Chapter 2
The Wadi Al-Arab

The research area Wadi Al-Arab is located in northern Jordan on the border of Syria and Israel, extending from E 747000 to E 770000 and N 3596000 to N 3618000 (UTM, WGS84, zone 36N) and covering an area of approximately 263.5 km². In the north, the catchment is confined by the Yarmouk river, to the south the Ajloun mountains, to the east by Wadi Shellal, and the Jordan River to the west (Fig. 2.1).

The catchment was chosen for the following reasons:

- It is similar to many in the Lower Jordan Valley and thus exemplary for the region. It descends from the Jordan Valley Escarpment down to the Jordan River. The elevation ranges from more than 500 m in the east to around −164 m a.s.l. at the Wadi Al-Arab dam.
- It has an appropriate size of 263 km², small enough to get to know most of the area in three years of research, and of a suitable size to evaluate the human impact on erosion while covering major land use units (personal communication Prof. Dr. Faust, EGU, 2013).
- The Wadi Al-Arab is originally a tributary to the Jordan River that is dammed before reaching the valley. The reservoir is one of the oldest in Jordan and has functioned as a final sink for the transported sediments since it came into operation in 1986. This is a great advantage for total sediment volume calculations and the sediments in the reservoir have served as a sediment archive since completion.
- To the east the catchment shows an agricultural basin. From here to the north, northwest, and southwest the relief energy increases until the Wadi Al-Arab reservoir. Its elevation ranges from more than 500 m a.s.l. in the east to around −164 m a.s.l. at the Wadi Al-Arab dam. Different land uses such as wheat and vegetable fields, tree orchards (olives, almonds), and grazing areas reflect the commonly distributed agricultural possibilities of Jordan.
- The City of Irbid is situated in the east as the third biggest agglomeration in Jordan with around 300,000 inhabitants. This has the advantages that the catchment is not only a pristine natural catchment scarcely inhabited but reflects
the population pressure, agricultural use, street density etc. that is characteristic of many areas along the Jordan River. Last but not least, field installations, special craftsmen, and workshops as well as extraordinary procurements demanded the possibility of a bigger city nearby.

The following section give a more detailed insight into its climate, geology, geomorphology, soil as well as vegetation, and land use.

2.1 Climate in Wadi Al-Arab

The climate in Wadi Al-Arab is classified as BSh-Csa climate according to the updated world Köppen-Geiger Classification (Peel et al. 2007). BSh describes a steppe climate where precipitation is below the potential evapotranspiration, average temperature above 18 °C, and the coldest month above 0 °C. Whilst Csa
characterizes a Mediterranean climate with average temperatures above 10 °C, dry summers and the warmest month are above 22 °C.

Rain only occurs between September and May, resulting in an average yearly rainfall of about 495 mm in the south, to around 390 mm in the west (MWI data 2007; Fig. 2.2). Potential evapotranspiration is low in the SE with 1312.75 mm year\(^{-1}\) and rises to 1425.44 mm year\(^{-1}\) in the NW of the catchment. The resulting aridity index (P/PET; UNEP 1992) describes the catchment with values between 0.27 and 0.35 as semi-arid.

Figure 2.3 indicates that between 1990 and 2007, the first decade (1990–1999) had on average higher rainfall compared to the years 2000–2007. A high inter-annual variability of the rainfall distributions is visible over the years. Stronger rain events were reported and are documented by the rain stations for the years 1992, 1997, and 2003. Besides the usual yearly flash floods, these events showed an enormous erosive potential as reported by farmers in the region.

The analysis of daily rainfall data and discharge volume allowed the calculation of a runoff coefficient. Most pronounced rainfall events show a runoff coefficient below 10 %, similar to those found by Gómez et al. (2009) in southern Spain (12 %).

