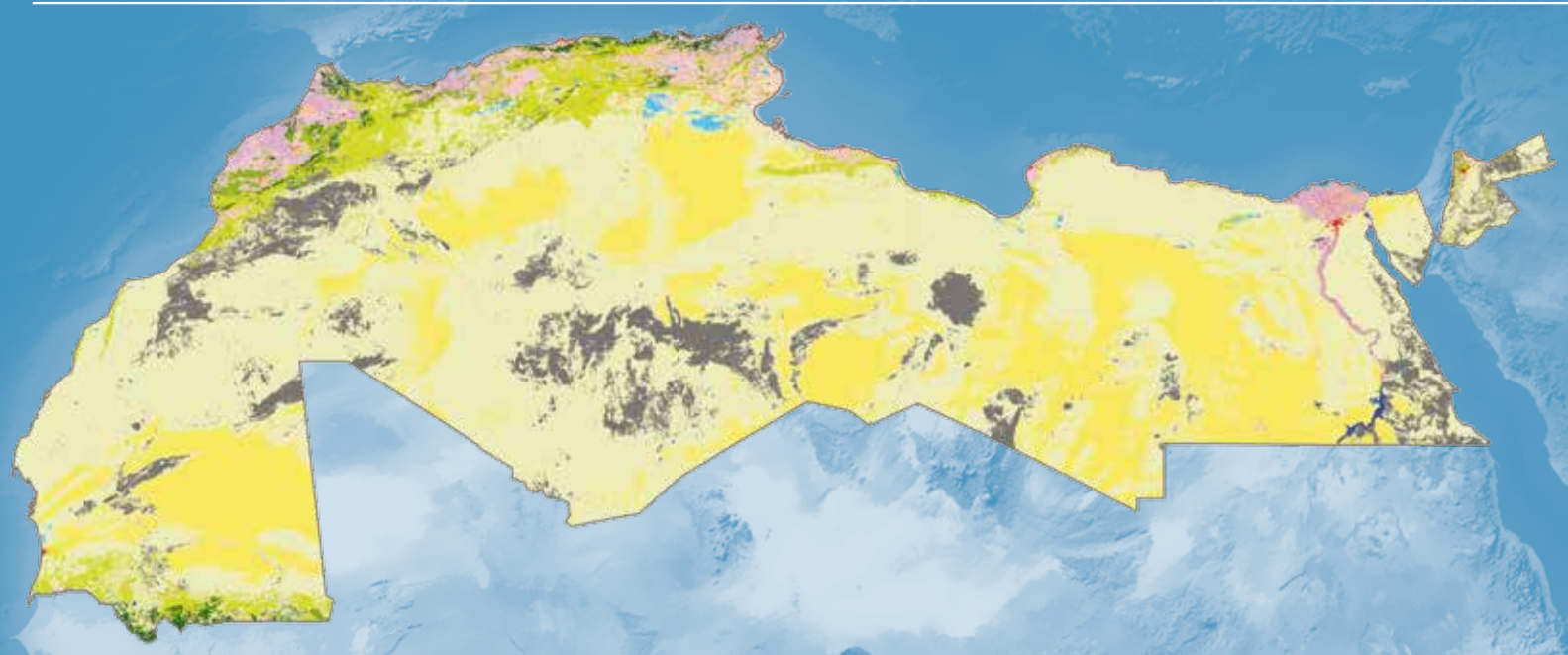
Observatoire du Sahara et du Sahel

ALGERIA, EGYPT, JORDAN, LIBYA, MAURITANIA, MOROCCO & TUNISIA

ATLAS OF LAND COVER MAPS



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WORLD BANK GROUP

SAHARA AND SAHEL OBSERVATORY

ALGERIA, EGYPT, JORDAN, LIBYA, MAURITANIA, MOROCCO AND TUNISIA

ATLAS OF LAND COVER MAPS

December 2017

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This atlas has been produced under the supervision of Mr Khatim KHERRAZ, OSS Executive Secretary, with Mr Nabil BEN KHATRA, Coordinator of the Environment Programme, as the publication manager.

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Cover: The cover illustrates the relation of both the natural vegetation zones and the agricultural lands with the desert ecosystems in the countries of the MENA region.

FOREWORD

Desert, arid and semi-arid zones cover a large part of the countries along the southern fringes of the Mediterranean. Despite their diversity, these countries have much in common, mainly climate and landscape that are rich in flora and wildlife, and include many ecosystems : oasis, desert, coastal, mountainous, insular and humid.

Anthropic factors have seriously jeopardized the ecosystems of the arid and desert zones of North Africa and the Middle East whose vulnerability to climate change and variability can cause a reduction in the arable lands and in the goods and services produced from these ecosystems. The ensuing increase in food insecurity and pressure on the sparse water resources could hold back economic growth, and exacerbate poverty, social inequality and conflict over the natural resources. This can lead to uncontrolled migration.

This situation requires urgent decisions and actions that must be based on knowledge supported by increasingly finetuned, reliable data. It is also important to strengthen cooperation between the national and regional institutions dealing with these issues, since this transboundary phenomenon knows no national borders or boundaries.

With this in mind, the Sahara and Sahel Observatory, through its MENA-DELP project: "Project on Coordination and Knowledge Sharing on Desert Ecosystems and Livelihoods", funded by the Global Environment Facility and implemented by the World Bank, strives to provide the stakeholders with mechanisms, methods and data needed to formulate effective sustainable development strategies for the desert zones by consolidating the bonds between the national or regional institutions involved.

This Atlas is meant to serve as a reference document that contributes to the efforts already being made to improve natural resources management in the seven countries it covers (Algeria, Egypt, Jordan, Libya, Mauritania, Morocco and Tunisia). It contains a host of information, derived from the Project's Monitoring & Evaluation mechanisms, that can facilitate the decision-making process.

It is intended for technical services, academics, national and regional organisations concerned with sustainable natural resources management as well as persons who are curious about the state of their environment.

We hope that this publication, the product of close collaboration between the many contributors, will fulfil a very simple yet very complicated function: to be of use.

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MONOGRAPH OF THE MIDDLE EAST - NORTH AFRICA REGION - MENA

GENERAL CONTEXT

Going beyond some similarities related to climate and a shared historical and socio-cultural heritage, the MENA (Middle East - North Africa) region has contrasting geographical characteristics in terms of spatial configuration, economic activity, land cover, institutional and legal issues, and natural resources.

The pre-Saharan and Saharan steppe in the MENA region is composed of rangelands, oases, more or less narrow valleys, and areas whose populations are attracted by the availability of water and subsistence farming.

In these lands there are:

- Mountains and canyons where nomads have settled in hamlets along the high valleys, engaging mainly in livestock production;
- Low valleys where the palm groves have more resources, thus allowing for storied tree cropping together with ground cultivation. The population, which is rather dense in these zones, occupies crowded roadside habitats that form semi-urban corridors over several kilometres;
- Semi-arid and arid spaces located along the edges of the Sahara, that are very spread out but whose meagre natural resources do not allow for significant agricultural activity.

These sets always had trade relations; sometimes they became conflictual, especially because of the need to share water and rangelands.

Social and economic development, improved living conditions, and growing needs encouraged the local populations to develop strong bonds based on complementarity since their strategic interests are increasingly intertwined. The development of the desert zones requires sound knowledge of how they function and interact with the rest of the territories.

The vitality of these zones is being seriously challenged by several factors such as anthropic pressures, land degradation, erosion, climate change,

Saharan landscape - Kabraoun - Libya

Flood irrigation in the Zaafrane oasis - Tunisia

drought, poorly planned urbanisation and other constraints due to land tenure. The combined effects of these factors are deteriorating the natural heritage and heightening the risk of compromising the future unless the parameters affecting their evolution are properly controlled.

Water scarcity and environmental fragility have always been factors that curtail the development of the desert regions. The imbalance between growing development needs and the means implemented in these regions constitutes a major challenge.

Aware of the importance of integrated supervision and support for the development of these areas, the public authorities in each country have carried out social equipment and basic services programmes. These programmes include hydro-agricultural and tourism components and development mechanisms that incorporate both the potentials and the constraints of the environment.

Geographically the MENA region reaches from Morocco to Iran, comprising all the countries of Middle East - North Africa (Figure 1).

The MENA-DELP project involves five countries in this area, namely: Algeria, Egypt, Jordan, Morocco and Tunisia.

The desert regions that characterise the region are vulnerable territories with special geographical, spatial, economic, social and environmental features. The climatic conditions, the scarcity of water resources, the complexity of the institutional and managerial systems are often a handicap to growth and development.

The economy of this region is based on subsistence farming, crafts and tourism. Other activities such as services, trade and agro-industry can be added to this economic gamut, but their development will be limited.

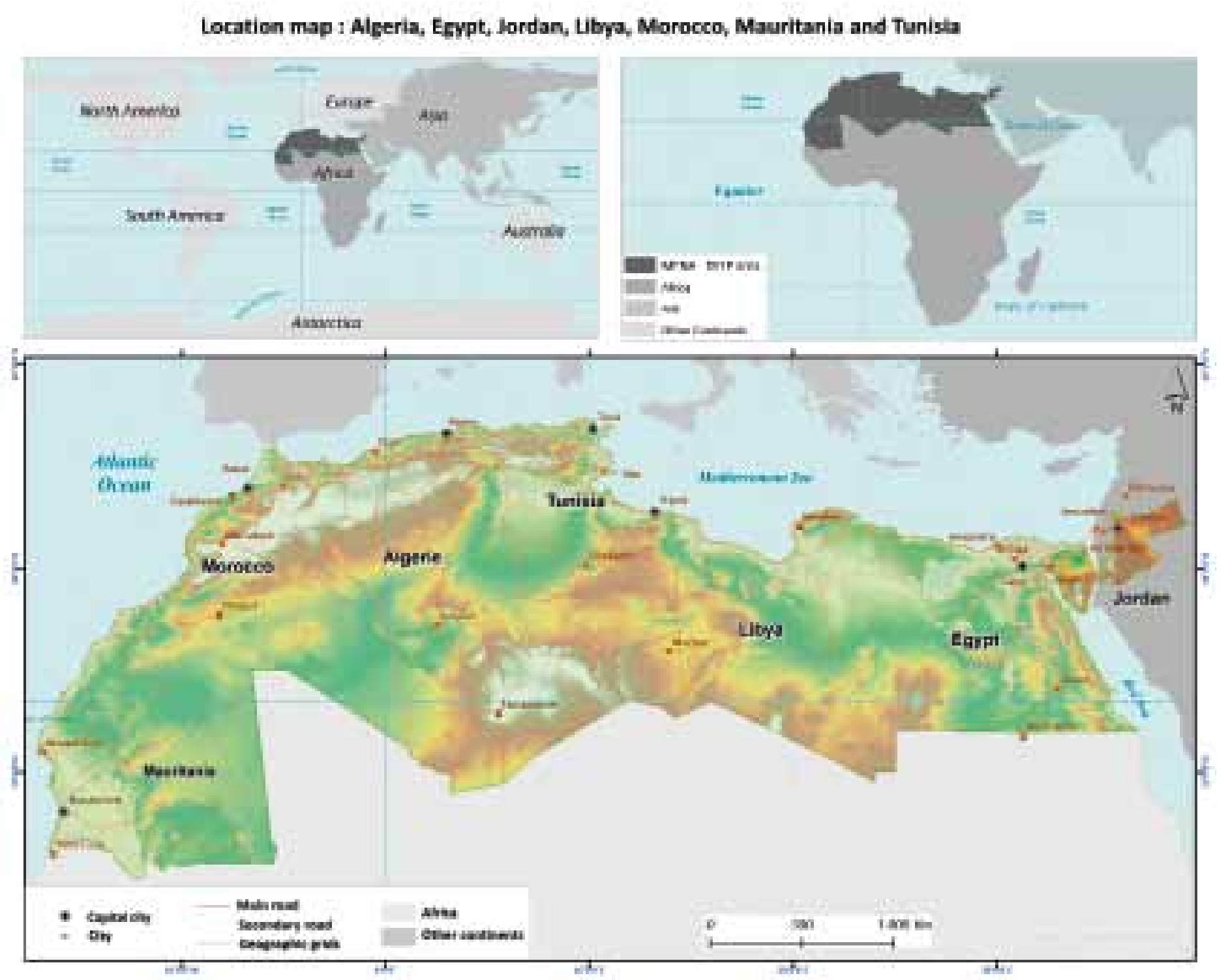


Figure 1. Map of the MENA zone (OSS, 2017) Source of data: Shuttle Radar Topography Mission (SRTM), NASA

This Atlas is being prepared as part of the MENA-DELP regional project, which has contributed to developing an understanding of the links between the ***ecosystem services*** and the ***livelihood of the people in the desert ecosystem***, in order to provide information for decision making, especially through:

- ✓ A better understanding of the links between the ecosystems and the livelihood in the desert zones, including the semi-arid and arid zones;
- ✓ An improvement of the knowledge sharing systems on issues connected to the desert ecosystems and livelihoods;
- ✓ An improvement of the information networks and flows at the national and international level for desert ecosystem programmes.

The identification of development potentials and prospects for the desert zones of Algeria, Egypt, Jordan, Morocco and Tunisia are part of the objective to ***transform the weaknesses of these spaces into development opportunities***. These elements, hitherto perceived as weaknesses or handicaps that hamper all prospects for progress, could become ***levers of dynamism.***

I. PHYSICAL AND BIOLOGICIAL CHARACTERISTICS OF THE ARID AND DESERT ECOSYSTEMS

1. PHYSICAL CHARACTERISTICS

1.1 Natural environment and relief

The desert regions in the study zone have specific topographical features, composed of mountains, plains, vast stretches of sand dunes, and immense high plateaus.

From Tobruk to Agadir, the zone has a *green maritime front* that runs close to 5000 km along the Mediterranean Sea. The coast gradually turns into desert land towards the south, on the Atlantic coast, which stretches over 2600 km, from Tangiers to the mouth of the Senegal River.

The area is dominated to the northwest by the Atlas mountain range that forms a barrier between the Mediterranean coast and the Sahara. To the south of the Atlas, 80% of the territory is desert. In the transition zone between the mountains and the desert, a coastal strip separates the mountains from the sea and provides most of the arable land.

Two of the biggest deserts in the world are in this region: the Sahara (4.6 million km², i.e., close to 10% of the African continent) and the Arabian Desert (2.3 million km²).

The Sahara covers most of Mauritania, Algeria and Libya and many regions of Morocco and Tunisia. It continues on to the east to Egypt and Sudan, and to the south to the semi-arid zones of the Sahel (Chad, Niger, Mali). Jordan, a mainly desert country, is composed essentially of a mountain region to the west and a dry desert plateau to the east.

The Sahara, the largest desert in the world, is composed of eroded sedimentary bedrock. Its relief includes basins interspersed with plateaux and a few isolated volcanic mountainous systems whose summits reach a maximum elevation of 3000 m (the Hoggar, in southern Algeria and the Tibesti straddling the Libyan-Chadian border).

Temperature differences and sand-laden winds have fashioned the Saharan landscape, dominated by regs, hostile barren flat lands covered with stone and gravel. One-fourth of the Saharan territory is covered with ergs (sand dunes).

The desert regions are located around Saharan spaces composed of wadis, mountain ranges and valleys interspersed with small oasis town along the roads.

1.2 Climate

The study area is characterised by the Mediterranean and desert climate.

The climate in this region reflects the influences of the Mediterranean Sea to the north, the Atlantic Ocean to the west, the Sahara in the centre-south and, to a lesser extent, the Sahel to the extreme south. Factoring in this variety of climatic influences, the overall climate can be described as follows:

The Mediterranean climate is characterised by a fresh, humid season in winter, due to the effect of subpolar dynamic depressions and a warm, dry season during summer caused by the subtropical dynamic anticyclone. The average maximum temperatures in summer are often slightly above 30°C while the average minimum temperatures are often around 5°C in winter, or even lower.
Average annual rainfall is between 400 and 800 mm per year, very unevenly distributed. The climate is more or less dry and sunny throughout the year. The gentle winters and the very hot summers make this climate a relatively hot one.

