rehman 2010). Moreover, the feedback on the climate alterations and the variables controlling climate regimes show very characteristic patterns across different regions (Mahlstein & Knutti 2010). Small-scale farms are more exposed to climate,

environmental, and various weather stress, including global warming (Lasco et al. 2014). The strategy of umbrella crowns allows the predominant trees wider leaf area in full sunlight. It also reduces root competition by overcoming neighbouring trees. Additionally, taller trees are vulnerable to high-temperatures burning (Bosc et al. 2003).

7. Conclusion

Our study was focused on the summary and extension of knowledge on farmers' use and priorities of tree species in Erbil province of Iraqi Kurdistan. In total 46 tree species were identified in both lowland and highland regions. We found out that the main product coming from those trees are fruits, which are an important source of income for the farmers and most of them relied on fruits farming for their livelihoods. Besides, the tree productive function, windbreaks were extensively used by farmers in lowland farms, to avoid hot and strong winds and to provide shade for fruit trees, crops and vegetables. Farmers were using seedlings and cutting as planting material and the most frequent form of vegetative propagation was grafting. In the future, further studies have to be done to understand more about fruit uses and qualities in the markets. Farmers should focus more on fruit tree species that are resistant to harsh climate. This might be achievable by a better tree management and species selection in both lowlands and highlands, taking into consideration the effects of climate change.

8. References

AAI. 2013. Agriculture and farmers in the Kurdish region. Available from https://www.google.cz/search?q=Agriculture+and+farmers+in+Kurdish+region (Accessed on February 2018).

Ahmad, S. A., and A. A. Askari. 2015. Ethnobotany of the Hawraman region of Kurdistan Iraq. Harvard papers in botany **20**:85-89.

Ahmed, H. M. 2017. Traditional uses of Kurdish medicinal plant Pistacia atlantica subsp kurdica Zohary in Ranya, Southern Kurdistan. Genetic Resources and Crop Evolution **64**:1473-1484.

Akinnifes, F., F. Kwesiga, J. Mhango, T. Chilanga, A. Mkonda, and R. Swai. 2004. Domesticating priority Miombo indigenous fruit trees as a promising livelihood option for smallholder farmers in Southern Africa.[http:/www. actahort. org/members/show. pdf/bookrarnr= 632] site visited on 14/05/2007. Research into Practice:307-317.

Al-douri, N. A. 2000. A survey of medicinal plants and their traditional uses in Iraq. Pharmaceutical Biology **38**:74-79.

Alsamarkandi, N. 1985. Principles of drugs composition (Esool Tarkeeb Aladwaii), investigated by Neglai Fathi University of Baghdad Publication (Center for the Revival of Arab Scientific Heritage). Baghdad.

Alston, J. M., G. W. Norton, and P. G. Pardey 1995. Science under scarcity: principles and practice for agricultural research evaluation and priority setting. Cornell University Press.

Amin, A., S. Ismail, T. Khaled, K. Anwar, K. Saleem, M. Anwar, T. Noguchi, and A. Matsuda. 2014. Extension System Survey (Baseline Survey Report), Extension Center under the Ministry of Agriculture and Water Resources (MoAWR), Erbil governorate - Kurdistan region of Iraq. p. 137.

Bacelar, E. A., D. L. Santos, J. M. Moutinho-Pereira, J. I. Lopes, B. C. Goncalves, T. C. Ferreira, and C. M. Correia. 2007. Physiological behaviour, oxidative damage and antioxidative protection of olive trees grown under different irrigation regimes. Plant and Soil **292**:1-12.

Batish, D. R., R. K. Kohli, S. Jose, and H. P. Singh 2007. Ecological basis of agroforestry. CRC Press.

Ben Salem, B., and T. Van Nao. 1981. Fuelwood production in traditional farming systems. Unasylva **33**:13-18.

Bosc, A., A. de Grandcourt, and D. Loustau. 2003. Variability of stem and branch maintenance respiration in a Pinus pinaster tree. Tree Physiol **23**:227-236.

Brandle, J. R., L. Hodges, and X. H. Zhou. 2004. Windbreaks in North American agricultural systems. Pages 65-78. New vistas in agroforestry. Springer.

Breisinger, C., X. S. Diao, J. Thurlow, and R. M. Al Hassan. 2011. Potential Impacts of a Green Revolution in Africa-the Case of Ghana. Journal of International Development **23**:82-102.

Brewbaker, J. L. 1985. Leguminous trees and shrubs for southeast Asia and the South Pacific. Blair, Graeme J.; Ivory, DA; Evans, TR (eds.). Forages in Southeast Asian and South Pacific agriculture: Proceedings of an international workshop held at Cisarua, Indonesia, 19-23 August 1985.

Buringh, P. 1960. Soils and soil conditions in Iraq. Ministry of agriculture.

Chapman, G. 1948. Forestry in Iraq. Unasylva **2**:251-253.

Climate Data. 2012. Climate Erbil. Available from https://en.climate-data.org/location/4976/ (Accessed on January 2018).

Connor, D., and E. Fereres. 2010. The physiology of adaptation and yield expression in olive. Horticultural Reviews, Volume 31:155-229.