Pronounced events or when several days of rain occur in a row, values of up to 30 % are possible (1992, 1996, 1997, 1998, 2003; Fig. 2.3). As most rain events lead to minimal discharge the average is 1.6 %.
Eltaif et al. (2010) estimate the kinetic energy of rainfall events in northern Jordan using the RUSLE (Renard et al. 1997) between 200 and 400 MJ mm ha\(^{-1}\) h\(^{-1}\) year\(^{-1}\) and conclude that the values are low compared to humid areas. However, other factors such as the sparse or missing vegetation cover and soil layer reduce the retention potential in the catchment and lead, together with pronounced rainfall events of high intensities, to torrential runoff events known as flash floods. These short-term peak discharges are characteristic of the region and result in a high erosive impact on slopes and as well as in the riverbed, again augmenting erosion following the cause-effect principle (Zielhofer and Faust 2002; Eltaif et al. 2010).

### 2.2 Geology of Wadi Al-Arab

This chapter will first give a brief introduction to the geological history and the genetic environment of the dominant geological units in the catchment, and then it will focus on north Jordan. For more detailed information on the geological genesis of the region please refer to Bender (1968), Horowitz (2001), and others.

#### 2.2.1 Brief Geological History of the Middle East

In the Precambrian, during the Pan African Orogenesis, the region today known as the Middle East was formed as a stable continental margin (Siebert 2005). In the
following pre-Neogene the region was situated in the periphery of the continental shelf and continuously “shaped and controlled by the struggle between the Arab Nubian Massif to the south and the Tethys Ocean to the north” (Flexer 2001). The marine trans- and regression of the Tethys-Ocean and the Arab Nubian Massif as “stable nucleus” dictated the geological evolution of the surrounding areas with the accumulation of shallow marine sediments and the delivery of terrestrial sediments (Flexer 2001; Moh’d 2000). Up until the Cretaceous, a gradual uplifting of the region occurred together with strong formative tectonic phases.

The arching of the Arab Nubian Massif from the Eocene onwards steadily led to the spreading of the region today known as the Red Sea and the Gulf of Aden. Contemporaneously the plate boundaries between the Sinai and the Arabian plate and the Dead Sea—Jordan Rift System developed (Siebert 2005).

Fig. 2.4 Plate tectonics in the Middle East (Horowitz 2001; http://iv-g.livejournal.com/295425.html)
The Middle East has been situated at this conjunction zone of the African, Arabian, and Anatolian plates, respectively, leading to ongoing tectonic processes in the region. Consequently, the region has always been affected by varying stress fields including spreading, divergence, and shearing along the Red Sea, the Cyprian Arc and the Taurus mountain range and the Dead Sea-Jordan Rift Valley, respectively (Fig. 2.4; Flexer 2001).

2.2.2 Environmental Conditions for the Geology in Wadi Al-Arab

Putting the focus on NW Jordan, Wadi Al-Arab as part of the “Ajloun plateau” developed during the Upper Cretaceous, when Jordan was covered by the Tethys Ocean. The sedimentation environment was dominated by shallow tidal-lagoonal conditions, which were interrupted by several transgressions between Santonian and the Late Eocene, leaving shallow to moderately pelagic chalks (Amman Silicified Limestone/Al Hisa Phosphorites, Muwaqqar Chalk Marl and Umm Rijam Chert; Appendix 2). This period was followed by the regression of the Tethys until the Oligo-/Miocene forming a limestone unit and the final regression in the Pliocene allowing lacustrine sedimentation (Waqqas Conglomerate). The more recent geological history is marked by volcanic activities leaving sheets of basaltic lava from about 5.1 Ma (Moh’d 2000).

Due to the development of the Jordan-Dead Sea Rift system at the end of the Oligocene/early Miocene and the following subsidence of the Jordan Valley, Wadi Al-Arab incised deeply into the Ajloun plateau. As a result of the regional structural history, the formations of the Ajloun Plateau including those of Wadi Al Arab are dipping north westwards, leaving the oldest rocks exposed in the SE and the youngest in the NW (Siebert et al. 2014). Various faults mainly aligning from NE to SW are present in the catchment and provide proof of the ongoing tectonic movements (Moh’d 2000).