The ocean climate exists but is very rare. It is only found in the small narrow strip of land on the western coasts of Morocco and Mauritania. The climate is characterised by a cool, wet winter season and a gentle, rather dry summer season with heat and drought much less pronounced than in the Mediterranean climate.

The average maximum temperatures in summer is often slightly above 25°C while the average minimum temperatures in winter are often around 5°C. Average annual rainfall is above 800 mm in general. The climate is gentle, wet but sunny throughout the year.

Reliefs in the Petra region - Jordan

Desert landscape - Mauritania

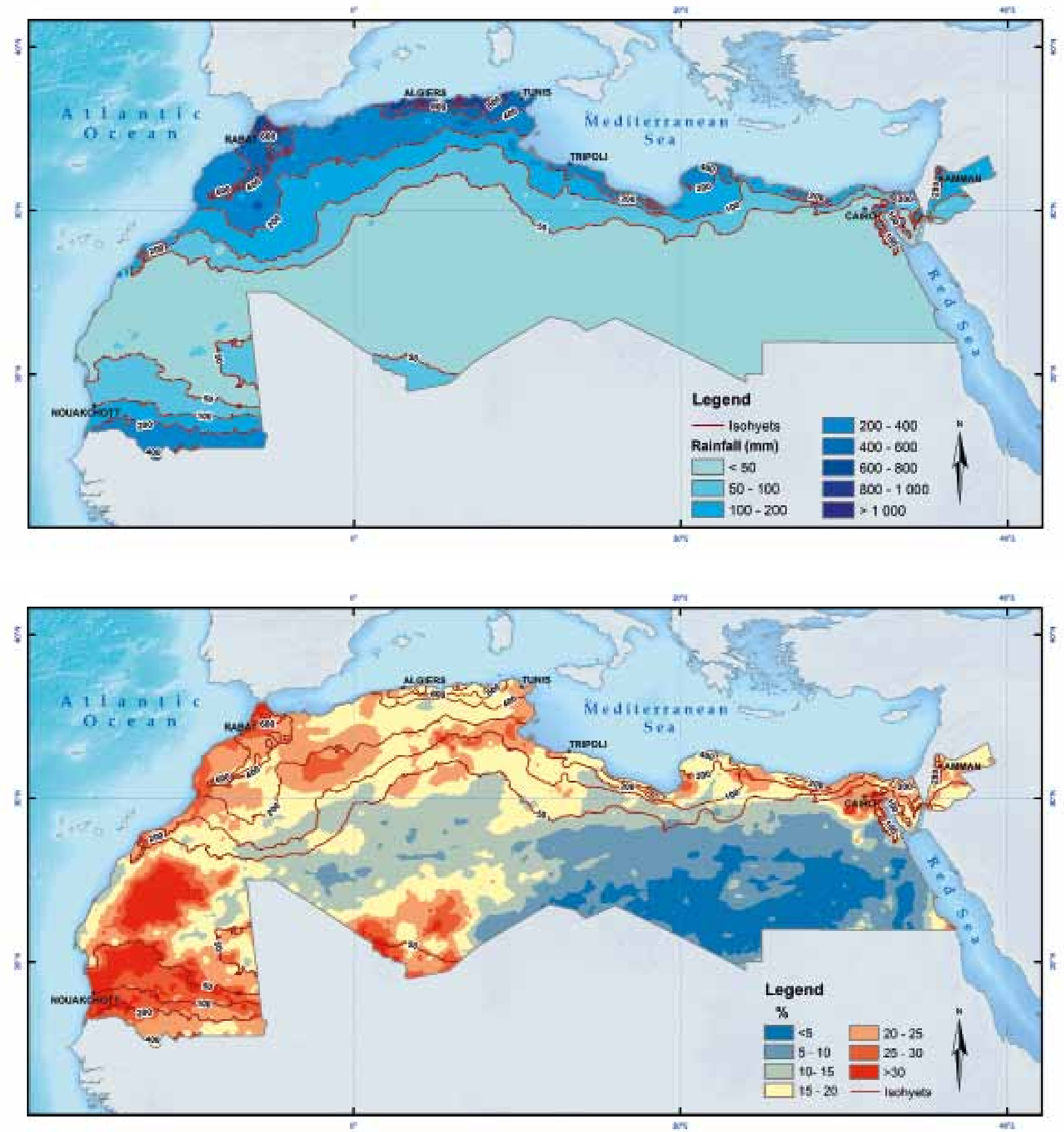


Figure 2. Annual average rainfall and annual variability in the MENA region, 1981-2016. (OSS 2017).
Source of data: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS)

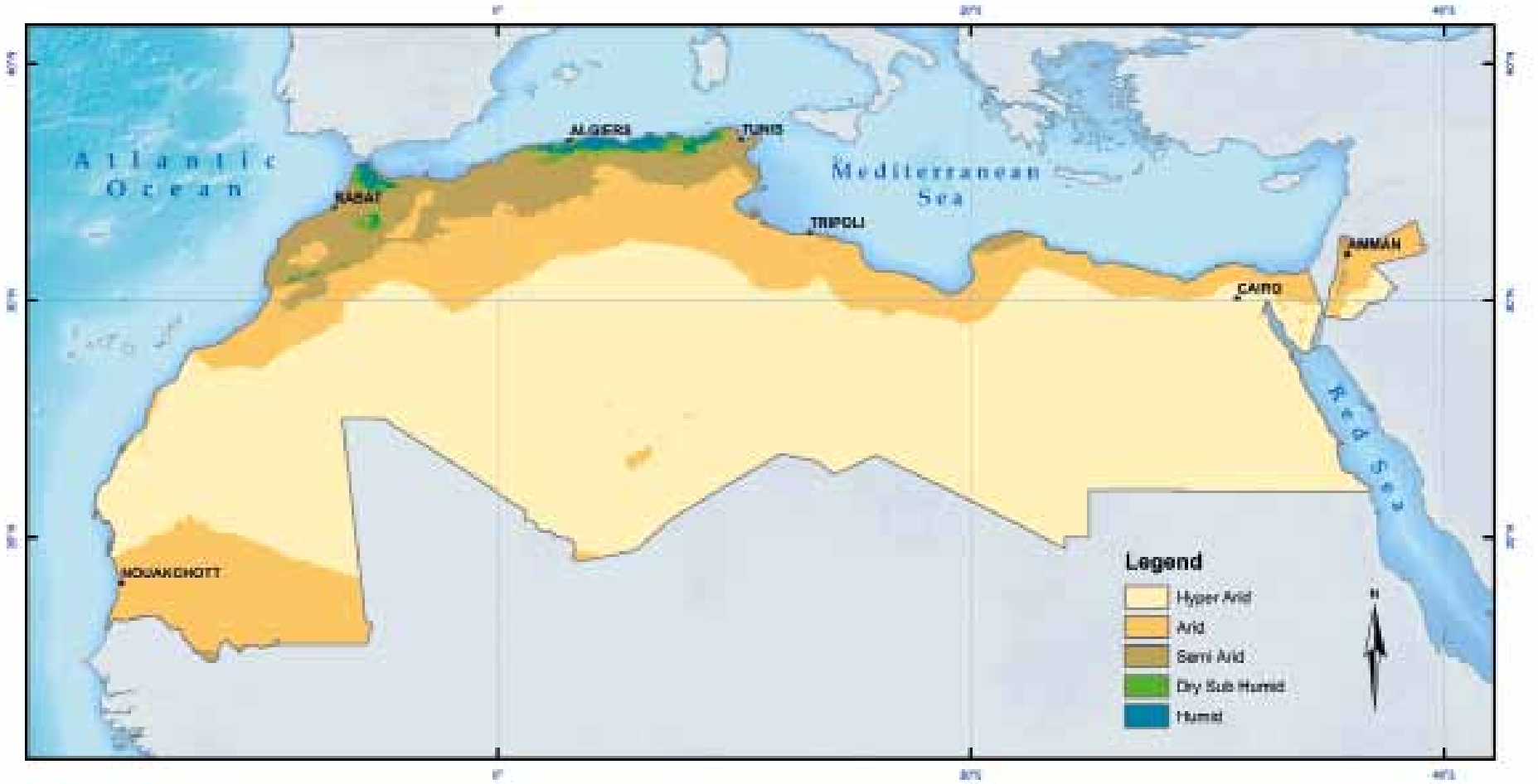


Figure 3. Aridity index (OSS 2017). Source of data: Consultative Group for International Agricultural Research (CGIAR)

The desert climate is the most common in the Sahara, the biggest desert of Africa and the biggest hot desert in the world. This climate is characterised by extreme aridity throughout the year and a lack of a clearly delineated rainy season.

This is due to the more or less permanent influence of the subtropical dynamic anticyclones and their continental trade winds (alizés), (northern and north-eastern winds).

The Sahara is a largely hyper-arid desert with average rainfall everywhere below 50 mm per annum. Only the most northerly and southerly fringes are arid. The gigantic hyperarid central area represents the part of the Sahara permanently under the most intense anticyclonic regime.

The most southerly part of the desert has the least dry regimes and receives up to 200 mm rainfall in its transition zone with the Sahel. The climate there is always very dry and hot.

The summers are stifling with average maximum temperatures above 40°C except in the high Saharan massifs (Hoggar, Tibesti, Aïr) where altitude lowers temperatures although, despite the topography, they can reach 48°C or even higher (up to 66°C in Ain-Salah, Algeria) in the hottest places.
Minimum temperatures can drop to under 4°C. The Sahara is an exceptionally sunny region throughout the year, whether in winter and summer.

While this zone is characterised by great climate variability, the aridity factor is common to all the countries covered in this atlas.

Arid environments are extremely diverse as a result of their landforms, soils, wildlife, flora, water balance, and their inhabitants' activities. Such diversity makes it impossible to provide a practical definition of the arid environments. However, one element that is common to all the arid regions is their aridity, usually expressed in terms of rainfall and temperature.

The aridity index can be used to define three types of arid zones: hyper-arid, arid, and semi-arid.

The hyper-arid zone (aridity index 0.03) covers the zone clear of vegetation except for a few scattered bushes. Nomadic pastoralism is frequently practiced in this zone. The annual rainfall is very low, seldom above 100 mm. It is rare and irregular, sometimes there is no rainfall at all for extended periods that can last several years.

The arid zone (aridity index 0.03-0.20) is characterised by pastoralism, but no agriculture other than in areas where irrigation is available. Indigenous vegetation is generally rare, composed of permanent, annual grasses and other herbaceous plants, bushes and small trees. Rainfall varies greatly with annual precipitation levels between 100 and 300 mm.

The semi-arid zone (aridity index 0.20-0.50) can support rainfed agriculture with more or less regular levels of production. Sedentary livestock production is sometimes practiced in this zone. The indigenous vegetation is composed of various species such as seed plants and grasses, forbs (non-graminaceous herbs), small bushes, shrubs and trees. Annual rainfall varies between 300-600 and 700-800 mm in the summer and between 200-250 and 450-500 mm in the winter.

1.3 Water resources

Water resources in the region depend on the climate and the geological structure of the ground. Their quality and quantity is subject to major spatial and temporal variability.

The hydrographic system in the region is not highly developed and is limited to the northern zones along the Mediterranean. Unlike the northern banks of the Mediterranean, the region does not have any sizeable permanent rivers other than the Nile. This information is essential when selecting adaptation strategies. Despite the above, the surface waters are still the major source of water for the region.

The region covered in this atlas is the world's most dry and most water-poor. This is increasingly affecting the social development of most of the countries. Approximately 0.7% of the available fresh water is found here.

At the worldwide level, the average amount of water available per person is close to 7000 m^3 /person/year, while in this region the figure is 1200 m^3/person/year. Half of the population living in these countries suffer from water stress. Moreover with population growth, the current population of about 300 million will rise to 500 million by 2050, with water availability per person expected to drop by 50%.

As concerns the mobilisation of the water resources, most of the countries have mobilised almost all of their available surface waters, and many of the big rivers no longer reach the sea. Some countries, like Egypt count mainly on the surface waters from the major international rivers while others, like Jordan and Libya depend almost entirely on groundwaters and desalinated waters. Others use a mixture of surface water and groundwater.

The region has six aquifer systems (Figure 4) including the following four:

- The Nubian Basin aquifer, a subterranean phreatic zone shared by Egypt, Libya, Sudan and Chad that covers 250,000 km^2. The aquifer receives a negligible amount of rainwater, about 2.9 mm/yr. in Tazebo to 1.3 mm/yr. in the Kufrah region. Based on this hypothesis, the quantity of water received cannot exceed a few million m^3 per year[1];

- The NorthWest Saharan Aquifer System (NWAS), a deep aquifer shared by Algeria, Libya and Tunisia, that covers more than 1 million km^2 of which 700,000 are in Algeria, 250,000 in Libya and close to 80,000 in Tunisia;

- The Disi aquifer in Jordan, where abstractions began in 2013, that will satisfy close to 25% of the water requirements of Jordan, one of the ten most arid countries in the world;

- The Senegalo-Mauritanian aquifer: a basin covering an estimated 180,000 km^2 with the arc des Mauritanides to the east, the Atlantic Ocean to the west, and the Senegal River to the south. This zone has over 4500 identified water points. The offtake in the year 2000 was estimated at 30 million m^3/yr.

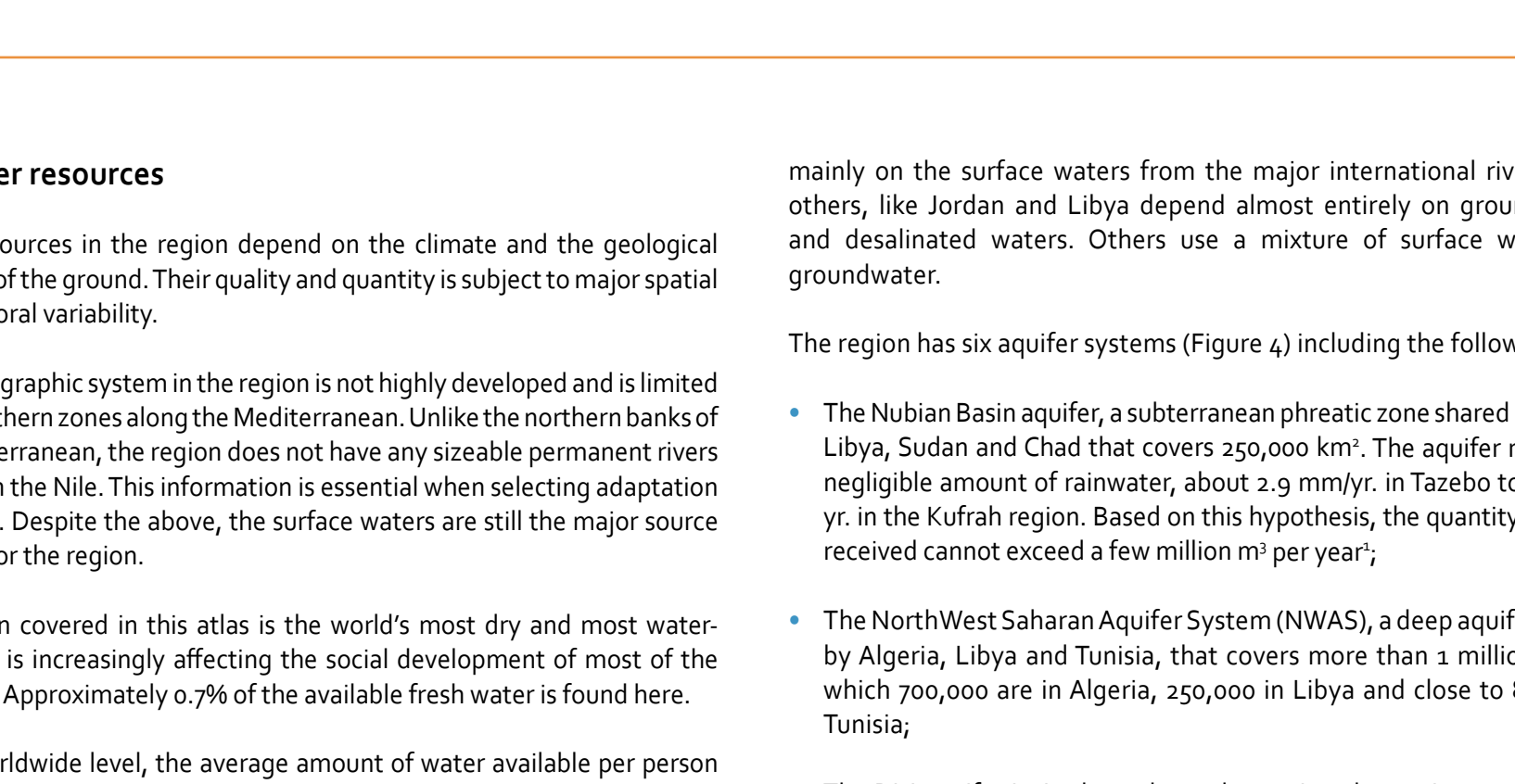


Figure 4. Groundwater resources (OSS 2017).
Source of data: World-wide Hydrogeological Mapping and Assessment Programme (BGR and UNESCO)

1 http://siteresources.worldbank.org/INTMNAREGTOPWATRES/Resources/Water_Sector_Brief--Fall2010.pdf

Water in the Ouargla oasis - Algeria

Olive tree groves in Sfax - Tunisia

In this region, more than anywhere else, water is a major stake for development. During the last decades, the countries in this region have invested in the infrastructure needed to cope with the water shortage. Much has been done to cover the needs of the water supply systems.