Contant, R. B., and A. Bottomley. 1988. Priority setting in agricultural research. Working Paper. ISNAR (Netherlands).

Davies, D. H. 1957. Observations on land use in Iraq. Economic Geography **33**:122-134.

Diao, X., P. B. Hazell, D. Resnick, and J. Thurlow 2007. The role of agriculture in development: Implications for Sub-Saharan Africa. Intl Food Policy Res Inst.

Diaz, H. F., and R. S. Bradley. 1997. Temperature variations during the last century at high elevation sites. Pages 21-47. Climatic change at high elevation sites. Springer.

Dixon, K. W., T. L. Delworth, T. R. Knutson, M. J. Spelman, and R. J. Stouffer. 2003. A comparison of climate change simulations produced by two GFDL coupled climate models. Global and Planetary Change **37**:81-102.

Elevitch, C. R., and K. M. Wilkinson 2000. Agroforestry guides for Pacific islands. Par.

FAO. 2007. COUNTRY REPORT TO THE FAO INTERNATIONAL TECHNICAL CONFERENCE ON PLANT GENETIC RESOURCES. BAGHDAD - IRAQ.

FAO. 2013. FAOSTAT database. Available from http://faostat.fao.org (Accessed on April 2018).

FAO. 2017. Iraq - Agriculture damage and loss needs assessment. Available from http://www.fao.org/emergencies/resources/documents/resources-detail/en/c/1036368/ (Accessed on March 2018).

FAO. 2018. FAO in Iraq. Iraq at a glance. Available from http://www.fao.org/iraq/fao-in-iraq/iraq-at-a-glance/en/ (Accessed on March 2018).

FAO, F. 2015. Global forest resources assessment 2015 Desk reference. Food and agriculture organization of the United Nations, Rome.

Felker, P. 1978. State of the art: Acacia albida as a complementary permanent intercrop with annual crops.

Franzel, S., H. Jaenicke, and W. Janssen 1996. Choosing the right trees: setting priorities for multipurpose tree improvement. ISNAR The Hague, The Netherlands.

Franzel, S. C., and S. J. Scherr 2002. Trees on the farm: assessing the adoption potential of agroforestry practices in Africa. CABI.

Gullo, M., and S. Salleo. 1988. Different strategies of drought resistance in three Mediterranean sclerophyllous trees growing in the same environmental conditions. New Phytologist **108**:267-276.

Hameed, H. 2013. Water harvesting in Erbil Governorate, Kurdistan region, Iraq: detection of suitable sites using geographic information system and remote sensing. Student thesis series INES.

Heshmati, A. 2009. Integrated water resource management in the Kurdistan region, Nova Science Publishers, Inc. Water Resource Planning Development and Management. Seoul National University, Seoul, Korea. p. 225.

Huml, L. 2011. Multipurpose tree species used by small farmers in the Ucayali region, Peruvian Amazon [MSc. Thesis]. Prague: Czech University of Life Sciences Prague. p. 47.

Hussein, S. 2017. A VEGETATION COVER TIME SERIES ASSESMENT IN ERBIL, IRAQ USING VEGETATION INDICES DERIVED FROM MODIS IMAGERY. Physical Geography and Geoinformatics, University of Szeged.

ICRAF. 1993. ICRAF: The way ahead – strategic plan. Nairobi, Kenya.

ICRAF. 2018. The World Agroforestry Centre. Agroforestry and our role. Available from http://www.worldagroforestry.org/about/agroforestry-our-role (Accessed on February 2018).

IPCC. 2014. Climate Change 2014: Impacts, Adaptation, and Vulnerability. Available from https://www.ipcc.ch/report/ar5/wg2/ (Accessed on April 2018).

Ismael, A. K., and I. Ngah. 2011. Rural population density effect on socio-economic characteristics: a review. Journal of Social Sciences **7**:655.

Jalali, H., A. S. M. Nejad, A. G. Ebadi, and G. Laey. 2009. Ethnobotany and Folk Pharmaceutical Properties of Major Trees or Shrubs in Northeast of Iran. Asian Journal of Chemistry **21**:5632-5638.

Jaradat, A. A. 2003. Agriculture in Iraq: Resources, potentials, constraints, research needs and priorities. Journal of Food Agriculture & Environment **1**:160-166.

Johansson, M. 2012. Agroforestry in the south of Kurdistan [BSc. Thesis]. SLU, Swedish University of Agricultural Sciences. Sweden, alnarp. p. 31.

Jose, S. 2009. Agroforestry for ecosystem services and environmental benefits: an overview. Agroforestry Systems **76**:1-10.

Khalid, B., and S. Bararasul. 2015. Peramagroon: Profile of a Kurdish Mountain. Nature Iraq, Royal Botanic Garden Edinburgh and BirdLife International. UK. p. 40.

Khalid, N. 2014. Urban heat island in Erbil city [MSc. Thesis]. Student thesis series INES. Department of Physical Geography and Ecosystem Science. Sweden. p.84.

Khalil, Y. 1979. Old Arab Medicine and Pharmacy. Baghdad university Library publication:9-57.

Khoshbakht, K., and K. Hammer. 2006. Savadkouh (Iran)–an evolutionary centre for fruit trees and shrubs. Genetic Resources and Crop Evolution 53:641-651.