Figure 2.5 depicts the main geological units in the catchment, which start with the oldest Amman Silicified Limestone/Al Hisa Phosphorite (ASL/AHP), Muwaqqar Chalk Marl (MCM) and Umm Rijam Chert Limestone (URC). These units derived from a marine environment and are characterised by calcareous depositions as limestone, dolomite, marl, and chalk of the Upper Cretaceous and the Tertiary interrupted by chert facies and siliclastics (Moh’d 2000). Especially the Al Hisa Phosphorites, which make up the 8–10 m of phosphoric rock between the ASL and MCM, have a high content of Uranium, ranking Jordan number 11 on the international scale of uranium deposits with locally up to 800 ppm Uranium (Bossone et al. 2013; Moh’d and Powell 2010). The genesis of that stratum is under debate, ranging from authigenic precipitation from seawater to synsedimentary phosphatization as a diagenetic or microbial process (Abed et al. 1989; Abed and Fakhouri 1990; Al-Sharhan and Naim 1997).
An xrd analysis of the minerals conducted by Prof. Pöhlmann from the University of Halle in 2012 also indicated terrestrial input like quartz into the MCM geology, which in a shallow lagoon could be of synsedimentary as well as subsequent aeolian input (own analysis; Al-Sharhan et al. 1997).

![Geological Units](image)

**Fig. 2.5** Wadi Al-Arab geological map (MWI data 2010; Projection: UTM, WGS84, zone 36N)
It becomes visible in Fig. 2.5 that the main Wadi and its tributaries (= ephemeral streams) have cut their way through to the ASL/AHP unit and older rocks. These units are part of the A7/B2 aquifer (Appendix 2) which is the major aquifer of the region and highly fractured and karstified. It is overlain by the bituminous MCM aquitard (B3) and the locally productive URC aquifer B4 (Rödiger et al. 2014; Siebert et al. 2014). Due to the NW-wards dip of the plateau, groundwater drainage follows this direction to the Yarmouk gorge in the north.

2.3 Geomorphological Features of the Wadi Al-Arab

The catchment displays a more or less coherent plateau with rolling hills and agricultural plains in the east. To the west and south, the relief energy is higher and agricultural areas are limited to top, saddle and footslope positions. The drainage network is assumed to be mainly controlled by faults, grabens, and lithological contact zones as it corresponds to the main fault direction (NE to SW) in the catchment. The Wadi itself is a V-shaped valley with steep flanks. The majority of the Wadi bed is only 1–3 m wide and eroded down to the basement rock leaving only shallow (<0.2 m) sediments in areas where a slight meandering is possible and small areas of point bars and cut banks can be defined. On the last 7.5 km of the stream bed, the Wadi opens up to a width of 12 m and big paleo-terraces of up to 6 m in height are present and are used agriculturally (Sect. 6.7, Fig. 6.9).

The Wadi Al-Arab is exclusively made up of carbonatic bedrock and, throughout the landscape, shows typical geomorphological features that are connected with a karstic environment such as grykes, sinkholes, uvalas, and lost rivers (Strahler and Strahler 2009). The slopes of the MCM geological unit show exposed consolidated limestone with patches of red Mediterranean soil and vegetation on the top and shoulder positions. Downhill, the MCM is present as unconsolidated marly substrate constituting steep slopes (>5–6°; Fig. 2.6).

Reasons for these differences in hardness of the same geological unit could be facies differences, as well as the hardening of the marly geology due to exposure and bio-chemical processes like crusting or cementation (personal communication Prof. Dr. Bandel, 2011). Another possible theory is adapted from the description of the “Nari” crusts in Israel (Singer 2007). These carbonatic hard layers result either from the precipitation of CaCO3 from capillary waters in the rock lifted by evaporation or are the result of the leaching of carbonates in relic soils. The carbonates accumulate deeper in the soil profile or directly above the bedrock, building a cemented layer. When the soil erodes, the cemented bedrock becomes exposed (Singer 2007). During the study the genesis of these differences in the same geological unit could not be clarified finally. The ASL unit in the east also shows hard limestone in top positions with soil patches.
On the slopes the silicified limestone leads to a more terraced morphology with a high stone content in the soil layer as seen in Fig. 2.7. A visible characteristic throughout the Wadi Al-Arab as well as in other Mediterranean regions such as reported by Kirkby et al. (1990), Cerdà (1998) and Bochet and García-Fayos (2004) is the phenotypical difference of south and north exposed slopes (Fig. 2.8).