Many countries have invested substantially in water storage infrastructure and the extension of their irrigation systems.

Furthermore, the region is a worldwide leader in innovative techniques for desalinisation and wastewater reuse. But these investments have not systematically been supported by the necessary reforms to public institutions and actions, and often do not yield optimal economic benefits. The problems connected to water use efficiency can be traced to policies other than water per se. Agriculture, for instance, consumes 85% of the region's water resources.

1.4 Soil resources

The soils in the MENA region vary greatly as a result of climate, the nature of the bedrock, and the relief. All types of Mediterranean and desert soils can be found. They are generally poor in organic matter and have a high concentration of salt.

In the northern part of central Maghreb, the "red fersiallitic" soils and the vertic soils (the vertisols) are mainly located downstream in the plains and are characterised by high levels of swelling clay. Their potential use in agriculture is encouraging but special cropping techniques are required to sustain the yields.

The Egyptian soils have been formed through the process of erosion, flooding and sedimentary layers. The extremely fertile alluvial river soil of the Nile Valley is composed of natural minerals and organic matter that are vital to the farmers who cultivate the land in and around the Nile valley and the delta regions.

Mauritania, where the relief is composed of rather low and even landforms, offers soils that are 80% skeletal, young and little differentiated. The North and Centre are composed of mountain ranges but most of the country is composed of dune lines that turn into pastures during the rainy season, thus allowing for rainfed agriculture.

In Jordan, Mauritania and Libya the soils are scarcely suitable for agriculture. Arable lands are very limited (6% in Jordan, 1% in Mauritania, less than 1% in Libya).

THE EYE OF THE DESERT

The Richat Structure, commonly called the Eye of Africa, is a geological structure 50 km in diameter, located near Ouadane, in the heart of the Mauritanian Sahara.

The Eye of Africa was formed during the cretaceous age, more than 100 million years ago and is only visible from the air, or from outer space.

It is gigantic phenomenon resulting from volcanism through the rise of the magma and the hot water from which it originated. Northwest of the Richat structure is the Kedia d'Idjil sedimentary plateau, that peaks at 917 m (highest point in Mauritania). The dark colour of this mountain comes from its large iron ore content.

2. BIODIVERSITY OF THE ARID AND DESERT ECOSYSTEMS IN THE MENA REGION

2.1. Ecosystems

Thanks to its particular geographic position and its bio-climate, the region has a rich marine and terrestrial eco-system (forests, oases, steppe, wetlands). (Figure 5).

Sorghum crop Medenine - Tunisia

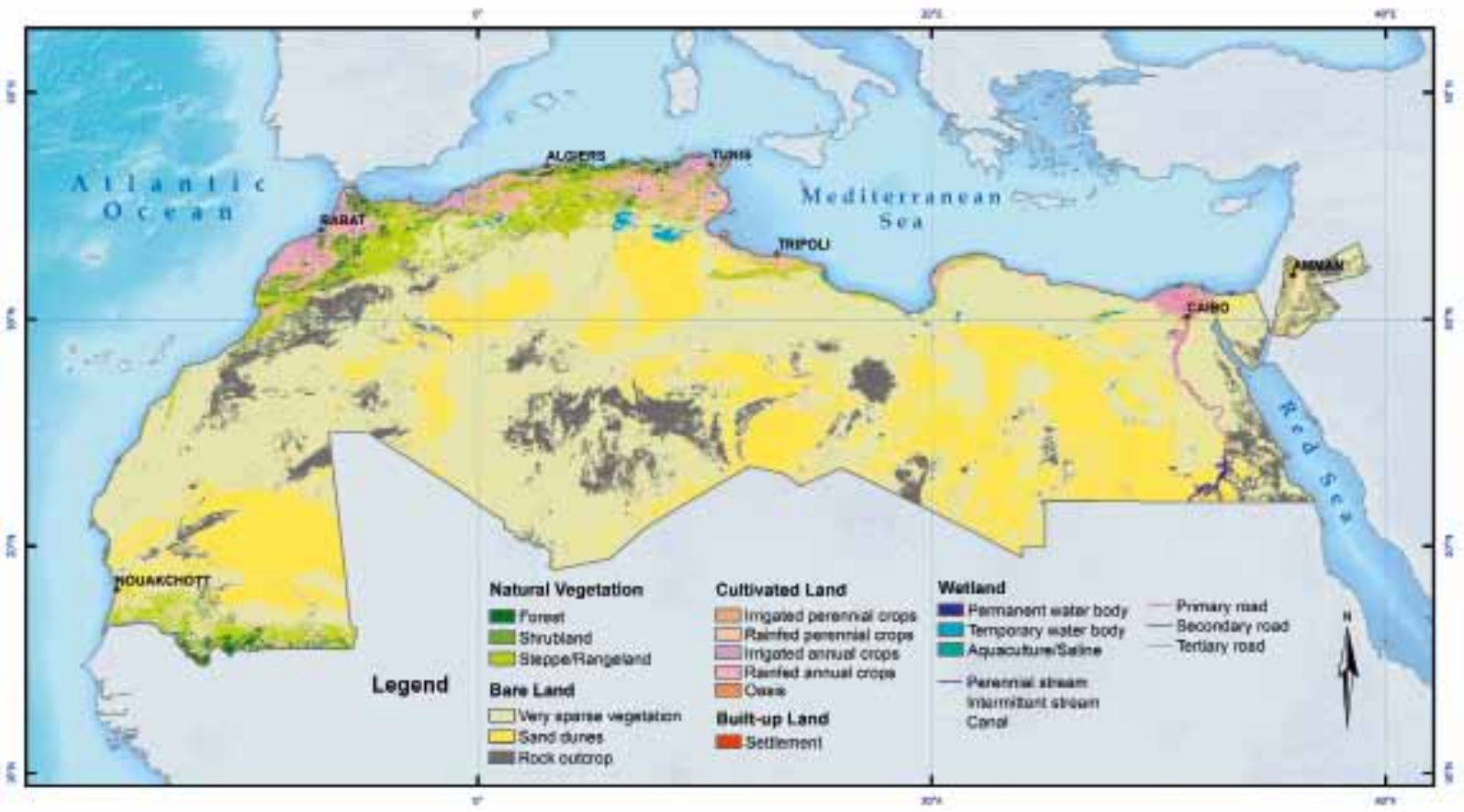


Figure 5. Land cover map (OSS 2017). Source of data: Landsat 8 - 2015-2016

2.1.1. Forests and wooded lands

An inventory of the forests and wooded lands has been made for all the countries in the region, with land areas unequally distributed. Egypt, Jordan and Mauritania have rather little forestland compared to the countries of the Maghreb where forestlands cover a substantial part of the territory and provide various services.

The forest ecosystems in the MENA region host a biodiversity that is adapted to extreme ecological conditions and play a vital role in maintaining the ecological balance and in improving the livelihood of people in the region thus offering a mechanism to protect them against poverty.

2.1.2. Steppe and rangelands

Steppes and rangelands are well represented in the region. They are mainly found, – and dispersed, – in Algeria, Morocco and Tunisia. In Egypt and Libya these ecosystems, composed of low, sparse vegetation, are only found

Forest landscape at Ajloun - Jordan

on more or less narrow coastal strips[2]. In many zones, they represent the transition between the hyperarid or Saharan and the humid or subhumid environments.

The Steppe of North Africa, located between 100-400 mm average annual isohyets, always brings forth the thought of large areas of more than 60 million hectares covered with low, sparse vegetation. Such steppe, which is reduced to a relatively narrow coastal strip in Egypt and Libya, covers an extensive area in the central Maghreb region.

For thousands of years it has been subjected to human exploitation through a number of practices that vary in intensity depending on the level of climate aridity, population density and the traditional local uses[3].

The steppe - Algeria.

The steppe of the Algerian Hautes Plaines is located between the Tellien Atlas to the north, and the Saharan Atlas to the south, at elevations between 900 and 1200 m. They have many salted depressions, ***chotts*** or ***sebkhas*** which are inland lakes formed in the Pleistocene age through torrential rains and the ensuing run-off.

Two major ensembles can be seen: the western steppe composed of the *Sud Oranaises* and *Sud Algéroises Hautes Plaines and the eastern steppe, east of Hodna, composed of the Sud Constantinois Hautes Plaines* (Nedjraoui, 2003).

The principal rangeland zones in Egypt are located in the northwestern coastal region, the Sinai Peninsula and the Halayeb-Shalayin region in southeastern Egypt along the Red Sea.

Most of the vegetation is composed of bushes and chamaephytes plants, together with pasturage based on grasses and therophytes plants, with the following main species: *Plantago albicans, Gymnocarpos decander, Artemisia herba-alba, Haloxylon scoparium, Anabasis articulata, Suaeda pruinosa*.

2 Ahmed Aïdoud, Édouard Le Floc'h, Henry Noël Le Houérou : Les steppes arides du nord de l'Afrique (The arid steppe of North Africa)

3 Ahmed Aïdoud, Édouard Le Floc'h, Henry Noël Le Houérou : Les steppes arides du nord de l'Afrique (The arid steppe of North Africa)

The natural pasturelands of Jordan are divided between the (Badia) desert and the (marginal) steppe.

- **Desert (Badia):** The land area is approximately 7,000,000 ha located in the 100 mm/yr rainfall zone. *Artemisia herba alba, Retama raetam, Achillea fragrantissima* and *Poa bulbosa* are common in the wadi beds while *Anabasis* is found nearly everywhere. Although the land is degraded, this region is the main grazing area in Jordan;

- **Steppe (marginal):** The land area of the steppe is estimated at approximately 1,000,000 ha of which 90% is private property.
  The steppe is divided into two regions, according to its vegetation: a shrubby region (between Ras El-Naqab in the south and Mafraq in the north considered to be the best grazing land in the kingdom. *Artemisia herba alba* combined with Poa and Carew are the dominant plants) and a herbaceous region stretching from Mafraq in the west along the Syrian border and covering an area of 400,000 ha;

The natural rangelands of Morocco cover close to 53 million ha. Their productivity and uses are variable. We can distinguish:

- The ecosystems of the *Hauts Plateaux Orientaux* and the Moulouya Valley composed of halophytic steppe, *Artemisia herba-alba* steppe, glacis steppe, alfa steppe (*Stipa tenacissima*), on different types of soil and substrata;
- The plains and plateaux in the north of the Atlas;
- The argan tree zone;
- The pre-Saharan and Saharan zone.

The Tunisian steppe, predominantly agro-pastoral, is divided into two socio-agro-ecological zones that are clearly distinct because of their morpho-pedology and, even more by their exploitation methods.

The *Haute Steppe*, in terms of climate, can be identified by continentality characterised by cool winters and hot summers, and enormous piedmont erosion.

Alfa steppe (Stipa tenacissima) - Kasserine - Tunisia.

The *Basse Steppe* is characterised by slightly bumpy, gentle relief dominated by crusted glacis with gentle downward sloping, vast alluvial plains and salt pans which form the base level of the main wadis that drain the Dorsale and the Haute Steppe (NAP Tunisia).

The main mapped steppe formations in Tunisia are:

- White wormwood steppe (*Artemisia herba alba*);
- Alfa grass steppe (*Stipa tenacissima*);
- *Rhantherium suaveolens steppe;*
- *Anthyllis henoniana* steppe;
- Steppe in the gypsum and halomorphic environment.

The Mauritanian landscape can be divided into three uneven horizontal fringe areas: desert in the north and centre (70% of the territory), steppe in the centre (livestock production zone, 15%), and savannah and cropping (15% millet, sorghum and palm trees)[4].

2.1.3. Wetlands

The MENA region is home to many classified sites on the Ramsar List of Wetlands of International Importance (in February 2015: Algeria had 50, Morocco 24, Tunisia 41, Mauritania 4, Egypt 4, Libya 2, Jordan 2). Representative and rare habitats (estuaries, chotts, coastal marshlands, mountain lakes, Saharan oases) can be found in these wetlands.

Wetlands of Al Azraq - Jordan

The national parks of Algeria can be divided in three specific biogeographical zones:

- A coastal zone, especially with the coastal ranges in the east of the country a well-watered region covered with the most beautiful and most dense forests, including the El Kala, Taza and Gouraya parks;
- A zone of mountainous drier inland plains and steppe, that includes the Djurdjura, Chréa, Belezma, Theniet el Had, Tlemcen and Djebel Aissa parks;
- A Sahara zone that includes the Tassili and Ahaggar parks (DGF, 2005).

The Nile delta, a swampy region since Antiquity, has always been rich in wildlife and flora. The Fayoum region southwest of Cairo is the entrance to the Wadi El-Rayan nature reserve, an area that offers a mixture of desert, mountains, and waterfalls. It also provides access to a site of worldwide importance: the Valley of the Whales (*Wadi El-Hitan*) that has been on the world heritage list since 2005.

The geographical distribution of protected areas in Morocco includes regions throughout the country. The total area is close to 4,000,000 ha comprising 2,723,610 ha of national parks (Fennane, 2004).

Tunisia has 17 national parks, 27 nature reserves, 4 wildlife reserves and 38 wetland zones of international importance (Ramsar) (Abid, 2013).

Jordan is home to large reserves. The Royal Society for the Conservation of Nature watches over protected areas where wildlife and flora can thrive.

Jordan has the Azraq Wetland Reserve located near the town of Azraq in the east of Jordan (home to rare reptiles and an important stop for migrating birds), the Ajloun Nature Reserve (pistachios and oak trees) and the Dana and Wadi Mujib Reserve.

Libya has seven national parks. The most famous one is the El-Kouf National Park, approx. 150 km from Benghazi. It is of critical importance to the flora since 90% of the plant species registered in Libya grow in this park[5].

In Mauritania, there are two national parks: Diawling and Banc d'Arguin, one of the biggest in West Africa.

2.1.4. Oasis

The oasis ecosystems are the best example of an ingenious system adapted to the needs of sustainable development in the arid and dry regions.

At the MENA regional level, this involves an area of close to 200,000 ha.

The unique feature of the oasis is still mainly its technique for cropping vegetation "in layers" to produce an "oasis effect", a microclimate created by the superimposition of plant layers. Moisture, heat and light are used to optimise the use of the space in an environment where fertile lands and water are scarce.

The oasis is an original ecosystem that plays many important economic, ecological, social and patrimonial roles. It is important at the national, regional and global level.

In Jordan, there are no real oases according to the definition of oasis in the north of Africa; the term "*badia*" is more generally used.

4 https://www.tresor.economie.gouv.fr/Ressources/File/438138

5 http://www.especes-menacees.fr/monde/afrique/libye//

Layered cropping in a Zaafrane oasis - Tunisia

But there are numerous date palm plantations located throughout the Jordan valley down to the city of Aqaba on the Red Sea.