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel. 2006. World map of the Köppen-Geiger climate classification updated. Meteorologische Zeitschrift **15**:259-263.

KRG. 2018. The people of the Kurdistan Region Government - Iraq. Available from http://www.gov.krd/p/p.aspx?l=12&p=214 (Accessed on March 2018).

Lasco, R. D., R. J. P. Delfino, D. C. Catacutan, E. S. Simelton, and D. M. Wilson. 2014. Climate risk adaptation by smallholder farmers: the roles of trees and agroforestry. Current Opinion in Environmental Sustainability **6**:83-88.

Leakey, R. 1997. Redefining agroforestry–and opening Pandora's box. Agroforestry today **9**:5.

Levingston, R., and R. Zamora. 1983. Medicine trees of the Tropics. Unasylva **35**:7-10.

Lojka, B., and D. Preininger 2006. Introduction to Agroforestry. Czech University of Life Sciences, Institute of Tropics and Subtropics.

Loss, S. P., A. Haddad, J. Desbiolles, H. Cicek, Y. Khalil, and C. M. Piggin 2015. The practical implementation of conservation agriculture in the Middle east. International Center for Agricultural Research in the Dry Areas (ICARDA).

Lundgren, B., and J. Raintree. 1983. Agroforestry. Agricultural Research for Development: Potentials and Challenges in Asia. Jakarta (Indonesia). 24-29 Oct 1982.

Mahlstein, I., and R. Knutti. 2010. Regional climate change patterns identified by cluster analysis. Climate Dynamics **35**:587-600.

Mazid, A. 2015. Status of Wheat Production in Kurdistan Region of Iraq: Results of Baseline Survey.

Mercer, D. E., and J. Soussan. 1992. Fuelwood problems and solutions. Managing the World's Forests: Looking for Balance between Conservation and Development:177-213.

Michon, G., and H. de Foresta. 1996. Agroforests as an alternative to pure plantations for the domestication and commercialization of NTFPs. Domestication and commercialization of non-timber forest products in agroforestry systems, Non-wood forest products:160-175.

Ministry of Environment. 2010. The Convention on Biodiversity in Iraq. The Republic of Iraq. p. 153.

Muhaimeed, A. S., A. Saloom, K. Saleim, and K. Alaane. 2014. Classification and Distribution of Iraqi Soils. International Journal of Agriculture Innovations and Research **2**:997-1002.

Nair, P. K. R. 1993. An introduction to agroforestry. Kluwer Academic Publishers, Dordrecht. The Netherlands.

Nair, P. K. R., B. M. Kumar, and V. D. Nair. 2009. Agroforestry as a strategy for carbon sequestration. Journal of Plant Nutrition and Soil Science **172**:10-23.

NCCI. 2015. Erbil Governorate Profile. NGO Coordination Committee for Iraq. Available from https://www.google.cz/search?q=climate+data+of+erbil+governorate (Accessed January 2018).

O'Shea, M. T. 2004. Trapped between the map and reality: Geography and perceptions of Kurdistan. Routledge.

Omer, T. M. A. 2011. Country Pasture/Forage Resource Profiles IRAQ. Food and.

Pepin, N., and J. Norris. 2005. An examination of the differences between surface and free-air temperature trend at high-elevation sites: Relationships with cloud cover, snow cover, and wind. Journal of Geophysical Research: Atmospheres **110**.

Pepin, N. C., and J. D. Lundquist. 2008. Temperature trends at high elevations: Patterns across the globe. Geophysical Research Letters **35**.

Poyck, A. 1962. Farm studies in Iraq. H. Veenman & Zonen NV.

Pye-Smith, C. 2009. Annual Report 2008-2009: Agroforestry - a global land use (long version).

Qin, J., K. Yang, S. L. Liang, and X. F. Guo. 2009. The altitudinal dependence of recent rapid warming over the Tibetan Plateau. Climatic Change **97**:321-327.

Raven, P. 1991. Global change and sustainability: what are the issues. Pages 17-27. The United Nations University ed., Global Environmental Forum, Tokyo.

Rehman, S. 2010. Temperature and rainfall variation over Dhahran, Saudi Arabia,(1970–2006). International Journal of Climatology **30**:445-449.

RFSAN. 2016. The Impact of ISIS on Iraq's agricultural sector. Regional Food Security Analysis Network. Available from http://rfsan.info/products/product/impact-isis-iraqs-agricultural-sector (Accessed on March 2018).

RFSAN. 2017. Regional Food Security Analysis Network - Iraq. Quarterly update (April - June 2017). Available from http://rfsan.info/products/product/iraq-food-security-quarterly-update-april-july-2017 (Accessed on March 2018).

Rhizopoulou, S., M. Meletiou-Christou, and S. Diamantoglou. 1991. Water relations for sun and shade leaves of four Mediterranean evergreen sclerophylls. Journal of Experimental Botany **42**:627-635.

Schnepf, R. D. 2003. Iraq's agriculture: Background and status. Congressional Research Service, Library of Congress.

Schroth, G., and F. Sinclair. 2003. Impacts of trees on the fertility of agricultural soils. Trees, Crops and Soil Fertility: Concepts and Research Methods:1-11.