South-facing slopes especially on marly geology contrast visibly in the density of the vegetation cover as well as the thickness of the soil layer (Sect. 2.4). Cerdà (1998) proved that for bare soils on south-facing slopes, higher bulk density values, less soil depth, and crusting are responsible for enhanced runoff and erosion processes and, for Spain, reports higher erosion than on south-facing slopes. This is due to the insufficient protective vegetation cover and hence, less organic content in the top soil layer (first 2 cm; Cerdà 1998; Bochet and García-Fayos 2004). The different erosion features and forms are described throughout Chap. 3.
2.4 Soils in Wadi Al-Arab

Many monographies have been written on the subject of Mediterranean soils and especially on red Mediterranean soils and their theory of genesis (Federoff and Courty 2013). This chapter will give a brief overview of pedogenetic processes and soil types according to the IUSS Working Group WRB (2007) that are relevant in Wadi Al-Arab and Jordan’s soil mapping efforts and field observations in the research area. The aim is to provide a general overview of the pedological processes and common soil types in the research area and should be in no case judged as an attempt for a holistic overview on the subject of soils in the Mediterranean area, genesis theories or a refurbishment of the nomenclature. Thus, this chapter will focus on the IUSS Working Group WRB (2007) soil type labels because these are internationally acknowledged.

2.4.1 Mediterranean Soils and Typical Pedogenetic Processes

Wadi Al-Arab shows the characteristics of a Mediterranean region as described by Yaalon (1997) with winter rains, carbonatic bedrock material, and a relief of rolling hills with steep slopes. The winter months are more important for the soil development than the longer dry season because of the excess rain. In summer the soils and vegetation dry out (Yaalon 1997). These conditions favour certain pedological processes which lead to the typical standard winter rain Mediterranean catena with chromic Cambi-/Luvi- or Vertisols in geomorphological stable positions as plateaus, saddle, footslopes, and terraces on carbonatic bedrock. Less geomorphological stable positions on slopes are characterised by shallow or initial soil horizons above consolidated or unconsolidated marly carbonatic bedrock material, classified as Lepto- or Regosols, with a high stone content.
Lepto- or Regosols are described on slopes for coastal sand dunes by Zech and Hintermeier-Erhard (2002, Fig. 2.9), but are also reported for the region to be extensive in eroding land (IUSS Working Group WRB 2007; Verheye and de la Rosa 2009).

The genesis of the chromic soils is strongly discussed in literature and three possible coexistent processes could contribute to the formation:

1. Solution weathering of the bedrock leaving the bedrock residue as soil matrix. The dissolution by meteoric water will eventually leach carbonates and other solubles from the soil matrix and cause the lowering of the pH, enhance the chemical weathering of the matrix leftovers to a very clayey substrate, and, finally, the migration of clay in the profile (Blume et al. 2002). In a more semi-arid climate carbonates might not be leached completely but precipitate in the lower parts of the profile as nodules, pores or ped coatings, or calcaric horizons (Yaalon 1997; Verheye and de la Rosa 2009).

2. Allochthonous dust inputs, often responsible for the secondary liming of the soil profiles (Federoff and Courty 2013; Yaalon 1997; Herrmann et al. 2010).

3. Isovolumetric replacement, where authigenic clay minerals grow in an over-saturated gel (Lucke et al. 2014).

The characteristic red color develops in hot and dry summers when the soil desiccates. Then iron oxyhydroxides released through weathering from the bedrock precipitate to red poorly crystalline ferrihydrates and fine-grained hematite, which coat the particles. This process, also known as rubification, can lead to very red
soils with a hue redder than 5YR and a chroma of above 5 (Yaalon 1997; Verheye and de la Rosa 2009).