The Algerian oasis epitomizes a very varied mosaic, with 93,000 ha of palm groves and more than 10 million palm trees, i.e. 11% of the world's total. 60% is in the northeast (Zibans, Oued Righ, El Oued and Ouargla) and 40% in the southwest (M'Zab, Touat and Gourara). The palm groves, more or less moderate in size, can be isolated, e.g. the Ouargla oasis that has over a million palm trees, or grouped, e.g. Oued Righ where 47 oases, distributed over 150 km, grow 1.7 million palm trees.

The Moroccan oases cover the whole South Atlas part of the country. Typology: the wadi oasis (banks of the wadis), the dune oasis (oasis in the large dune formations of the Sahara), and the mountain oasis (oasis alongside the mountain areas, in the steep valleys) (Kabiri, 2014).

In Tunisia, the land area of the oasis is constantly increasing, from 16,720 ha in 1973 to 41,710 ha in 2010, and is about to triple the 1973 figure. Approximately one-third is composed of traditional oases. Oases account for 9% of the irrigated lands and 0.8% of the country's arable lands. They are located in the south, mainly in the governorates of Tozeur, Kébili, Gabès and Gafsa. There are some small size oases in the Médenine governorate[6].

There are about 350 oases in Mauritania, mainly in the regions of Adrar, Tagant, Assaba, and the two Hodhs. Extraction techniques and production development methods are different from one region to the next. There are two types of oases:

- oasis located in the interdunary depressions, especially in Assaba, and the two Hodhs
- oasis located along wadis dug in stony plateaus, mainly in the Adrar and the Tagant[7].

6 The Tunisian oasis. 2012. http://www.environnement.gov.tn/PICC/wp-content/uploads/Lesoasis-de-Tunisie-%C3%Ao-prot%C3%Agger-contre-le-changement-climatique.pdf

7 http://www.raddo.org/Info/Les-oasis-de-Mauritanie

2.2. Flora and wildlife

Besides their cultural diversity the oasis and desert zones also harbour exceptional biodiversity, a great wealth in terms of flora and fauna biodiversity.

Plant biodiversity in the oasis ecosystems and the desert zones is very important (UNDO-Algeria, 2002; Ozenda, 2004; INRA-Morocco, 2005; HCEFLCD-Morocco, 2008; GIZ, 2010; Bensaleh, 2012; MAPM-Morocco, 2014; Neffati and Sghair 2014 in Kabiri, 2014).

The date palm (*Phenix dactylifera L.*), which is essential to human existence in the oasis and desert zones, is the backbone of these environments.

Olive trees and fruit trees like almond, fig, quince, pear, apple, orange, pomegranate and apricot trees as well as grapevines are often found in the oasis environment together with date palms and other underlying plants (three layer system) such as cereals, fodders and vegetables crops.

Cactus flowers Opuntia ficus indica

Fast-maturing soft wheat and barley are popular crops in these environments. Maize and, even more so, alfalfa are produced on a large scale as animal feed.

Aromatic and medicinal plants (AMP) such as henna, cumin, mint, parsley, coriander and roses are grown there. The rangelands and deserts are full of a variety of ligneous AMPs such as rosemary and jujube trees.

Animal biodiversity in the MENA oasis ecosystems and desert zones are also important. Many local breeds (sheep and cattle) that live there contribute substantially to the nomadic households.

Equidae also can be found in this environment. Mules and, even more so, donkeys are numerous and provide the services people need most (work, transport). Camels are plentiful especially in the rangelands and in the desert.

Beekeeping is traditional in the region and is rather common throughout the oases and the desert. The yellow bee (*Apis melliffica var.sahariensis*) is the bee of the oasis but now has a competitor, the aggressive black bee (found in the Moroccan oasis for more than two decades).

There is also a rich and diversified wildlife that includes:

- *mammals:* wildcats, foxes, hare, jackals, fennec, jerboa, hedgehogs, antelopes (gazelles and oryx);
- *birds:* Bustard houbara, eagle, hawks, owls, hoopoe, raven, swan, sparrow, crow, pigeon, dove;
- *reptiles:* horned viper, spiny-tailed lizards, varan, grass-snake, cobra, turtles, and lizards;
- *amphibians*: toads, green frogs;
- *fish*: pike, trout.

An extremely important group of animals is composed of invertebrates, many of which are endemic, e.g. crickets, cockroaches, wasps, dragonflies, scorpions, butterflies, ants, spiders, and snails (Kabiri, 2014).

II. SOCIO-ECONOMIC CHARACTERISTICS AND ANTHROPIC IMPACTS

1. HUMAN ENVIRONMENT

1.1 Demography

The annual population growth rate worldwide is 1.2% while the countries in the study zone have a rate of between 1.25% and 2.20%.

The difference between national situations is interesting and confirms the fact that the arid regions generally have the lowest rates. This observation is connected to the fact that arid zones have strong migration rates, people leaving to areas with more abundant natural resources.

Maps of population density (2015) and of large cities in the MENA zone indicate that Cairo is the most highly and densely populated city (close to 23 million inhabitants) followed by Algiers (7,796,923 inhab.) and Casablanca (4,270,750 inhab). (Figure 6).

The age pyramid in the region reflects its youthfulness. The young people (under 24 years of age) account for more than 50% of the total population in three of the countries, i.e. Mauritania (58%), Jordan (55%) and Egypt (52%) and over 35% in the other countries: Algeria (45%), Libya, Morocco (43%) and Tunisia (39%).

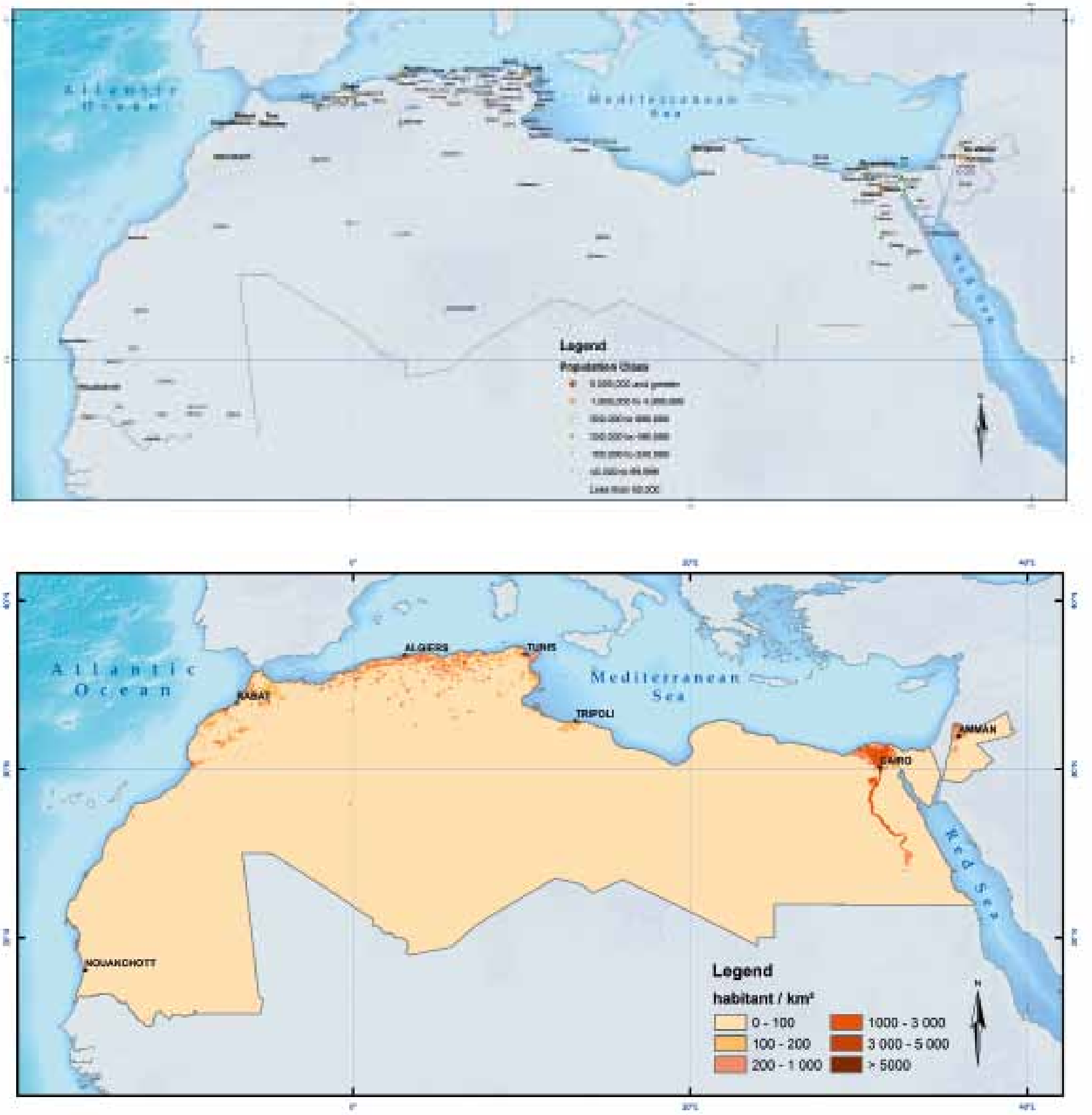


Figure 6. Main cities and population density 2016 (OSS 2017)

Source of data: Environmental Systems Research Institute (ESRI) basemaps, Gridded Population of the World (GPW, v4)

The extreme youthfulness of the population in the MENA zone can be explained essentially by the high fecundity rate and the relatively large decrease in infant mortality. Actually between 23% and 39% of the total population is under 14 years of age, and within this age group, there are fewer girls (49.8%) than boys (50.2%).

The study zone is mainly rural, and the age pyramid for the rural population has a large base. This is a corollary to a high fecundity rate, but the most noteworthy fact is the shortage of males in the working class age group, probably due to the high emigration rate for young men who move to the urban areas.

The incidence of these departures can be seen in the age pyramid where there is a numeric imbalance in favour of the female population. The numeric imbalance is the opposite in the 65-79 age group, since it favours men. This numeric superiority can be explained by an under estimation of the age of women. In the older age group the population is small.

1.2. Migration and lifestyle

The people in the desert zones largely depend on natural resources, especially arable lands.

With a growing population and ever-scarcer natural resources, the standard of living of the local populations has been declining, especially since jobs are scarce except in agriculture. The unemployment rate in the zone is rather high; women form one of the most vulnerable groups.

Agricultural areas in the oases have been shrinking mainly due to inheritance problems and land tenure issues. Changes that can cause a drop in the profitability of the Utilised Agricultural Area (UAA) usually lead to the farmer's gradual impoverishment. Young people are no longer interested in agriculture and leave their land uncultivated or turn it over to a third party (family or not) (Kabiri, 2014).

For a long time, the economic balance of most of the desert lands depended mainly on agriculture, transhumance (seasonal cattle migration) and a few artisanal skills, but the importance of these activities has declined considerably since the beginning of the century, especially in terms of people of working age, leading to a mass exodus to cities and urban centres.

Many of the nomads have been sedentarised and have built up new communities in the desert, gradually putting an end to their nomadic life. The lands with fodder have been degraded mainly through overgrazing of rangelands where transhumance, as a discipline, has been replaced by anarchic, individual forms of pastureland utilisation, aggravated by the sedentarisation of the nomads.

1.3. Urbanization

The desert lands and the oases are seriously threatened as a result of their lack of basic infrastructure. They are overcome by a type of urbanisation that gnaws at lands meant for agriculture.

The development activities are not equitably divided and, most important, lead to large human concentrations and sometimes also industrial installations that deteriorate the condition of the land and environment. These installations are often built in key localities that are ecologically and strategically more fragile than the ecosystem as a whole.

The rural electrification policy in the oases has undoubtedly accelerated the abandonment of traditional habitations and the invasion of lands previously slated for the oasis inhabitants' agricultural, cultural and religious activities.

The tendency of marginalisation, gradual oasis abandonment, the drying out and then the desertification of these zones are factors that cause the loss of territories with a high heritage value.

Actually, the result is that people abandon the traditional dwellings built of rammed earth, the "ksours" to settle in the outskirts or on agricultural lands in new housing built of reinforced concrete.

Urban settlement in Jerash region - Jordan

2. ECONOMIC ACTIVITIES AND LIVELIHOODS

During the last few decades, there have been profound changes in the natural resources management and apportionment method, with an "ownership" phenomenon of rangelands that are being converted into agricultural lands, and individualised water management.

This has led to the abandonment of traditional irrigation systems and rapid development of small hydraulic installations (motor pumps) connected to the collective lands sharing process.

This individual land ownership also has encouraged the development of private "gardens" and a few large water pumping operations, especially from the shallow water tables, water that could also be used in the traditional irrigation system.

In some of the desert regions, this new agricultural trend was supported by the construction of new *séguias* (canals) and the densification of the irrigation system leading to increased abstractions from the wadis and the development of new marketable tree crops: apples, almonds, pomegranate, fig and olives, plus garden crops.

Perennial irrigated crops in El Kalaa Marrakech - Morocco

The drop in water resources, the increase in irrigated lands and the growing number of wells and motor pumps together with rising population figures has led to a major increases in consumption, which has led to a lowering of the phreatic zones and the obligation for owners to dig deeper and deeper.

As a result, the water being drawn is increasingly salt-laden, thus not useable for human consumption or for irrigation. This situation has led to the abandonment of some of the agricultural undertakings.

The rapid increase of unruly urbanisation in certain desert regions grew worse as the members of various tribes wanted to own rangelands, especially the lands near urban centres. At the same time, there was a profound change in the livestock production system and in pastoral practices. As a result of the drought and the gradual decrease in rangelands, nomadic and semi-nomadic herding was replaced by sedentary and semi-sedentary livestock production.

These very basic transformations have contributed directly to the reduction of water and land resources and to the degradation of the grazing lands. Besides these initial observations, current changes and their impacts on the zone's ecological system must be analysed bearing in mind the very close relationship between the social organisation, on the one hand, and the management of resources and the desert areas, be it for agricultural or pastoral purposes, on the other.

The continued reduction in water resources, and the degradation of the desert space and operating methods have contributed to the deconstruction of the tribe as an institution providing supervision and territorial management.

Changes observed in water and land rights and related management modalities are meaningful factors in the fragmentation of these societies. The individual "rights" transgress the rights of the community and accentuate the differences and conflicts between users. It is clear that the technical solutions being proposed to curtail the development of these degradation processes are inadequate and insufficient, because the problem is first and foremost a social one. Degradation is only its physical representation.

2.1. Agriculture

In the desert and semi-desert environments where agriculture predicates on water for irrigation, rainfall levels are very low (under 150 mm) and, more importantly, irregular. Sun and evaporation contribute to the water balance deficit.

As the pillar of the desert economy, agriculture seems seriously handicapped by the shortage of arable lands since only a rather small percentage of the lands are Useful Agricultural Areas (UAA).

Moreover, the lands are very dispersed as a result of population pressure and land fragmentation, which further increases the managerial problems of these "micro-properties". Another factor is the concentration of rural populations in the valleys, which has reduced the irrigated land areas.

These lands are located in a series of small and medium hydraulic areas where irrigation waters are drawn from the wadis, traditional irrigation systems, and wells. Grains, fruit trees, fodder and garden crops are the main crops with, to a lesser extent, the so-called special crops on small plots.

Well water for agriculture - Jordan

Market gardens near Tripoli - Libya

2.2. Livestock production

Pastoralism in this region is dictated by the complexity of relief and altitude, the scarcity of water, and the vegetation. In general, livestock production is a source of revenue that is complementary to agriculture.

In the desert areas and the oasis in our study zones, there are two methods of livestock production: intensive and extensive.

The first type is practiced by the sedentary herders, the second mainly by the transhumant and nomadic herders.

Intensive livestock production concerns first and foremost the bovine stock, mainly the local breeds, and sheep, but very few goats. It is practiced in the oasis, often in stalls with zero-grazing and the addition of feed "supplements".

When the traditional institutions fell apart, the government started managing the rangelands whose degraded condition convinced the public authorities to attempt to reduce pressure on these lands by distributing the cattle to multiple pastoral sites, creating water points, and developing feeding centres.

The analysis of the evolution of cattle stock figures (2013) in most of the region countries conducted[8] between 1991 and 2011, reported a considerable increase during those twenty years. The numbers vary depending on the country but the increases are about 45% for sheep and 20% for goats; the numbers of camels did not change significantly.