Sheikh, M. I. 1988. Planting and establishment of windbreaks in arid areas. Pages 405-423. Windbreak Technology. Elsevier.

Simons, A., and R. Leakey. 2004. Tree domestication in tropical agroforestry. Pages 167-181. New Vistas in Agroforestry. Springer.

Tengnäs, B. 1994. Agroforestry extension manual for Kenya. World Agroforestry Centre.

Thaman, R., and W. C. Clarke. 1987. Pacific island agrosilviculture: Systems for cultural and ecological stability. Canopy International **13**:6-7.

Thaman, R. R., C. R. Elevitch, and K. M. Wilkinson. 2000. Multipurpose trees for agroforestry in the Pacific Islands. Holualoa: Permanent Agriculture Resources.

USAID, I. 2008. Kurdistan Region: Economic Development Assessment. United States Agency for International Development.

Van Eimern, J. 1964. Windbreaks and shelterbelts. Secretariat of the World Meteorological Organization.

Von Maydell, H. 1987. Agroforestry in the dry zones of Africa: past, present and future. Agroforestry:89.

Von Oppen, M., and J. G. Ryan. 1985. Research resource allocation: Determining regional priorities. Food Policy **10**:253-264.

Wood, P. J., and J. Burley 1991. A tree for all reasons: introduction and evaluation of multipurpose trees for agroforestry.

World Bank. 2008. Iraq Household Socioeconomic Survey – IHSES-2007. Washington, DC: World Bank. http://go.worldbank.org/GMS95L4VH0.

World bank. 2017. Employment in agriculture (% of total employment) - Iraq. Available from http://www.worldbank.org/ (Accessed on March 2018).

World Weather. 2017. Erbil Monthly Climate Averages. Available from https://www.worldweatheronline.com/erbil-weather-averages/arbil/iq.aspx (Accessed on March 2018).

WPR. 2018. World Population Review - Iraq. Available from http://worldpopulationreview.com/countries/iraq-population/ (Accessed on March 2018).

Yengoh, G. T., and S. Brogaard. 2014. Explaining low yields and low food production in Cameroon: a farmers' perspective. GeoJournal **79**:279-295.

Young, A. 1997. Agroforestry for soil management. CAB international. The UK.

Appendices

Appendix 1 – Questionnaire

Questionnaire for evaluation of tree species and products used by farmers

Questionnaire for individual farmer

No. of the farm: 13 Date: 16 / 8 / 2017

Part I. Socio-demographic data

District (Village):	Korre (Gorasher)	Name:	Tariq Kareem Mawlood
Altitude (m):	748	Gender:	Male
GPS:	N: 36° 23' 56.3" E: 44° 13' 55.4"	Age, years here	41 y (28 y)
Nationality:	Kurdish	Education:	High School Certification
Members of the family:	1	Farm size: (ha)	0.15 ha
Socio-economic status:	Self-evaluation	1–2–3	1= Best **2**= Ave. 3= Worst

Part II. Tree species/products used and preferred by farmers:

(A1) Tree species that I use (grown, collected, products):	(B) Priority species (1-most important, 10-least important):	(C) Species that I do not grow but would like to:
1. Apple	1. Apple	1. Citrus spp.
2. Pomegranate	2. Pomegranate	2. Cherry
3. Fig	3. Pear	3. Loquat

(A2) What are the tree products I use:
1. Fruits
2. Fruits, vinegar, juice
3. Fruits, jam

Part III. Species-specific part:

Vernacular name Kurdish \ English	Scientific name	1. Commercial or subsistence purposes?	2. The worst problems in establishing?	3. The most important trait * and why?	4. Where and how do you grow this species?	5. The main threats? (pests & diseases)	6. Harvest, Season, starts to produce?	7. The Source of planting material?	8. Agroforestry systems
Sew Apple	*Malus pumila*	Com.	Lack of water	Taste, good profits	Scattered or mixed in the farm	Fruit worms	Sept., autumn	Seedlings, nursery, grafting	Homegardens

* Yield, resistance, fruit size, taste, oil, etc.

Part IV. Species abundance (individuals), main field characteristics.

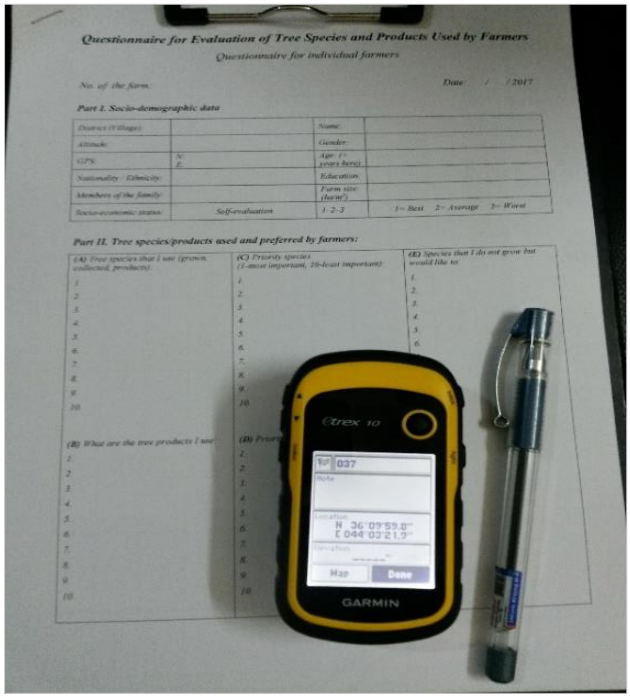
A. Tree \ shrub species abundance on farmers' fields (Filed Observation):