High proportions of swellable clays in a soil can lead to peloturbation and cracking resulting in a constant internal turnover processes of the soil material and the respective micro relief structures as the gilgai relief and visible slickensides (=Vertisols; IUSS Working Group WRB 2007).

Often the clayey soils on common cretaceous marls contain a high sodium saturation which leads to the dispersion of aggregates (Faust and Schmidt 2009). Together with the long anthropogenic history of land use, deforestation, and vegetation cover removal, these changes strongly supported erosion processes resulting in eroded soil profiles up to the uncovering of the bedrock. Other land use changes affecting soil development include terracing and irrigation (Yaalon 1997; Verheye and de la Rosa 2009).

2.4.2 History of Soil Mapping in Jordan

Jordan was the first to object to soil mapping in 1950 using the US Soil Taxonomy and identifying 12 different soil groups on a regional scale of 1:1,000,000. For areas with an average precipitation of more than 250 mm/year, as is the case in Wadi Al-Arab, mostly Verti- and Cambisol soils were identified. However, structured mapping did not start before 1989 with an international team of experts resulting in 3 levels of land and soil mapping (Table 2.1; MoA 1993; Al-Qudah 2001). Wadi Al-Arab and the region around Irbid have been subject to Level 1 and partly Level 2 mapping. This resulted in a generalized soil map with 4 different soil groups following the FAO guideline from 1979 (Fig. 2.10).

The classification groups chosen are not suitable to make more detailed statements about the relationship between relief, geology, and soil development. But they do give a broad overview of soil types that can be found in the region with the tendency of vertic Cambi- and Vertisols in more geomorphological stable relief

<table>
<thead>
<tr>
<th>Level</th>
<th>Density of observation site</th>
<th>Materials used</th>
<th>Map scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1—General survey</td>
<td>7.6 km²</td>
<td>LANDSAT, aerial Photography, field observations</td>
<td>1:250,000</td>
</tr>
<tr>
<td>2—Areas suitable for agriculture</td>
<td>3.5 km²</td>
<td>Panchromatic SPOT imagery combined with LANDSAT thematic mapper</td>
<td>1:50,000</td>
</tr>
<tr>
<td>3—Priority areas</td>
<td>15 observation site km⁻²</td>
<td>Additional field surveys</td>
<td>1:10,000</td>
</tr>
</tbody>
</table>
as reported by Ziadat et al. (2010), Catenal studies relating topography to soil development have rarely been done in Jordan. In Wadi Al-Arab itself, Khresat et al. (1998) as well as Lucke (2007) analysed soil profiles on different source rocks but not with the intent of mapping the area on the basis of a topographic and hence, morphologic relation.
2.4.3 Soils in Wadi Al-Arab—Own Observations

The sediment transport model demanded a soil map with various parameters for the top and subsoil horizons of the different soil types. Therefore, 28 profiles along topo sequences in the major geological units ASL/AHP, MCM, URC, and basalt were recorded and analysed. Land units characteristic of the analysed soil types were defined using morphological indicators, exposition and land use. A detailed description of the setup of the soil map of Wadi Al-Arab is to be found in Sect. 6.4 and Appendix 6.

An exemplary Catena from the soil mapping campaign is given in Fig. 2.11 for a typical valley in the north of the catchment with MCM on the slopes and ASL/AHP in the Wadi bed. Chromic Vertisols and Luvisols with a depth of more than 2 m were observed on geomorphological stable positions or in colluvial depressions (own observations; Khresat et al. 1998). Deepest soils exist on the plateau area to the east of the catchment and on the basaltic plateau in the north west (own observations, Lucke 2007). The soil development on the slopes varies with the geological parent material and its hardness. On consolidated geology (URC, MCM and ASL) usually only brown soil patches are left (Leptosols). On marly MCM slopes either Cambi- or Regosols were indentified, mainly depending on the exposition and how advanced erosion processes have denudated the soil profile (Fig. 2.11). Recent Wadi deposits are classified as Regosols, old terraces as Fluvisols.