Extensive livestock production - Kasserine - Tunisia

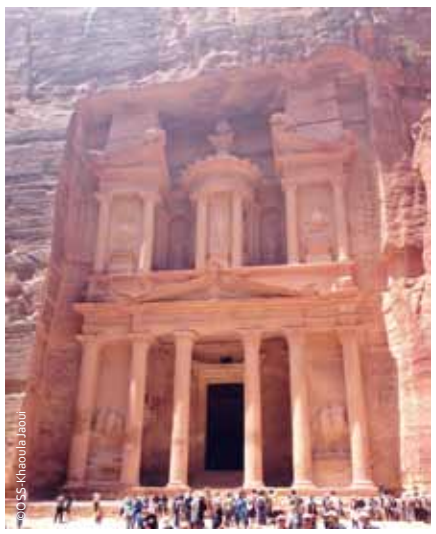
2.3. Tourism

Desert tourism is part of a series of paradoxes and should be developed with great precaution. It can be a vector of development and the fight against desertification and poverty if well managed and respectful of the specific nature and fragility of the desert ecosystem. But it can very easily destroy the lifestyles of the local populations and the natural environment if it is not well controlled.

More than elsewhere in the world, tourism must factor in the challenge of sustainability of destinations that, up to now, have been spared the negative effects of this activity.

The region is not lacking in varied, picturesque touristic sites with mountain peaks, escarpments, long canyons, and sharp cliffs as well as green valleys. These sites, reputed well beyond the borders, are especially attractive to tourists looking for different types of adventures (rural tourism, athletic hikes, with escalation, discovery tourism, etc.).

The region is also known for its sun and lively colours together with a rich architecture that includes ksour, kasbahs and troglodytes (habitats dug into the cliffs).



Petra - Jordan

Traditional architecture at Adrar - Algeria

Tourism has gradually made inroads, especially in Morocco, Tunisia and Jordan with preference for the rural areas. The hospitality of the people and the culinary quality and diversity contribute to the attractiveness. The accommodation facilities include a wide offer: guesthouses, non-classified hotels, gites, camping installations and inns.

Improving the number and quality of products for tourism will require the promotion of rural tourism enhancing awareness-building campaign for tourism professionals and also for the resident population on certain fundamental aspects such as the quality of the hospitality, food safety, sanitary facilities, etc.

8 Ferchichi (2013).

2.4. Mining and energy resources

The whole zone has geological potentials with concentrations of mineral ore and hydrocarbons and major sources of renewable energy.

"Algeria, Egypt and Morocco" form a group that can be distinguished for its wealth of mineral resources. The underground of the Morocco oasis contains resources such as gold, silver, copper, iron, cobalt, talcum and barite.

The geological diversity of Morocco in general, and especially the southern and eastern parts of the country have been quite naturally developed as a result of favourable outcropping conditions, especially in the eastern part of the Anti-Atlas structure, which forms the main part of the Dra and Tafilalt oasis.

Algeria, Libya, Egypt and more recently Mauritania form a group of net hydrocarbon exporting countries, and are heavily dependent on such exports, especially in the case of Libya and Algeria.

Egypt is rich in petroleum, natural gas, iron ore, phosphate, manganese, limestone, gypsum, talcum, asbestos, and zinc. The attractive geological sites include the landforms along the Red Sea composed mainly of very ancient marmatic and metamorphic rock that form the Arabo-Nubian Massif.

Tunisia is more sedimentary. Besides oil, its main resources are phosphate, iron, zinc, copper, fluorine and barite.

Jordan is not rich in natural resources. It lacks hydrocarbons. Its three main resources are phosphate, potash and limestone plus shale oil.
The development of Jordan owes a lot to its geology; its geological layers contain large quantities of fossils that are very common and can even be found in the walls of buildings in Amman that are built of limestone.

III. FRAGILITY AND POTENTIALS OF ARID AND DESERT ECOSYSTEMS

1. FRAGILITY

1.1. Human pressure

To meet his needs, man has always exerted pressure on different types of ecosystems.

The MENA zone has a limited, vulnerable, fragile contingent of the principal natural resources (water, soil, animal and plant biodiversity, plus landscape, renewable energy and geology). They are prone to profound changes caused by natural and manmade factors such as climate deterioration and population and cattle growth rates, and the replacement of traditional and collective land management methods. Intensive and extensive exploitation of plant resources, especially to rear domestic animals, cultivate new lands and collect firewood have deeply affected these ecosystems.

Economic globalisation is encouraging the local populations to adopt new consumption and productions patterns to improve their standard of living. These factors imply drawing more heavily on the natural resources and hence weight on the ecological, economic and social factors.

The pressure on the natural resources in the study zones is accentuated by the fact that agriculture is still the mainstay in the rural world where there is little income diversification. Anthropic pressure on natural resources has increased steadily since the 1960s.

These disturbances also affect the biological resources and land potential, which in turn, disturb human activity even to the extent of causing abandonment of land and emigration of populations to zones deemed more hospitable.

El Hamma quarry - Tunisia.

Plantations and dune consolidation – Mauritania.

1.2. Vulnerability to climate change

Their geographical position makes the countries in the study zone rank among the regions of the world that are most vulnerable to climate change, although in different ways, depending on the country.

Between 1961 and 1990, the MENA experienced a 0.2°C temperature rise per decade. The Intergovernmental Panel on Climate Change (IPCC) expects exceptional heat waves on the zone during 20-40% of the summers according to a scenario that predicts an increase in the average temperature of about 2°C[9].

Oasis under the sand in Adrar - Algeria.

The increase in the average temperature should bring about a drop of at least 20% in the rainfall in the countries of the region. This situation is alarming since these countries are among the world's water-poorest, where agriculture relies heavily on climate.

Hence the expected rise in temperatures and the drop in rainfall could increase the frequency of droughts, leading to a major risk of aridification.

The effects expected in the MENA region will be seen especially through the decrease in water resources, soil degradation, rising sea levels, and saltwater penetration in soils. As for the ecosystem, major degradation is already occurring through the decrease in the biodiversity, which impacts the related services.

In these situations, numerous pastoral species that are unable to adapt could be lost. Compared to the forest ecosystems in the arid and desertic zones, it is difficult to anticipate future composition and functioning but it is very likely that this recomposition, with more popular species, will heighten the simplification process and lead to lower ecosystemic yields in the long term (Neffati et al. 2016).

9 World Bank. 2014. Turn Down the Heat: Confronting the New Climate Normal. Washington, DC: World Bank. License : Creative Commons Attribution—Non Commercial—No Derivatives 3.0 IGO (CC BY-NC-ND 3.0 IGO).

With regard to the vulnerability of the oasis system, the oasis ecosystem is vulnerable and fragile. It can be damaged by exogenous factors such as climate change but also by endogenous factors. Mention is made of loss of plant biodiversity, soil impoverishment and salinisation (OSS, 2014).

The factors cause loss of profitability and abandonment of the oasis system, leading to its internal desertification.

The oases will be affected as follows:

- Greater water needs for the crops which will mean a continuous lowering of the static water level of boreholes and increased water salinity;
- Risk of non-hibernation of tree species that require cold weather, leading to a drop in production. This phenomenon has already been observed for the pomegranate trees in 2010 in the Gabès governorate, in Tunisia;
- Dates drying out in case of succession of very hot days;
- Greater frequency of mite (*Boufarova*) attacks on palm trees;
- Fewer tourists: high summer temperature not favourable to open air activities (GIZ, 2012).

1.3. Sensitivity to desertification

OSS has made a desertification sensitivity map (Figure 7) showing that the zones prone to degradation are in the Tellien areas composed of eroded mountain massifs and the steppe rangelands in the 100-400 isohyet.

The results obtained from the desertification sensitivity map, viewed in relation to three maps of the zone (aridity index, average annual rainfall, and annual rainfall variability) show a good match, which proves that the rainfall deficit observed during the last few decades is one of the main causes of soil degradation.

There are many varied causes and consequences of this degradation. They depend on the natural components and the socio-economics of the region.

In the Tellien part, the main cause is water erosion, which can be traced to a combination of factors affecting the soils: climate and pedological factors, socio-economic conditions and anthropic actions. Degradation can cause a profound change in the physical environment (disappearance of plant cover, gullying, silting of dams) and the social environment (impoverishment of certain classes of the rural populations).

In the steppe, a zone suited to agropastoralism, wind erosion is the main cause of soil degradation. It affects the arid and semi-arid rangelands and is caused by natural phenomena (drought, drop in nourishment capacity of the plant cover, drying of water points) and by greater pressure from growing cattle populations and unmanaged grazing routes, as reported in recent socio-economic data.

Whatever the original causes of quantitative and qualitative degradation of the plant cover, the top soil layer is being subjected to both wind and water erosion.

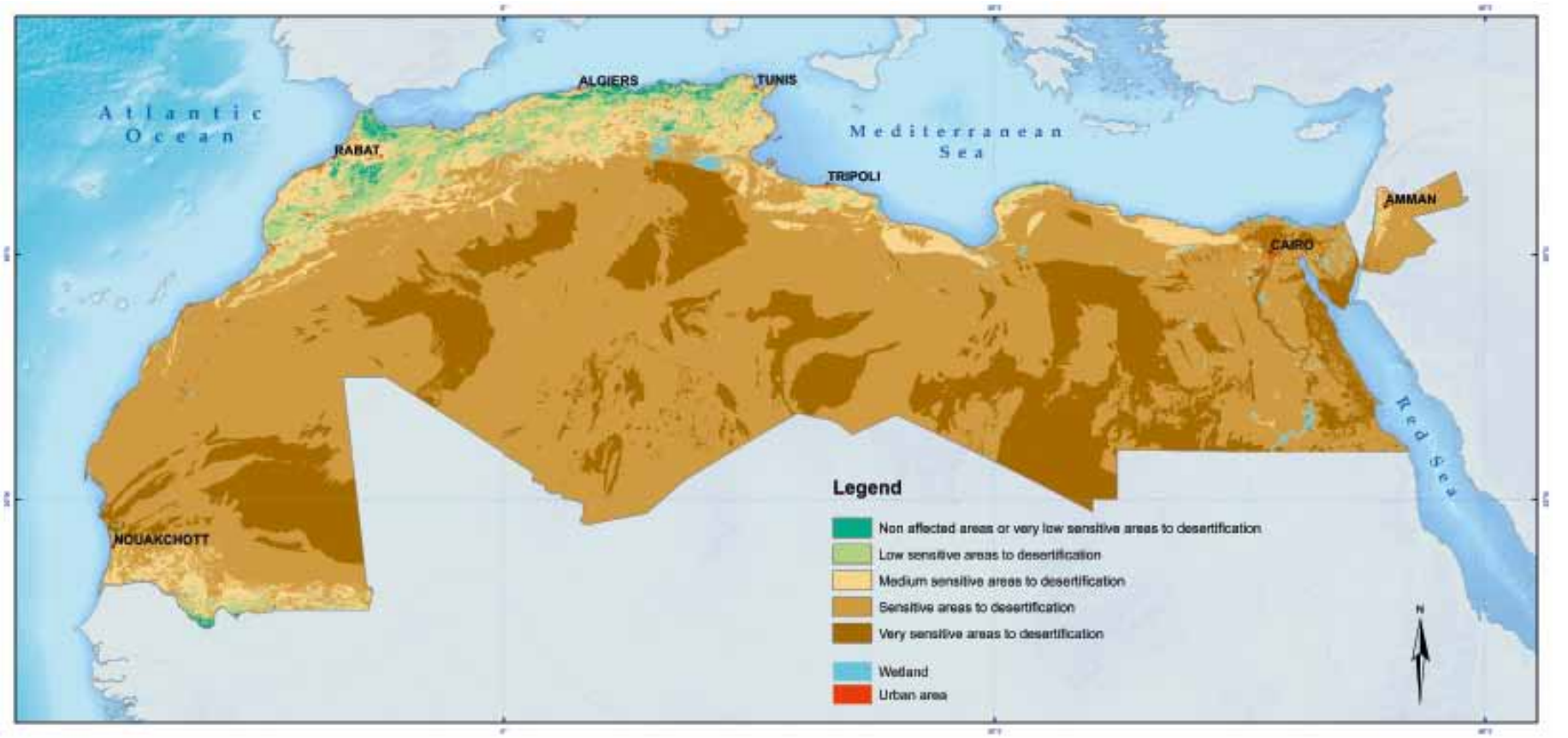


Figure 7. Sensitivity to desertification (OSS 2017). Source of data: approach MEDALUS

Degradation of the physical environment only becomes stable at the depth of the more compact layers of ground, where water penetrates considerably less. If land cover intensity is not relieved during drought periods, arid ecosystem degradation occurs faster and turns desertification into a self-sustaining mechanism (Nahal, 2004).

With regard to the degradation of rangelands, rainfed cropping in dry zones and irrigated plots, the problems of desertification are different. They entail different environmental maintenance and regeneration techniques (Requier-Desjardins et Caron, 2005).

2. POTENTIALS

Despite pressure exercised by man and animals, climate change vulnerability, and proneness to desertification, the region is rampant with potentials worth knowing better and optimising.

2.1. Carbon sequestration

Aboveground biomass, (live plant biomass, aboveground expressed in kg of dry matter per hectare), and Net Primary Production (NPP) expressed in grams of carbon (GC) per m^2, are fundamental characteristics of an ecosystem.

The high figures for soils with heavy plant cover represent the forests found in north-east Algeria and the Nile Delta area in Egypt where conditions are favourable for growing rice, barley, maize, legumes, sorghum and wheat in the delta area, and farther to the south along the banks of the Nile towards the Aswan dam (Figure 8).

Flood irrigation in Zaafrane oasis - Tunisia

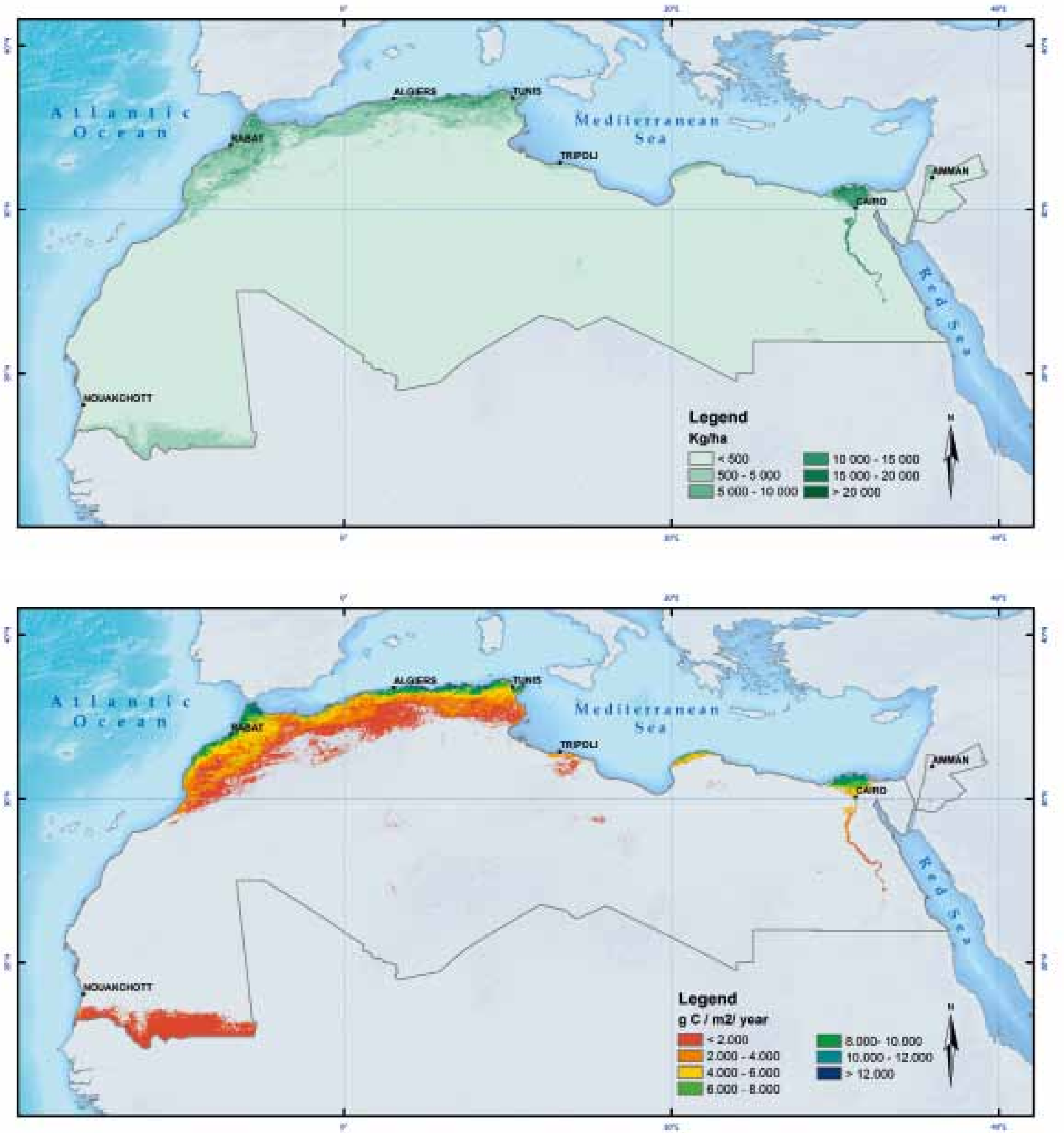


Figure 8. Above-ground biomass and Net Primary Production (NPP) (2000-2014), (OSS 2017)
Source of data: Water Productivity Open-access portal (WaPOR, FAO), MODIS (MOD17)

Average figures are recorded for soils with medium plant cover, e.g. lands in the northern part of Morocco and western Algeria.