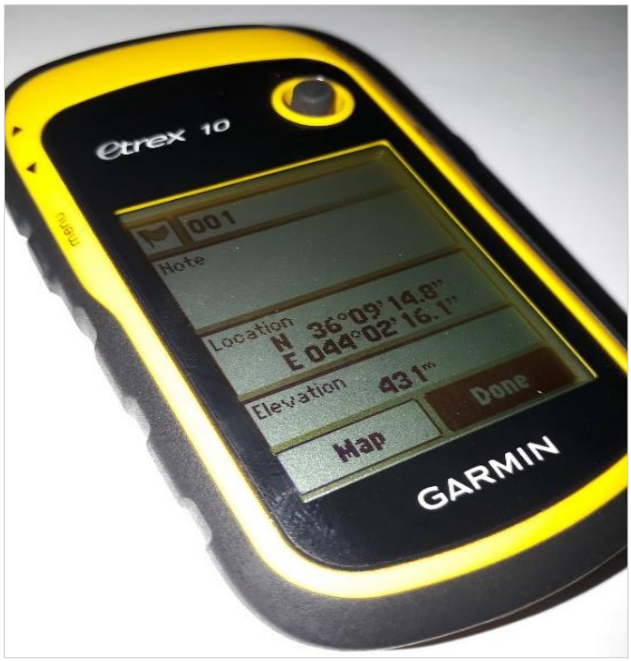
No.	Tree \ shrub species name	Number of individuals
1.	Apple	50
2.	Pomegranate	45
3.	Fig	15

B. Field main characteristics (main crops, pastures, livestock.…)

1. Drip irrigation system
2. Mixed planting trees
3. Beds for fig cuttings
4. Moderate clay soil
5. Pruning and the fertilising process usually done in February

Appendix 2 – Materials





Survey's materials: Questionnaire form, pen, and GPS and elevation (Garmin) Device.

Appendix 3 – The basic description of all farmers in lowlands vs. highlands.

Region	District (Village)		Altitude (m)	Latitude N			Longitude E			Number of households	Name	Gender	Age (+ years here)	Education	Farm size (ha)	Financial condition
				D°	M'	S''	D°	M'	S''							
Lowlands	Qushtapa	Kucha Biyas	398	36	3	52.1	44	1	7.3	10	Kakakhan Awlla	M	70 y (20 y)	Agri. mentor	20 ha	2
		Small Murtka	395	36	2	15.5	44	1	23.6	3	Ali O. Muhamed	M	43 y (12 y)	Worker	2.3 ha	2
		Small Murtka	406	36	1	46.3	44	2	0.1	4	Ismail H. Mamand	M	60 y (10 y)	Worker	1.5 ha	2
		Qushtapa	399	36	0	47.2	44	1	59.3	3	Fariq A. Muhamed	M	62 y (27 y)	Worker	8.5 ha	2
		Dolabakra	386	35	59	11.5	44	4	61.2	6	Zhyan Aziz Hamad	F	53 y (27 y)	Agri. diploma	15 ha	1
		Dolabakra	413	35	59	43.9	44	4	52.3	4	Hussam A. Noraldin	M	60 y (13 y)	Worker	15 ha	1
		Dolabakra	386	35	55	53.6	44	4	29	2	Lashkry K. Hamad	M	67 y (12 y)	P.S.C.	7.5 ha	2
		Hemzakor	410	35	57	27.3	44	3	40.6	5	Saadula A. Kassem	M	48 y (24 y)	P.S.C.	6.25 ha	1
		Kardis	406	35	59	32.5	44	5	64.8	3	Sarkawt Ismail	M	61 y (12 y)	Worker	2.5 ha	2
		Hemzakor	412	35	56	59.9	44	4	26.2	6	Safin M. Amin	M	26 y (14 y)	Worker	10 ha	2
		Dolabakra	386	35	56	4.4	44	4	16.1	1	Shukur K. Hamad	M	65 y (10 y)	P.S.C.	7.5 ha	2
	Khabat	Goraban	407	36	14	21.9	43	47	9.1	3	Ramazan S. Khedher	M	60 y (7 y)	Worker	18 ha	2
		Girdarash	331	36	16	3.9	43	42	19.7	5	Muhamed M. Ahmad	M	40 y (8 y)	H.S.C.	8.75 ha	2
		Goraban	397	36	14	22.9	43	47	9	4	Ahmad M. Khalifa	M	71 y (17 y)	Worker	0.38 ha	2
		Jadida	399	36	14	43.8	43	47	20.9	5	Shaker E. Kareem	M	60 y (14 y)	Worker	100 ha	1
		Jadida	391	36	14	9.3	43	48	18.3	2	Ali M. Kareem	M	48 y (10 y)	Worker	0.5 ha	2
		Jadida	397	36	14	10.3	43	48	10.5	7	Khorshed Saleh	M	58 y (14 y)	Worker	1.5 ha	2
		Jadida	344	36	16	0.7	43	46	50.6	5	Pishtiwan Asaad	M	25 y (6 y)	Worker	6 ha	2
	Shamamik	Qarya Taq	363	36	9	44.2	43	53	19	2	Ismail J. Othman	M	40 y (3 y)	Worker	0.5 ha	1
		Qarya Taq	343	36	9	23.2	43	52	13.4	2	Hadi Khalid	M	48 y (10 y)	P.S.C.	2.5 ha	2
		Qarya Taq	348	36	9	26.9	43	52	14.3	3	Kheder M. Omar	M	65 y (3 y)	Worker	11.25 ha	2
		Qarya Taq	349	36	9	25.7	43	52	18.5	2	Thyab M. Sarhan	M	38 y (5 y)	H.S.C.	2.5 ha	2
		Qarya Taq	355	36	9	43.1	43	52	30.2	2	Masud H. Muhamed	M	71 y (11 y)	P.S.C.	4.25 ha	2