A general compilation of the main observed characteristic of the soil types for the three major geological units are listed in Table 2.2, whereas Muwaqqar Chalk Marl (MCM) and Umm Rijam Chert (URC) tend to show similar developments on
respective positions. None of the sediments examined show red colors of 5YR and a chroma >5 as often described for soils in the Mediterranean (Yaalon 1997). Low organic matter content in the A-horizons (<1%) were analysed. Intense biological perturbation of the first 10–20 cm of the profiles was visible in the field.

A basalt profile revealed a carbonated enriched (c4; AG Boden 2005) red loam with nearly no stone content (<3%) and a thick carbonatic layer above the underlying basalt rock. Together with the carbonatic nodules and pseudomicelia in the overlaying red-brown sediments, it indicates secondary carbonatization of aeolian character. However, in recent profiles at the Golan Heights, Jahn (1995) found only 2–5% of the soil originating from dust input, whereas a Paleosol from the same region showed 20–40% of clay minerals from aeolian input, postulating that this might be the case for the whole region.

In conclusion it can be stated that the general pedogenetic processes of the Mediterranean region listed in this Chapter are to be found in Wadi Al-Arab soils, too. Soil types vary more with the hardness of the geological bedrock particularly on slopes and the exposition of the slopes. Geomorphological stable positions are

<table>
<thead>
<tr>
<th>Position</th>
<th>Muwaqqar Chalk Marl and Umm Rijam Chert</th>
<th>Amman silicified limestone/Al Hisa Phosphorites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geomorphological stable position as plateaus, saddles, footslopes and terraces or soil patches on hard limestone slopes</td>
<td>Sediments with a more red color (5YR 3/4 to 7.5YR 2.5/4)</td>
<td>Sediments tend to be more brownish (10YR 4/3 to 7.5YR 4/4)</td>
</tr>
<tr>
<td></td>
<td>– Sediments are very clayey (around 45%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Cracks and signs of pedoturbation (incorporated calcareous stones from the top, slickenslides) are often visible throughout the profile</td>
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</tr>
<tr>
<td></td>
<td>– Argillic horizons occur sometimes together with the leaching of carbonates</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Sediments are mostly calcareous (c2-c4; AG Boden 2005), with visible nodules, calcareous horizons and pseudomicelia</td>
<td></td>
</tr>
<tr>
<td>Slopes</td>
<td>– On marly substrate hardly any visible differentiation between soil horizon and geology possible</td>
<td>– Shallow Ah horizon with 10YR 4/3 in color</td>
</tr>
<tr>
<td></td>
<td>– Light colors as 10YR 6/4 prevail</td>
<td>– Following horizons much yellower and extremely stony with a high silicified limestone content</td>
</tr>
<tr>
<td></td>
<td>– All sediments are carbonatic (c3-c4; AG Boden 2005)</td>
<td>– All sediments are carbonatic (c3-c4; AG Boden 2005)</td>
</tr>
<tr>
<td>Wadi bed</td>
<td>– Wadi beds are mostly eroded to the bedrock (ASL/AHP; Sect. 2.2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Old Wadi terraces show deep profiles with +6 m, an alternation between gravels and sands and a red soil color (7.5 4/4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Recent Wadi deposits consist of greyish sands</td>
<td></td>
</tr>
<tr>
<td></td>
<td>– Carbonatic (c4; AG Boden 2005)</td>
<td></td>
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</table>
characterized by red or dark brown sediments. All these observations pose many additional questions to the soil’s genesis, age, and environmental conditions at that time, which cannot be clarified here and are not the focus of this work. For further readings on the region please refer to Verheye (1973), Torrent (2004), Cordova et al. (2005), Lucke (2007), Lucke et al. (2014), and others.

2.5 Vegetation in Wadi Al-Arab

2.5.1 Potential Natural Vegetation of Northern Jordan

Wadi Al-Arab is bio climatically classified as Mediterranean to semi-arid following the “quotient pluviothemique of Emberger” (Al-Eisawi 1983; cited in Al-Eisawi 1996).