Lower figures characterise the desert-like barren areas, generally found in the steppe region.

An evaluation to explore the potential for carbon sequestration using sustainable management practices for forest ecosystems has produced the following results:

- In Algeria: the potential for forest ecosystems to sequestrate carbon amounts to about 16 million tons of equiv. CO_2 (Mt CO_2-eq)/yr.). Reforestation and extension of the forest cover over 1,245,000 ha (included in Algeria's INDCs [intended nationally determined contributions]) would contribute 11 Mt CO_2-eq /yr;

- In Egypt: the restoration and regeneration of 700,000 ha of rangelands over a five year period would allow for the sequestration of about 1 Mt CO_2-eq /yr. This potential is not very significant; additional study is needed;

- In Jordan: a greenhouses gases emissions attenuation programme connected to rangeland exclosure and regeneration would offer an average annual sequestration potential of 1.6 Mt CO_2-eq. This programme would be able to contribute 37% of the quantity pledged by Jordan as its INDC;

- In Morocco: potential carbon sequestration, that includes the conversion of marginal lands into Argan tree forests, could involve a net amount of carbon of close to 4.9 Mt CO_2-eq. This potential would be able to contribute 13.4% of the quantity pledged by Morocco as its INDC;

- In Tunisia: potential carbon sequestration, that includes the extensive afforestation of olive trees, would allow for the sequestration of 1.88 Mt CO_2-eq./yr. This potential would be able to contribute 14.6% of the quantity pledged by Morocco as its INDC;

- In Mauritania: due to its limited industrial development and low population density, greenhouse gas emissions are rather slight, about 6.6 Mt eq. CO_2 in 2010, corresponding to 0.015% of the global emissions (INDC, 2015). According to projects for 2030, greenhouse gas emissions will be about 18.84 Mt eq CO_2[10];

This exploratory evaluation of the carbon sequestration potential using sustainable ecosystem management practices shows that there is a veritable potential for carbon sequestration through better management of forest ecosystems.

This potential could be developed from the present very low level to close to 15% of the countries' commitment under their INDC. A regional approach would make it possible to realise this potential by integrating it in the GHG emissions reduction strategy at the national level (Neffati et al., 2016).

10 SNEDD and its action plan for Mauritania (2017-2030). http://www.unpei.org/sites/default/files/e_library_documents/Strat%C3%A9gie%20Nationale%20de%20l%E2%80%99Environnement%20et%20du%20D%C3%A9veloppement%20Durable%202017-2030.%20Mauritanie.pdf

2.2. Optimisation of aromatic and medicinal plants

In the arid and desert regions of these countries, the main plant formations are composed of steppe, essentially Mediterranean. Their physiognomy and structure can be very varied.

A distinction can be made between the graminaceous, chamaephytes, and crassulescent steppe and the shrub to nanophanerophytes pseudo-steppe (Le Houérou, 1995).

There is a vast range of spontaneous and cultivated plants exploited in the MENA region including both common plants and plants specific to each country.

A large range of plants falls into this category, the most important ones being thyme, rosemary, carob, oregano, bay leaf, cedar, artemisia, myrtle, and pennyroyal.

Jordan, geographically at the crossroads of three continents (Africa, Asia and Europe), has very rich, diverse flora. The area covered with aromatic and medicinal plants stretches from the eastern desert to the highest altitudes in the west and the semi-arid levels to the north and down to the hyperarid levels to the south. It covers close to 20% of Jordanian forests and grazing lands.

Traditional distillation of rosemary - Tunisia

Growing cactus (Opuntia ficus indica), Rhamna - Morocco

Artisanal crafts and valorization of the by-products of the Tamerza oasis - Tunisia

The cactus (*Opuntia ficus indica*) is one of the most common multi-purpose plants in the arid zones of the MENA countries and can serve as a lever for local and regional development in these zones. It is a product with high added value and has many therapeutic and pharmaceutical virtues (OSS, 2014).

2.3. Optimisation of artisanal crafts

Habitats in the oasis and desert ecosystems contribute numerous services to the local populations and the global ecological balance. The oases fulfil "territorial" functions as places for trade and sedentarisation and as such serve as a rampart against desertification.

Their considerable abundance of biodiversity offers a range of goods and services that guarantee a fair degree of socio-economic stability through the development of activities such as agriculture, livestock production, tourism, crafts and industry.

As central elements of national sustainable development strategies, oasis zones are given special support. These strategies are specific to each of the countries but all of them urge greater attention to the context in which the oases must cope with global change. They encourage the adoption of an integrated approach to territorial development that embraces its environmental, economic, social and cultural dimensions.

Nearly all the countries are developing the synergies of partnerships and collaborative organisation that engages the local, regional and national levels through a network of actors supported by the private sector and the civil society that ensures the interaction with the local population.

In these regions, the trump cards of these rich and varied artisanal activities are the results of numerous influences and cultural heritage stemming from secular traditions. They need to be protected for they are drivers of the local socio-economic development.

This artisanal heritage is composed of many types of activities, the most important ones being carpet-making, pottery, wickerwork, ceramics, sculpture, lace, embroidery, copperware, leatherwork, jewellery and weaving.

As for the "useful" crafts, various professions developed alongside efforts to build up these regions. They include bricklaying, plumbing for sanitation, electricity for building, and carpentry. The by-products of the fruit trees and the date palm trees have great potential and should be well managed and exploited in the oasis zones (OSS, 2014), e.g. use of oasis by-products as compost.

Artisanal crafts provide an additional source of wealth since they enjoy a position similar to that of tourism, and contribute to socio-economic advancement for the oasis population. The non-negligible revenue they generate for the local population can balance family budgets and contribute to the fight against poverty.

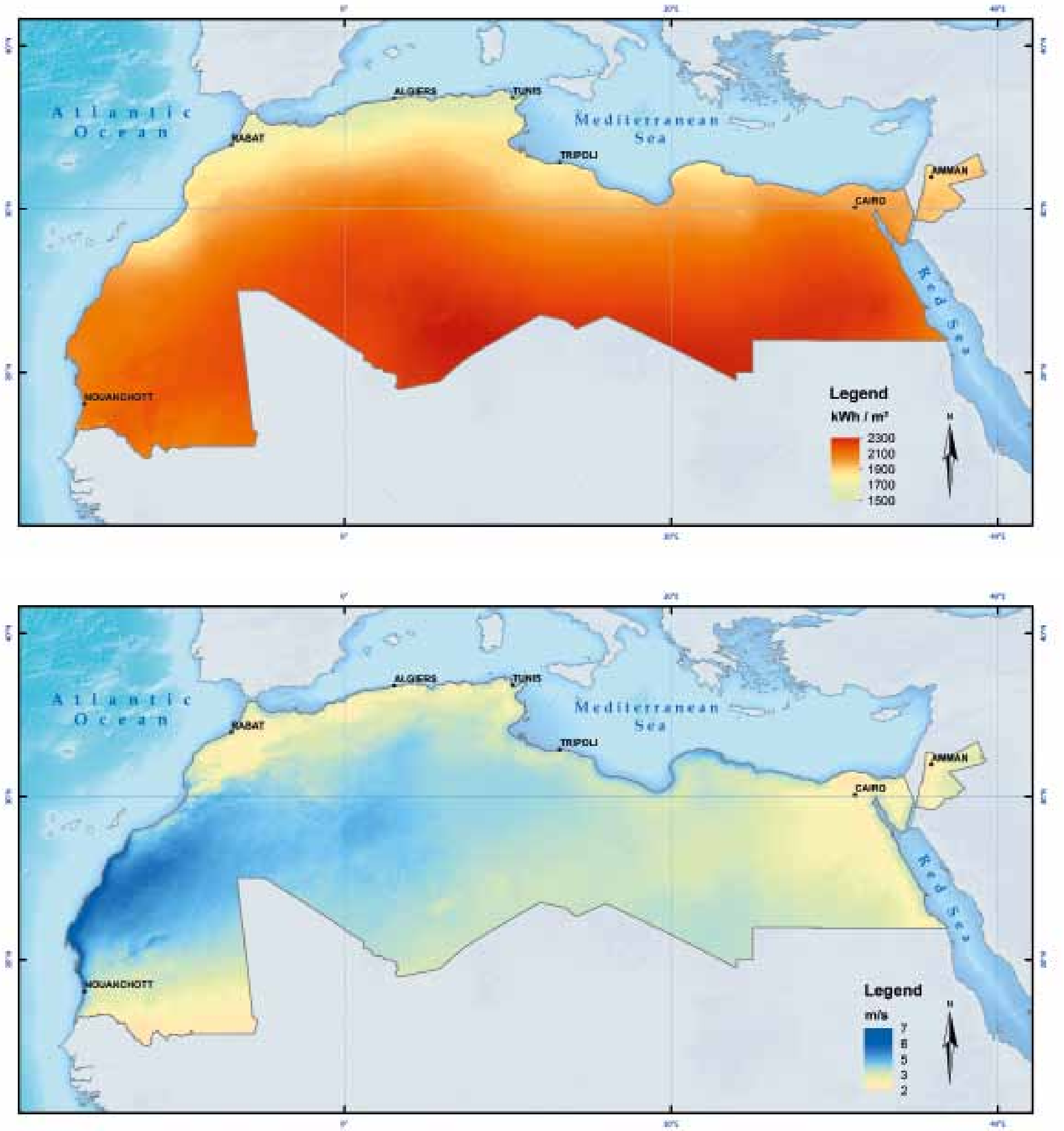
2.4. Renewable energy

Supplying useable energy is and will continue to be a major concern for all human societies.

In the world of today, the fight against climate change and the best way to deal with the impact of our activities on the environment, oblige the industrial world to rethink its energy system and to invent a new way to produce and consume energy.

Renewable sources, as the word indicates, are sources that are self-renewing and thus will not be depleted during the time of human beings or "the duration of life on earth". Solar, eolian, geothermic, marine, biomass and hydraulic energy can be defined as sources of renewable energy that emit very little greenhouse gas.

"Noor" the concentrated solar power plant in Ouarzazate became operational in February 2016. With over 500,000 solar panels, it should cover the energy needs of close to 40% of the Moroccan households within 5 years (i.e. 700,000 households). This project is expected to develop its capacity for renewable energy to 20 GW by the year 2020.



Potential of the region in solar and wind energy (OSS, 2017). Data Source: Worldclim

IV. ADAPTATION OF ECOSYSTEMS AND POPULATIONS TO CLIMATE CHANGE

The ecological crisis is mainly seen through the loss of **biodiversity**, the reduction of national spaces and the erosion of **ecosystem functions** at the local, regional and global levels (MEA, 2003).

And the climate largely conditions and determines the wildlife and flora distribution areas.

With regard to the ecosystems in the study zone, knowledge of the percentage of biogeographical types with affinity to "wetland" ecology and to "hot" ecology is important to understanding the vegetation and predicting productive and adaptive potentials of ecosystems faced with climate change.

In special situations, certain so-called "invasive" species attracted by the new warmer, drier climate, will disperse to larger areas and thus 'conquer' more terrain. These are species that are not very palatable, are less appealing for human consumption and cover large ecological niches that will be expanding as the competition for food and water decreases.

1. ADAPTATION CAPACITY OF ARID AND DESERT ZONE POPULATIONS

People living in the arid and desert parts of the MENA zone are seriously threatened by socio-economic and climatic factors since the ecosystems in these regions are often no longer able to provide the services required for socio-economic development, especially to fulfil the needs of populations that depend heavily on their natural resources.

Date picking, Zaafrane oasis - Tunisia

These threats are extremely serious in regions with a shortage of water and arable land, where resource degradation and climate change create major socio-economic problems for the livelihood of local populations.

Classifying the various means of subsistence in terms of sources of income has shown that there are a large number of varied sources contributing to the security of rural households that are prone to the effects of fluctuating climatic and socio-economic conditions.

The main sources of income are: sale of agricultural and pastoral products, sale of stocks accumulated during the preceding period, savings, non-agricultural activities such as crafts, tourism and services.

Consolidating the dunes, Noueil - Tunisia

Other sources of incomes are retated to the regular transfer of funds from regional, national and international emigrants, and different types of subsidies and loans.

The measures identified for strengthening the adaptation capacity of the arid and desert zone populations, with an eye on sustainable management of natural environments in particular the steppe and pastoral systems, will be linked to several factors: networks and relations; knowledge and skills; demography (population, urbanisation, gender); assets and finances.

Networks and relations
Promote social organisation (NGOs, associations, socio-professional organisations, farmers' groups, cooperatives); develop regional cooperation within the MENA region as part of collaborative regional actions to strengthen the capacity to adapt to climate change.

Knowledge and skills
Inventory, record, document, optimising and promoting the local know-how to bolster the local population's capacity for independent adaptation; fight against the disappearance of such know-how and the very rich local heritage; promote inter-regional and inter-country exchanges to capitalise and adapt local know-how; promote education at various levels: dissemination and apprenticeships in building up awareness of and adapting actions to climate change.

Demography (population, urbanisation, gender)
Control population growth and the depopulation of arid and desert zones; fight against exodus and emigration; control urbanisation in order to avoid the loss of fertile lands; promote adequate plans for habitat development; endow the arid and desert regions with the social equipment and resources needed to improve the living conditions of the resident populations; promote the gender approach in the adaptation and socio-economic strategies in these regions; promote equal opportunities for access to employment, resources, decision-making for young people and women.

Assets and finances (assets of households, revenue, access to loans/ subsidies, social solidarity)
Promote social amenities for households (electricity, potable water, habitats, means of transport, land ownership, access to water); promote means of production (cattle, land, equipment); promote diversification of revenue sources, especially sources that are not heavily dependent on the natural environment; capitalise eco-systemic services (cultural tourism, landscape); promote conditions for increasing farm income (higher yields, improved management and exploitation of the ecosystem's natural resources, access to markets, better capacity to negotiate prices, finding a place in the value chains) and non-agricultural income; establish simple, rigorous mechanisms for access to credit, especially for the poor; control the mechanisms for extending State subsidies and aid and, last, promote a social and solidary economy (Neffati et al., 2016).

These measures are inherent to the modernisation of agro-systems and ecosystems, the diversification and increase in sources of non-agricultural revenue, and the strengthening of the local population's capacity for independent adaptation.

At the political and institutional level, it is becoming urgent for the MENA countries to start incorporating the measures set out in sections of the national development plans on national climate change mitigation and adaptation strategies and to offer political and institutional support for such adaptation.