Appendix 3 - Continued

		Ben Birez	326	36	8	27.8	43	50	57.8	1	Ismail H. Qader	M	63 y (10 y)	Worker	6.25 ha	2
		Ben Birez	332	36	8	36.5	43	50	59.6	5	Askander O. Abdulla	M	65 y (5 y)	Worker	0.25 ha	2
		Ben Birez	337	36	9	5.8	43	51	32.8	5	Namiq Q. Kareem	M	67 y (15 y)	Worker	12.5 ha	1
		Swery	359	36	9	49.5	43	53	39.3	7	Dara Ahmad	M	37 y (7 y)	Engineer	13.75 ha	3
	Bahirka	Kark	426	36	15	27.6	44	1	27.5	4	Saadulla A. Khafor	M	27 y (10 y)	Worker	7.5 ha	1
		Kark	460	36	15	42.6	44	2	4.2	4	Mudhafar Shaker	M	37 y (13 y)	H.S.C.	1 ha	2
		Zarza	459	36	15	33.5	44	2	25.3	1	Yassin A. Ismail	M	50 y (26 y)	H.S.C.	0.38 ha	2
		Zarza	463	36	15	33.6	44	2	28.8	4	Zerar O. Ahmad	M	42 y (24 y)	H.S.C.	2.5 ha	2
		Qala Murtka	535	36	21	35.1	44	7	5.6	2	Aziz Salem	M	53 y (10 y)	Worker	2.1 ha	2
		Qala Murtka	536	36	21	28.7	44	5	52.1	2	Yassin T. Mustafa	M	58 y (9 y)	Business	16.75 ha	2
		Qala Murtka	530	36	21	23.7	44	5	45.2	1	Sangar Y. Aziz	M	35 y (5 y)	Worker	4.63 ha	1
		Qala Murtka	505	36	21	20.9	44	5	45	3	Salahaddin Muhamed	M	61 y (5 y)	Worker	1.25 ha	2
		Qala Murtka	537	36	21	2.8	44	5	49.4	4	Rostem S. Rashid	M	48 y (8 y)	P.S.C.	2 ha	1
		Qala Murtka	536	36	21	10.7	44	5	41.4	6	Sadiq M. Osman	M	63 y (7 y)	Worker	3.75 ha	2
		Qala Murtka	538	36	21	8.6	44	5	43.6	1	Saman Z. Rasheed	M	43 y (7 y)	Worker	2.5 ha	2
		Shinawa	741	36	20	48.7	44	9	36.4	3	Hasan Younes	M	41 y (6 y)	Worker	2.5 ha	2
		Sayukan	656	36	19	57.5	44	10	52.5	2	Ahmad Faraj	M	29 y (6 y)	Worker	0.38 ha	2
	Pirmam	Khorkhawa	619	36	21	18.7	44	8	46.5	3	Sirwan H. Sadiq	M	41 y (7 y)	Worker	0.75 ha	3
		Khorkhawa	630	36	21	31.6	44	8	41.7	1	Bahram M. Abdulla	M	50 y (8 y)	Worker	0.5 ha	2
		Khorkhawa	627	36	21	26.5	44	8	45.5	3	Akram M. Abdulla	M	40 y (7 y)	Worker	0.5 ha	2
Highlands		Shinawa	552	36	21	41.5	44	6	41.1	4	Nasir Y. Muhidin	M	34 y (22 y)	M.Sc.	2.5 ha	2
		Birezh	811	36	23	26.5	44	14	58.9	1	Nariman Hussein	M	42 y (25 y)	Worker	0.38 ha	2
		Gorasher	748	36	23	56.3	44	13	55.4	1	Tariq K. Mawlood	M	41 y (28 y)	H.S.C.	0.15 ha	2
	Korre	Gorasher	804	36	23	50.7	44	14	47.9	5	Tahsin M. Muhamed	M	40 y (15 y)	P.S.C.	2.5 ha	2
		Gorasher	765	36	24	14.3	44	13	31.9	3	Sabir Hasan	M	60 y (25 y)	Worker	0.07 ha	2
		Gorasher	766	36	23	44.3	44	14	19.6	2	Anwar A. Hasan	M	38 y (3 y)	Worker	0.25 ha	2