Covering the mountainous region of the Jordan Valley Escarpment, Al-Eisawis (1996) concludes that these characteristics support the most fertile soils and “best vegetation especially the forest climax” in Jordan (1996). Trees such as Aleppo Pine (Pinus halepensis), Palestinian Oak (Quercus calliprinus and the subspecies Q. coccifera), Valonia Oak (Q. ithaburensis), Carob tree (Ceratonia siliqua), and Pistacio (Pistacia spp.) are to be found (Lucke 2007; Al-Eisawi 1996).

The deciduous Valonian Oak forests and associated plants, like the Spiny Broom (Calycotome villosa) and the Persian Cyclamen (Cyclamen persicum), belong to the potential natural vegetation in the region (Al Eisawi 1996), which is still to be found mainly on top positions in soil patches on hard limestone and in areas of sparse density.

Dating back as early as the 2nd century AD the Romans prohibited lumbering, and today the government safeguards the trees through the introduction of rangers and penalties (personal communication Dr. H. Kirsch; BGR, Jordan Rangers, 2012).

2.5.2 Land Use in Wadi Al-Arab

From GLS 2010 Landsat ETM+ scenes Mallast (2011) generated a land use map for the Wadi Al-Arab showing the current most prominent landscape units (Fig. 2.12; Mallast 2011; modified Kraushaar 2012). These are by coverage percent bare soil/rock (34 %), olive orchards (27 %), areas with natural bush vegetation (=low Maquis; 11 %), agricultural fields and urban settlements each with 14 %. Trees and water together cover an area of around 0.4 %. Agricultural fields are mainly present in the Irbid basin west of the City of Irbid. In the mountainous regions NW of the catchment agricultural areas are limited to top, saddle, and footslope positions, as well as some terraces. Most of the agricultural land is reforested with rain-fed olive
trees (*olea europaea* cultivar *Nabali* or *Baladi*) of different age (personal communication with farmers, Fig. 2.12). Especially since the nineties the Government has supported olive cultivation and hence the orchards extend onto steep slopes throughout the catchment (Venot 2003; own data, 2012).

The typical most abundant landscape unit “bare soil/rock” features patchy vegetation (Fig. 2.13). Common flora found in these regions are the Spanish Nut (*Gynandriris sisyrinchium*), Common Asphodel (*Asphodelus aestivus*), Poppy
(Papaver Genus), many different species of the Asteraceae family like the Spring Groundsel (Senecio Vernalis), the Cornflower (Centaurea hyalolepis), Dwarf Chicory (cichorium pumillum), Globe-(Echinops Genus), Syrian-(Notobasis Syriaca) and Palestine-Thistles as well as the Common Fig (Ficus carica), which prefers to grow in cast holes or abandoned cisterns. Sage (Salvia Genus), Mallow (Malva spp. Malvaceae) and Zaarta (Origanum Syriacum) are just a few of the many edible plants that are regularly harvested by the people.

On more marly slopes with natural shrubs and grasses different exponents of the Brassicaceae family like Mustard (Brassica and Sinapis Genus) and Buckler Mustard (Biscutella didyma), the Common Horse Shoe Vetch (Hippocrepis unisiliquosa), Jerusalem Buttercup (Ranunculus millefollius), Squirting Cucumber (Ecballium elaterium), Caper (Capparis Genus), Dwarf Mesquite (Prosopis farcta), Colocynth (Citrullus colocynthis) and Thistles are to be found (Al-Sheikh and Kumamoto 2010; Maani 2008; MWI 2011).

Many areas show biota that refers to degradation as the Common Asphodel (Asphodelus aestivus, Fig. 2.13) as well as the Levantine Tortoise (Testudo graeca terrestris), which often can be found in the field (personal communication PD Dr. habil. Ollesch, 2011 and Dr. Badarneh, 2011). Al-Eisawi (1996) gives different reasons for this degradation connected to human activity like settlement, construction work, grazing of animals, and fires etc., which are impaired by Lucke’s findings (2007).

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