V. PROSPECTS FOR THE DEVELOPMENT OF ARID AND DESERT ECOSYSTEMS

1. ADAPTED DEVELOPMENT STRATEGY AND ENRICHING TERRITORIAL APPROACH

1.1. Protection and optimisation of the use of natural resources

Actors (NGOs, development institutions, governments, scientists) have long recommended land management techniques to maintain, or even increase the soil carbon rate. The main challenge is to manage the organic matter and water resources well in order to maintain a sufficient fertility level to ensure sustainable production.

The techniques called Soil and Water Conservation Management (SWCM) (Roose et al., 2011), are nearly all recognised now as techniques that maximise carbon management. Many so-called "traditional" techniques can also be used to improve the management of organic matter. A recent study by the Desertification Working Group stresses the fact that many agro-ecological practices bank on local know-how (GTD, 2013).

As part of the MENA-DELP project, an inventory has been made of the good WSC/DRS practices adapted to the desert zones including the conditions required for their implementation (Mekdaschi et al., 2014).

According to these authors, any good practices that are adopted should be profitable for their users and the local communities. The technologies should be simple, inexpensive and easy to manage.

The technologies should be adapted to the natural, local socio-economic and cultural environment.

Agricultural innovation and research on increases in productivity for rainfed crops, the reduction in the difference between yield levels, risk management, technology transfer, and capacity building should be strategic priorities (Mekdaschi et al., 2014).

Further investments retated to Sustainable Land Management (SLM) need to be assessed and planned. Hence concerted efforts will be needed and sufficient resources must be made available to exploit the wealth of knowledge and learn about the success of SLM (Liniger and Critchley 2007).

Hence, territorial differences (geographic location, ethnic groups, socio-spatial organisation, management methods, etc.) require that zones be treated, in a manner compatible with their specific historical, cultural and spatial characteristics.

All development actions should ensure complementary and solidarity-based development (communication channels, social equipment, resource-sharing, trade).

Sustainable Land and Water Management:

Sustainable land management is essential to sustainable development and plays a vital role in merging complementary goals whereas historically production and environmental goals were divergent. From this angle, sustainable land management has two objectives: i) maintain the long-term productivity of the ecosystem's land, water, and biodiversity functions and, ii) increase the productivity (quality, quantity and diversity) of goods and services, in particular food safety. To implement this twofold goal, sustainable land management should also factor in the existing and emerging risks (Source: FAO).

The aim is to ensure harmonious coexistence of people and nature in the long term in order to guarantee the supply, regulation, and cultural and support services provided by the ecosystems. This means that sustainable land and water management should focus on increasing the productivity of the agro-ecosystems, all the while adapting to the socio-economic contexts, improving resilience to environmental variability, including climate change, and preventing natural resources degradation. (Source: TerrAfrica)

Rational water management should first and foremost meet the requirements of health, public sanitation, civilian security, and potable water supply. It should also make it possible to satisfy or reconcile, in connection with these uses, activities and work related to the requirements of the biological life in the host environment, protection against flooding, and economic activities including agriculture. Since water is essential to food production and affects the crop yields, hydraulic installations are being built to overcome the problem of too much, or too little water.

At this juncture, the society has to face three major challenges linked to sustainable water management. On the one hand, the challenges of food safety. On the other hand the challenges of climate change that required due consideration of adaptive agriculture.

Garrigue - Tunisia

Water in the Ibn Chabbat oasis, Tozeur - Tunisia

Intervention strategies for developing desert zones should contribute to solving identified problems, structuring territories in a balanced manner, and organising future actions in keeping with the logic of sustainable development.

Considering the extent of degradation, it is urgent to intervene in order to protect the local ecosystems (plant cover, irrigation water, rangelands), and ensure sound management of natural resources.

New exploitation techniques should factor in the traditional techniques and possible ways to combine modern and traditional techniques.

The goal is not to prioritise static conservatism but to convert traditional know-how that is in harmony with nature's resources, into engineering that correlates with present-day conditions and circumstances.

Further to this situation, all pastoral improvement practices in the arid and desert zones of the MENA region should give due attention to the ecosystem's specific characteristics such as extremely dry climate and very difficult edaphic conditions (very poor xeric soils, sanded areas, etc.). Other factors to bear in mind include the special land tenure status of these collective rangelands and their distance away (disconnected between spaces and their users).

The restoration of the forest ecosystems in the MENA arid and desert zones should make it possible to fulfil both the socio-economic goals (improvement of the standard of living in the rural areas, preservation of pastoral society, increased livestock production and hence animal production, development of non-pastoral goods and services obtained from these ecosystems) and the environmental goals (greater carbon sequestration capacity, biodiversity conservation, fight against desertification, etc.).

Archieving these goals will require a global, integrated approach based on the multifunctionality of these ecosystems.

Forest ecosystem degradation in the arid and desert zones, ongoing human and animal pressure, and continued aridification of the climate have reached a point where sophisticated development (restoration/rehabilitation) and sustainable land management techniques will be required to reconstitute the natural plant cover.

1.2. Territorial development through patrimonial values

The purpose is to develop the desert and oasis lands by optimising the tangible and intangible heritage, transforming it into projects and products whose value could generate socio-economic dynamism, especially in the field of tourism, artisanal crafts, and services.

A consensual development strategy divided into phases comprised of short-, medium- and long-term actions to meet the needs of various situations, especially the urgent one.

A strategy based on the triptych: ***Improvement-Strengthening-Functionality:***

- Improving the attractiveness of the desert zones
This entails improving the conditions for receiving people and investments, and making these areas more attractive by improving the living conditions of the resident populations and making proximate services available. This will require the creation and modernisation of the main community equipment and improved access to trade and commercial relations.

- Strengthening the productive and institutional capacity
Capitalising local potentials depends on the development of efforts to foster the local historical, human and cultural potentials, in order to generate jobs, added value, and higher incomes for the desert populations. Achieving these goals will require the introduction of tools for the creation and management of assistance and support methods that, if combined with a quality approach, would allow for better entrepreneurship and better products.

- Upgrading the functionality of the desert areas
Despite the constraints on these territories, their composition allows for specific modes of functioning that are adapted to their contexts. As a result of the many changes in these areas over the last few decades and the new requirements of contemporary life, the desert zones suffer from problems of readaptation and need an upskilling strategy especially in field of planning, support measures and monitoring.

With this in mind, the strategy proposed recognises these zones as versatile development centres. For each selected territory, with its potentials and constraints, the actors involved will consult with each other and work out well-adapted, operational responses. These development centres will be organized to fit into the existing situation and create developmental links with the neighbouring territories.

2. SOCIAL SOLIDARITY ECONOMY AND ENTREPRENEURSHIP

2.1. The sustainable agriculture sector or agro-ecology

The agricultural model for the desert regions is entering a critical phase as a result of climate change, natural shortages (water, soil), skill gaps, and social movements. Instead of fulfilling the basic needs of the communities or improving the workers' socio-economic situation, agricultural activities in the oasis regions are now connected to rural poverty and environmental degradation.
Beyond production techniques per se, there are several socio-economic and cultural factors that explain the downfall of this profession.

Intensive agriculture could not be practiced in the MENA desert territories and could not provide lasting solutions for the economic development of these zones.

Perhaps an alternative based on agro-ecology could be adopted, with variations to accommodate the potentials and constraints of each of the countries.

Ksour rebuilt, Médenine - Tunisia

Joussour and Tabia - Tunisia

2.2. Local products: sectoral development

Actions to develop the oasis industries must have strong territorial roots and high levels of involvement in the governance of their operating zones. The partnership approach is essential in encouraging investment in the desert regions.

A sustainable development process must be kept in mind when creating enterprises in these nascent sectors. This is important for mastery of business principles, knowledge of the evolution of social demand, and an opportunity for progress in these desert regions.

The principal development activities for an oasis production sector can include:

- capitalisation of local products with high added value, such as dried fruits, fresh fruits, olives and related products, honey;
- improvement of the quality (healthiness) of these products;
- organisation of grouped equipment purchasing;
- encouragement for actors to work as a group on product production and processing;
- better control of the market by the authorities;
- increase in the number of senior staff trained in the agro-food sector;
- promotion of private investment in the agro-food sector, small enterprises and small trade;
- renewed enthusiasm for current-day agriculture that needs technical and commercial support.

2.3. Eco-tourism and well-being activities

The oasis heritage is the work of many generations and civilisations of peasants. It is also the cradle of many ancestral lifestyles and much know-how that now form an invaluable historical national and universal patrimony of tangible and intangible goods.

The strong tourist demand for oasis products is largely due to the originality and the unique features of this type of land cover, and the integration of the oasis into the fragile but resilient desert areas.

Actually, tourism as a vanguard sector that could make the desert zones dynamic again and develop the oases would require structural reforms in order to create a distinctive tourist product that fits in with the local ecosystems, under the emblem of sustainable, responsible tourism.

Responsible ecotourism that optimises the qualities of the region and the tangible and intangible heritage, and generates revenue for the local population is completely in step with sustainable economic development of desert spaces.

The goal is to develop a type of tourism that consolidates the fast-growing global niche markets with high added value, tourism that would gravitate around the local artisanal crafts and an understanding of the local heritage.

Date picking

Ancient village in the Tamerza oasis - Tunisia

CONCLUSION

Strong population growth with the increase in related needs, and the manmade actions combined with the effects of climate change are among the main causes of the environmental degradation in the region.

The challenges to the environment are immense and must be tackled through close cooperation, environmental surveillance, information sharing, and adaptation to global change.

The Sahara and Sahel Observatory (OSS) knows that relevant decisions cannot or can no longer be taken without increasingly detailed knowledge based on reliable, updated data.

That is why OSS, like many other research and development organisations, is encouraging the introduction of measurement and control mechanisms and tools to provide the best possible information that can support effective, sustainable development strategies.

Thus, advancing the achievements of the Sahara and Sahel Observatory in mastering knowledge and development of natural resources monitoring tools and the dynamics that affect them, the ***Land cover maps atlas***, that has been produced as part of the project entitled: "***Desert Ecosystems and Livelihoods Knowledge Sharing and Coordination***" ***"MENA-DELP"*** presents ***the main natural qualities, the strengths, the weaknesses and the potentials of the arid and desert ecosystems in the region***.

With a view to using the distinctive economic position of the desert zones to capitalise their strengths and mitigate their weaknesses, it would be well to design and implement a regional programme together with financial and technical partners.

This would provide us with international advocacy to use with decision-makers, to ensure continuing rather than sporadic interest in the problem of the desert territories, and to mobilise funding for sustainable development projects and programmes.

It is a matter of organising actions as part of an ***overall strategy*** clearly distinguishing actions that can be carried out in the short, medium, and long term, under the umbrella of a regional programme.

The design of the approach to programme preparation will affect the ***territory's untapped potential*** in terms of human resources (unemployed, potential entrepreneurs), innovation pools (ideas and projects of local entrepreneurs), abandoned or forsaken physical and patrimonial resources (landscapes, historical buildings, small heritage sites), intangible resources that are fading away (know-how, traditions, common and identity values) and financial resources (savings, non-reinvested profits, transfers from emigrants).

This approach also stimulates the creation of links between the people involved, favours stronger relations with markets that can generate added value for the enterprises located on the territory, encourages project initiators to become entrepreneurs and supports the introduction of local products on the market by focusing promotional activities on the required steps of the traditional production methods and on their human and community potential and innovation.

PROGRAMME ON DESERT ECOSYSTEMS AND LIVELIHOODS IN THE MIDDLE EAST - NORTH AFRICA REGION MENA-DELP

CONTEXT

The many landscapes and environments of the countries of the Middle East - North Africa are rich in the flora and wildlife biodiversity found in their numerous types of ecosystems: oasis, desert, coastal, mountainous, insular and humid. Certain types of natural resource utilization have led to overexploitation. This is the case of water resources in the arid parts of the MENA desert regions.

Such uses can only be sustainable if an approach is adopted that can reverse the downward trends. In some environments, pressure is exercised on the natural resources because, at least partly, of the loss of certain traditional practices that are especially well adapted to the natural conditions in the MENA region and hence should be protected as a human and cultural heritage and a reference model for development.

The World Bank, as a partner of several countries and the GEF, has launched the **regional "Desert Ecosystems and Livelihoods Programme - MENA-DELP"** whose purpose is to improve the livelihood of people in the desert ecosystems by using these ecosystems in a manner that ensures the continued flow of goods and services connected to the desert zones and thus is environmentally and socially sustainable.

By establishing a positive feedback loop the MENA-DELP programme is trying to maintain and improve the flow of the desert's ecosystemic services to sustainable development. The programme focus on managing economic development opportunities that are specific to the desert environment and allow for the inclusion of protective measures for the desert-diversity duo as part of the potentially innovative, profitable activities that also provide support for the precious knowledge pool connected to adaptation practices.

This type of approach is designed to stimulate opportunities to improve desert livelihoods and strengthen the resilience and adaptive responses of the desert communities and ecosystems to the expected climatic pressures.

The MENA-DELP programme is composed of six projects: **five national projects** (Algeria, Egypt, Jordan, Morocco and Tunisia) and **one regional project**. The national projects include a variety of themes, from ecotourism to agriculture and livestock production, but they all seek to improve the sustainability of the investments by using an integrated approach to ecosystem management. Emphasis is also placed on participatory approaches, capacity building, and the use of local knowledge. At the regional level, the aim is to share more knowledge and data on experiences among the five countries.

Landscape, Boutilimit - Mauritania

THE REGIONAL "DESERT ECOSYSTEMS AND LIVELIHOODS KNOWLEDGE SHARING AND COORDINATION PROJECT"

The regional (umbrella) project entitled "Desert Ecosystems and Livelihoods Knowledge Sharing and Coordination project" has been coordinated by OSS (2014-2017). It was designed from the viewpoint of solidarity and consultation to better network the organisations in charge of project implementation in the beneficiary countries.

The objectives of the regional project

Considering the goals and expected outputs, this regional project seeks to create a better understanding of the connections between the ecosystemic services and the livelihood of the people living in the desert ecosystems in order to enlighten the decision-making process, especially through:

- A better understanding of the links between ecosystems and livelihoods in the desert zones, including the semi-arid and arid zones;
- An improvement of the knowledge-sharing systems on issues connected to the desert ecosystems and the livelihoods;
- A better networking and information flows of desert ecosystem programmes at the national and international levels.

In their "knowledge sharing" component, the studies and summary notes have contributed to providing answers to the main questions related to problems of desert ecosystems and guidance to decision-makers. Study trips, forums and online questionnaires were opportunities for exchanges and training for participants on good practices in natural resource management in the region. Training sessions contributed to information and capacity building on new concepts (LDN – Land Degradation Neutrality and CSA – Climate Smart Agriculture) and on opportunities for climate financing. In practical terms, the participants learned about a certain number of tools, including Collect Earth.

All of these activities have contributed to strengthening the link between institutions and to the sharing of knowledge on good practices in the sustainable management of desert ecosystems.

An example: a twinning agreement was signed between Jordan's Hashemite Fund and the Centre de Formation et de Qualification dans les Métiers de l'Artisanat de Marrakech (CFQMAM – crafts training centre) in Morocco on upgrading local products (crafts).

The Monitoring-Evaluation (M&E) component generated information that was needed to assess the efforts made in sustainable management of desert ecosystems and to measure progress in reaching the targeted goals. The development of the Geoportal (information system and M&E tool) and the training on how to use it have contributed to technical M&E capacity building on national projects. The atlas and the booklet on M&E will complete the recently developed M&E system and will facilitate the decision-making process for natural resources management.

The beneficiaries and the actors in the regional project

The direct beneficiaries of the regional project include several national and regional organisations involved in the implementation of the MENA-DELP national projects. One of the expected outputs of the project is its contribution to making up for institutional shortcomings and lack of know-how in sustainable management of desert ecosystems.

The following organisations and institutions are involved in implementing the project:

- **Algeria:** Ministry of Land Use Planning and Environment (MATE);
- **Egypt:** Egyptian Environmental Affairs Agency (EEAA) and the Desert Research Center (DRC);
- **Jordan:** National Center for Agricultural Research and Extension (NCARE), Royal Society for the Conservation of Nature (RSCN), and the Hashemite Fund for the Development of Jordan Badia (HFDJB);

Study visit, Jerash - Jordan

Study visit, Marrakech - Morocco

- **Morocco:** Ministry of Agriculture and Fisheries (MAF), Agricultural Development Agency (ADA), National Institute of Agricultural Research (INRA), and the National Agency for the Development of the Oasis and the Argan Tree Zones (ANDZOA);

- **Tunisia:** Ministry for Local Affairs and the Environment (MALEv).