Appendix 3 - Continued

	Jorash	770	36	23	58.2	44	13	51.3	2	Shadan Ali	M	61 y (10 y)	Worker	0.08 ha	2
	Birezh	779	36	23	36.1	44	14	41.4	3	Abu zeid A. Hasan	M	64 y (42 y)	Worker	0.09 ha	2
	Gorasher	794	36	23	32	44	14	53.5	4	Ibrahim A. Rahman	M	35 y (28 y)	P.S.C.	0.38 ha	2
	Gorasher	785	36	23	35.8	44	14	44.9	5	Luqman Gazu	M	68 y (4 y)	Worker	0.25 ha	2
	Mawan	754	36	24	8	44	13	38.3	2	Dilshad I. Amin	M	38 y (30 y)	P.S.C.	0.25 ha	2
	Gorasher	795	36	23	29.3	44	14	55.6	4	Qarani Rahman	M	65 y (32 y)	Forest mentor	0.75 ha	2
Shaqlawa	Akuban	1,011	36	20	40.8	44	24	33.5	4	Kamil Saleh	M	53 y (18 y)	Worker	0.5 ha	2
	Punjinah	1,049	36	19	42.2	44	25	29.1	5	Hakim A. Uzer	M	46 y (12 y)	Worker	1.5 ha	2
	Punjinah	1,031	36	19	37	44	25	52.5	1	Ziad A. Hasan	M	46 y (15 y)	Worker	4.25 ha	2
	Punjinah	1,051	36	19	37.7	44	25	39.8	3	Sami J. Majid	M	40 y (24 y)	Worker	0.5 ha	2
	Punjinah	1,026	36	19	36.1	44	25	52.8	2	Darbaz K. Hamad	M	35 y (17 y)	P.S.C.	0.15 ha	2
	Punjinah	1,003	36	19	36.3	44	25	54.2	1	Ali H. Mustafa	M	62 y (7 y)	Worker	0.1 ha	2
	Dawra	1,001	36	17	26.7	44	28	48	2	Ahmad Muhamed	M	37 y (27 y)	Worker	0.4 ha	2

Latitude & Longitude (Coordinate System); D°: Angle; M´: Minute; S´´: Second. Gender; M: Male; F: Female. Education; P.S.C: Primary School Certificate; H.S.C.: High School Certificate. MSc.: Master's degree; Financial condition: 1=best, 2=average, and 3=worst. Note: Nationality of all the farmers were Kurdish. Socio-economic status: self-evaluation questionnaire for all the farmers in both lowland vs. highland.

Appendix 4 – Average salience index (%) of tree species in the lowland farms.

English name	Lowland																																					Ave (%)
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28	F29	F30	F31	F32	F33	F34	F35	F36	F37	F38	
Olive	100	100	100	100	100	100	100	100	100	100	100	100	100	100		100	100		27	100		65	100		85	100	100	100	100		57	100	100	100	65	100	100	100	**94**
Pomegranate	60	74	86		74	90	83	50	86			75	67	75	100	67		100	91	83	89	94		100	92	70	82	50	67	100	86		90	94	78	91	89	78	**82**
Fig	70	87	57		87	80	92	37				67	83	50	80			78	82	67	45	82		83	77		91	70	93	83	71		70		86	82	79	89	**76**
Apricot					50		59	74			80	92		92				89	36		78	76				80	55	90	80				88		64	58	67	**73**
Grape	80	62	29		62	50	67	62	71	86	40	42	34	67			67	67		100	100		67	100	90	64	80	41		100		80	82	72	73	95	45	**69**
Peach												83		83				56	73		67	88			62	60	73		47				50	76		55	84	33	**66**
Pear	90					60	75	87		43									55		56	59			69	50		60	74	67				93		52		**66**
Mulberry (black)																									46								60	65	50		74		**59**
Orange																			100			71			54				54					71	57	36	68	11	**58**
Loquat								25											64			41							87				30	59	100		36		**55**
Almond										71																				34		67					42	56	**54**
Prune																						53																	**53**
Pistachio															60											40													**50**
Plum																		45															40				63		**49**
Mulberry (white)	50				37	70			57	57		50	50	59				33		50	33	35		50	38	30	36	40	60	50	28					45			**46**
Grapefruit																																		36					**36**
Lime																													27					43					**35**
Apple																			9			47					45		34										**34**
Poplar (black)						30						34															27							47		27	31		**33**
Date palm																								34	31														**33**
Walnut																			18										14					52	29		47		**32**
Pine	20	37				40	50		14		20	25		34																				23					**29**
Chinaberry	30					20	42					42						22			11	17	50											35		18			**29**
Eucalyptus	40	50	71	50	25	10	25	13	43	29	60	17	17	17	40	33	33	11	45	17	22	29	75	17	23	10	9	10	7	17	43	33	10	6			5	22	**27**
Heaven tree																																					26		**26**
Cypress (pyramadilis)	10	25												42									25																**26**
Horsetail														25								23																	**24**
Locust																																		22					**22**
Fan palm		13	43				8																					20						29			15		**21**
Weeping willow																																					21		**21**
Cypress (horizantalis)			14		13		34		29	14		8		8	20					34		12			15	20	18	30	21				20	41					**21**
Persimmon							17																																**17**
Ash																																		17					**17**
Albizzia																															14								**14**
Chaste tree																																		12					**12**
Bottle brush																						6			8										15	9			**10**
Cypress (leyland)																																			7		10		**9**

Appendix 5 – Average salience index (%) of tree species in the highland farms.

English name	Highland																							Ave. (%)
	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	
Pomegranate	100	91	93	83	100	100	100	100	100	100	91	87	73	100	75	100		100	100	100		100	100	100	**95**
Apple		100	100	100	25	64	67	90	83	86	100		55		59	86	95				36			92	**77**
Fig	71	82	79		62	82	78	80		71	73	50	82	89	83	57	84	37	77	94	82	69	22	67	**71**
Olive				50								100	27	78			100								**71**
Grape	43	64	86		87	73	89	70		43	36	37	64		25		89	74	92		100	92	78	83	**70**
Apricot	86	45	36		74		45	60	67	57	82	62	100	22	100		63		69	82	64	85	67	59	**66**
Orange						55			50							71	74								**63**
Mulberry (black)														56	42		79								**59**
Cherry			72	17		36														88		62		75	**58**
Walnut	28	55	57	67		91	56	30		14	55				50		52	87	38	76			89	34	**55**
Peach	57	73	65	34			33	50		28	64	74	91		92	14	68	13	54	23	73	77	56		**55**
Pear		9	50			45		40			45			67	34	86			62	65	91			8	**50**
Almond													18				47	62	85	71		15			**50**
Oak (brantii)																			46	47	45	46	45		**46**
Oak (infectoria)																				59	55	23			**46**
Persimmon			43														42			12		54			**38**
Plum		36	22			27							45		67	28									**38**
Hawthorn																				35		38			**37**
Ash																	36								**36**
Mulberry (white)	14	18	7			18					27		63					50	31	52	9		33	50	**31**
Loquat			29											33	17		58				18				**31**
Pear (Syrian)																						31			**31**
Lime									34			25													**30**
Pistachio (stocks)																				29					**29**
Pistachio													9							41	27				**26**
Sycamore																								25	**25**
Willow (white)					37		22	20			18			22										17	**23**
Poplar (black)		27	15		50	9	11	10			9						31	25	8	17				42	**21**
Sumac																			23				11		**17**
Chinaberry																			15						**15**
Pine					13				17								10								**13**
Eucalyptus												13		11	8		5								**9**
Locust																						8			**8**
Cypress (pyramidalis)																				6					**6**

Appendix 4 & 5: F = Farm. Ave. (%) = Average percentage. The percentage numbers for each cell represented salience index (%) for each species, cells' values from 1% to 100%.

Appendix 6 – Photos of preferred species in both regions

Author's personal photo documentation 2017

Olive mature trees in systematic planting (7 × 5) m distance between trees, with drip irrigation system (common species in lowland)

Olive (young tree)

Alley cropping: crops and vegetables intercropping with olive trees

Olive fruits and leaves

Olive flowers (google.com)

Pomegranate (mature tree) common species in highland

Pomegranate (mature fruits and leaves) + flower (google.com)

Pomegranate planting (cuttings)

Pomegranate in row planting 2.5 m distance between trees with drip irrigation system

Pomegranate (immature fruits)

Fig (mature tree) more preferred in highland with drip system irrigation

Fig (mature fruits)

Fig leaves

Fig in row planting 5 m distance between trees

Fig young tree (seedling)

Apple (mature tree) very common species in highland

Apple fruit and leaves

Apple flowers (google.com)

Apple, mixed planting in the farm with other fruit species such as peach, pear, and apricot

Apple fruits collected and ready for transport to markets for selling

Apricot trees row planting 6 - 7 m, with drip irrigation system, more preferred in highland

Apricot flowers (google.com)

Apricot, branch drooping fruits (google.com)

Apricot leaves

Apricot fresh fruits


Grape drooping fruits, mature woody species, common species in lowland

Grape vineyard plantation

Grape row plantation with drip irrigation

Grape flowers (google.com)

Eucalyptus (mature tree) very common species in lowland (used as windbreaks and shading)

Eucalyptus leaves and capsules

Eucalyptus flowers (google.com)

Eucalyptus home garden planting for shading other species such as fig

Appendix 7 – Photo gallery of agricultural systems

Agroforestry, Eucalyptus as boundary trees with pomegranate and plantation

Crop plantation in open fields and vegetable plantations in greenhouses

Plantation tree species in rows arrangement

Mixed plantation of tree species in highland

Forest farming in highland on slopes, oak and almond (wild species) with crops and vegetables

Agroforestry: orchard olive plantation in lowland surrounding by eucalyptus and cypress

Agroforestry (Agrosilvopastoral system)
Trees + Crops + Animals (pasture)

Goose breeding in the farm (additional profits)

Loquat trees in 5 m row planting in the farm

Livestock (cows, sheep, and goats) in the farm

Silvoarable system (Eucalyptus and olive)
Trees plantation

Cucumber plantation in open field with drip irrigation system