Other partners and national institutions benefitted indirectly from the regional project, e.g. community organisations, regional and local authorities, research institutes, and universities.

Main outputs of the regional project

1. Knowledge sharing on good practices in sustainable management of desert ecosystems.

- **Guidance notes for decision makers and replies to questions connected to the problems and potentials of developing desert ecosystems**
  1 regional atlas of land cover maps, thematic studies (11 regional studies), summary notes (6), extension documents, and policy briefs.

- **Contacts concerning good practices in natural resources management in the region** (study visits, online forums, international meetings 5CoP UNFCCC, CoP UNCCD, etc.), 600 participants.

- **Capacity building for experts** (New concepts [LDN and CSA], Opportunities for climate financing, Surveillance and M&E tools-Collect Earth, Ex-Act, etc.).

2. Measurement of efforts made to reach the goals of the national projects

- **Development of a M&E tool** that can be used to assess the efforts made in the field of desert ecosystems sustainable management and to measure the level of expectations from the targeted goals.

  - Production of a M&E training kit and documents on GEF trocking tools and Risk Assessment;

  - Putting a M&E database on line to interactively update MENA-DELP programme indicators;

  - Publication of a M&E guide to facilitate the process of taking decisions on questions connected to natural resources management;

  - Preparation of a summary document on indicators of the MENA-DELP regional project.

- **Setting of an information system**
  Development of a **Geoportal** that centralises the basic thematic maps produced as part of the project or by OSS partners on the natural resources in the region. Training was provided to build up the technical M&E capacity of the national projects.

  Development of a **"Temporal profile"** tool incorporated in the project's internet portal to create the capacity for quasi-realtime monitoring of a series of climatic and ecological variables (vegetation, rainfall, etc.).

MENA-DELP Geoportal (http://www.oss-online.org/mena-delp)

NATIONAL MENA-DELP PROJECTS

JORDAN

Badia Ecosystem and Livelihood

The purpose of this project is to support sustainable livelihoods and improve ecosystemic services using participatory approaches in certain parts of Badia, in Jordan.

The project has produced the following results:
1. Established of ecotourism in the north of Badia;
2. Improvement (physical and human) in water management capacity in two poverty pockets in southern Badia;
3. Support for alternative sources of livelihood;
4. Establishment of project monitoring & evaluation system.

Three components have been identified to achieve the expected outputs:

Ecotourism for the community in Northern Badia:

The component includes plans for:
- Creation of the Al Azraq / Shaumari-Burqu ecotouristic corridor;
- Encouragement of community involvement in the planning, development and operating of the ecotouristic corridor.

Adapted management of rangelands and alternative support for livelihoods in southern Badia

At this level, plans include:
- Construction of durable water storage reservoirs (hafirs);
- Establishment and/or restoration of improved rangeland reserves;
- Maintenance and improvement of source of livelihood in targeted communities.

Project management, monitoring and evaluation

This involves the establishment of a project management unit (PMU) capable of administering and supporting project implementation.

Development of Rangeland - Jordan

Forage Crop in the Badia - Jordan

Project achievements

The project has allowed for the construction of Burqu'ecolodge, the acquisition of two mobile Bedouin camps and cooking tents, as well as the construction and maintenance of two *hafirs* (one in Al Husseini and the other in Al Jafr) to provide water for small-scale livestock and fodder production.

It has also been possible to establish and/or remodel and operate two unfenced pasturelands in Al Jafr and Al Husseinieh.

The project has also assisted with initiatives in support of alternative sources of subsistence at the community level, with emphasis on women and youth people. In Al Husseinieh and Al Jafr, 25 cooperatives have benefitted from these initiatives. The total number of beneficiaries is about 24,928 (of which 3,568 were direct beneficiaries and 46% were women).

MOROCCO

Solidary and Integrated Agricultural Projects

The goal of the project is to promote and disseminate the outputs of national agronomic research related to land conservation and biodiversity preservation measures through eight inclusive, solidary agricultural projects, in the Moroccan greening plan (Plan Maroc Vert) at the Marrakech, Safi and Souss Massa regional level.

Outputs of this project:
- Diversification of sources of income and creation of synergy between sectors;
- Account taken of cumulative impacts of the projects;
- Improved social integration and promotion of feminine activities;
- Projects labelled and differentiated;
- Training and supervision for local communities.

The following two components have been adopted to achieve this goal:

Irrigated perennial crops El Kalaa - Morocco

Capacity building for public and private institutions related to soil and biodiversity conservation in the project for small-scale farmers in the two regions identified.

Transfer of soil and biodiversity conservation to the small-scale farmers in the two targeted regions, through identified sub-projects.

The project's integrated measures, as added components to pillar II projects of the Plan Maroc Vert, focused mainly on:

- The management and valorization of farm waste, i.e. liquid waste of olives, olive pomace and the by-products of cactus plants and argan trees;
- The Soil conservation techniques such as bench terraces;
- The biodiversity through the development or aromatic and medicinal plants, and bee-keeping.

Project achievements

With regard to training and capacity building, 378 officers from the Ministry of Agriculture and Fishery, Rural Development, Water Resources and Forests, including 43% women and 162 senior employees (43%) from the private sector have been trained in soil conservation and biodiversity protection. Furthermore, 7,660 farmers of which 2,261 (35%) were women were trained on these same subjects.

Moreover, 8 valorization units (from cactus plants by-products and the honey products sector) have been completed and 6 more (2 accumulation basins, 2 compost facilities and 2 valorization units for by-products from the argan tree are well underway (70-90% completed) and will be completed by the end of the project.

TUNISIA

Ecotourism and Desert Biodiversity Conservation

The goals of the Ecotourism and Desert Biodiversity Conservation Project is to contribute to the preservation of desert biodiversity and the sustainability of desert lands in the three national parks located in southern Tunisia (Bouhedma, Jbil, and Dghoumes) by factoring in ecotourism development and community commitment.

The expected outcomes:

1. The political and regulatory framework governing sectors other than the environment sector, e.g. tourism, are incorporating sustainable utilisation and biodiversity conservation measures;
2. Implementation of well-chosen investments in ecosystems / productive landscapes and restoration and integrated management of natural resources systems.
3. Promotion of sustainable subsistence systems in the investment zones.

The goal and outputs will be obtained through the implementation of the following three components:

Promotion of conditions propitious to the management of protected areas, the strengthening of Sustainable Land Management, and the development of ecotourism.

This component includes:

- Strengthening the institutional, legal and strategic framework for the management of the national parks;
- Strengthening and integrating the national and local capacity for sustainable land management and biodiversity preservation using the Integrated Natural Resources Management (INRM) approach;
- Establishing a monitoring-evaluation (M&E) system.

Support for the implementation of development and management plans for the three national parks

This component includes:

- Implementation of priority investments identified in the current development and management plans for the three parks;
- Encouragement for partnerships with the local communities with focus on the national parks through small subsidy programmes;
- Promotion of environmental education and restoration or ecomuseums.

Project management:

This component is supported by the installation and operationalisation of the Project Coordination Unit.

Project achievements:

On the ground, the project has contributed to greater involvement of the sectoral level, i.e. the central services of the ministry in charge of protected areas and the regional services of the ministry of tourism. An ecotourism promotion strategy in and around the protected areas has been developed and the legal texts on ecotourism have been improved to ensure more involvement of the local populations, women and young people, the private sector and the civil society. The management plans for the three parks have been updated to include ecotourism as an alternative way for site promotion and a driver of local development. The project prioritises activities to strengthen infrastructure in these areas. Other activities include creation and maintenance of trails, restoration and reinforcement of ecomuseums, creation of wells and water points.

Thanks to the project, the local NGOs and populations have benefitted from micro-loans to start profit and non profit activities connected to ecotourism, small-scale agriculture, optimisation of local produce, etc.

Sustainable Management of Oasis Ecosystems

The purpose of this project is to improve the sustainable management of natural resources and diversify the means of livelihood in the six traditional oases that are shared by four governates in southern Tunisia: Gafsa, Tozeur, Kébili and Gabès.

The goals of the project are:

1. Improved conservation and management of biodiversity, land and water resources;
2. Greated investment in land management;
3. Improved and diversified life styles and livelihoods.

Distribution of palm discards in the Tamerza Oasis - Tunisia

Planting of palm discards in the Tamerza Oasis - Tunisia.

Three components have been identified to achieve these goals:

Capacity building in sustainable management of oasis ecosystems

Plans focus on:

- The formulation of a sustainable development action plan and a strategy for the oasis;
- Capacity-building for the stakeholders;
- Introduction of a monitoring-evaluation system for project activities.

Support for the implementation of the project's pilot oasis participatory development plans (PDPO)

The expected output for the component:

- Funding and implementation of community micro-projects in the field of sustainable management of land, water and biodiversity;
- Funding and implementation of community micro-projects in the field of livelihood diversification.

Project coordination and management

Output expected: Creation of operational project management unit.

Project achievements

Under this project, several activities have already been carried out, e.g. formulation of an oasis sustainable development action plan and strategy, a communication strategy, an atlas of the traditional oasis, capacity-building and enhancement for various actors, and installation of a mechanism for project monitoring and evaluation.

Furthermore community micro-projects have been carried out in the field of sustainable land, water and biodiversity management, e.g. protecting the oases against flooding, sanding, and destruction by wild boar, and restoration of the oasis ecosystems. These activities have been consolidated and supported by research carried out partnering with specialised institutions.

Community micro-projects aimed to diversify the livelihoods of the local population have also been carried out, e.g. renovation and capitalisation of local artisanal know-how by craftswomen, promotion of sheep rearing, development of bee-keeping, ecotourism, development of hiking trails, support for sustainable management of fishery resources, etc.

LAND COVER MAPPING METHODOLOGY

The unprecedented changes in land cover in the arid and semi-arid regions during the last few decades makes it especially important to document the state of the local ecosystems. Standardised characterisation and classification of land cover units to contribute to increasing knowledge of the state of the natural resources is the first step in implementing sustainable land management and preservation actions. Knowledge such as this is essential in decision-making and supporting the planning processes. Despite a strong demand for this type of information in most of the MENA countries, data are generally not available, or obsolete, or poorly disseminated. Furthermore, problems related to the harmonisation of legends and classification systems curtail the use and optimisation of especially for spatial and temporal comparability purposes.

To solve the problems above, the MENA-DELP project worked to produce Land cover maps for Algeria, Egypt, Jordan, Libya, Morocco, Mauritania and Tunisia using coordinated approaches and standardised techniques.

Following the example of other OSS member states, the Land cover maps for this zone have been produced using a participatory procedure that involves both national partners and OSS experts.

METHODOLOGY

The mapping methodology used Earth Observation data that were analysed and processed. The methodology combined the following two techniques:

- ***Automated multi-date classification*** of multispectral LANDSAT images at a spatial resolution of 30 m. Landsat 8 OLI images covering the whole action zone were used. For each scene two images (one per season: summer/winter) were acquired between November 2015 and August 2016 and processed. The availability of several images for each scene improved the thematic precision. More than 700 images were used.

- ***Photo-interpretation*** to regroup classes generated by the automated classification. Very high resolution images on Google Earth made it possible to identify land use classes in accordance with the pre-defined legend. Other, complementary ancillary data (maps, reports, databases, experts' opinions) have been used to enrich, finetune and validate the map.

The following data were used especially during the finalisation and validation phase:

- GlobCover, 2010 (European Space Agency and the Catholic University of Leuven);
- GlobCover30, 2010 (The Institute of Remote Sensing and Digital Earth - RADI), Chinese Academy of Sciences - CAS);
- Global Urban Footprint (GUF), 2016 (German Aerospace Center - DLR).

TECHNICAL SPECIFICATIONS

The legend and the technical specifications of the map were defined together with the national partners to meet the natural resources management requirements of the national programmes. This definition reconciles the limits to the technique and data used, on the one hand, with the users' needs on the other. In an effort at standardisation and harmonisation, a legend composed of 15 classes has been developed on the basis of the FAO Land Cover Classification System (LCCS) which is an international standard.

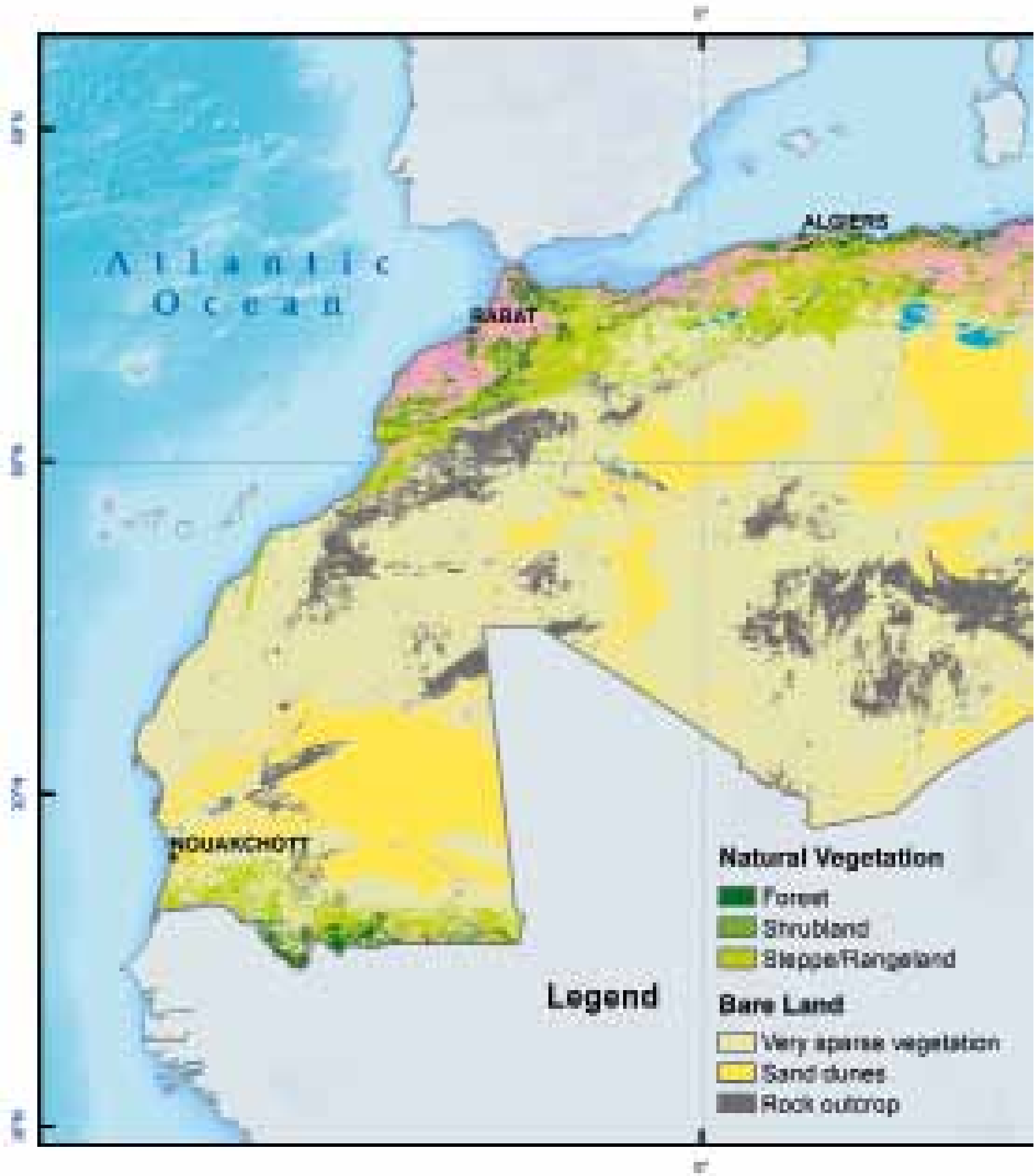
A compilation of cartographic sheets has been edited and a paper copy has been sent to the main national partners for validation. In the final version, the comments of the national experts have been taken into consideration.

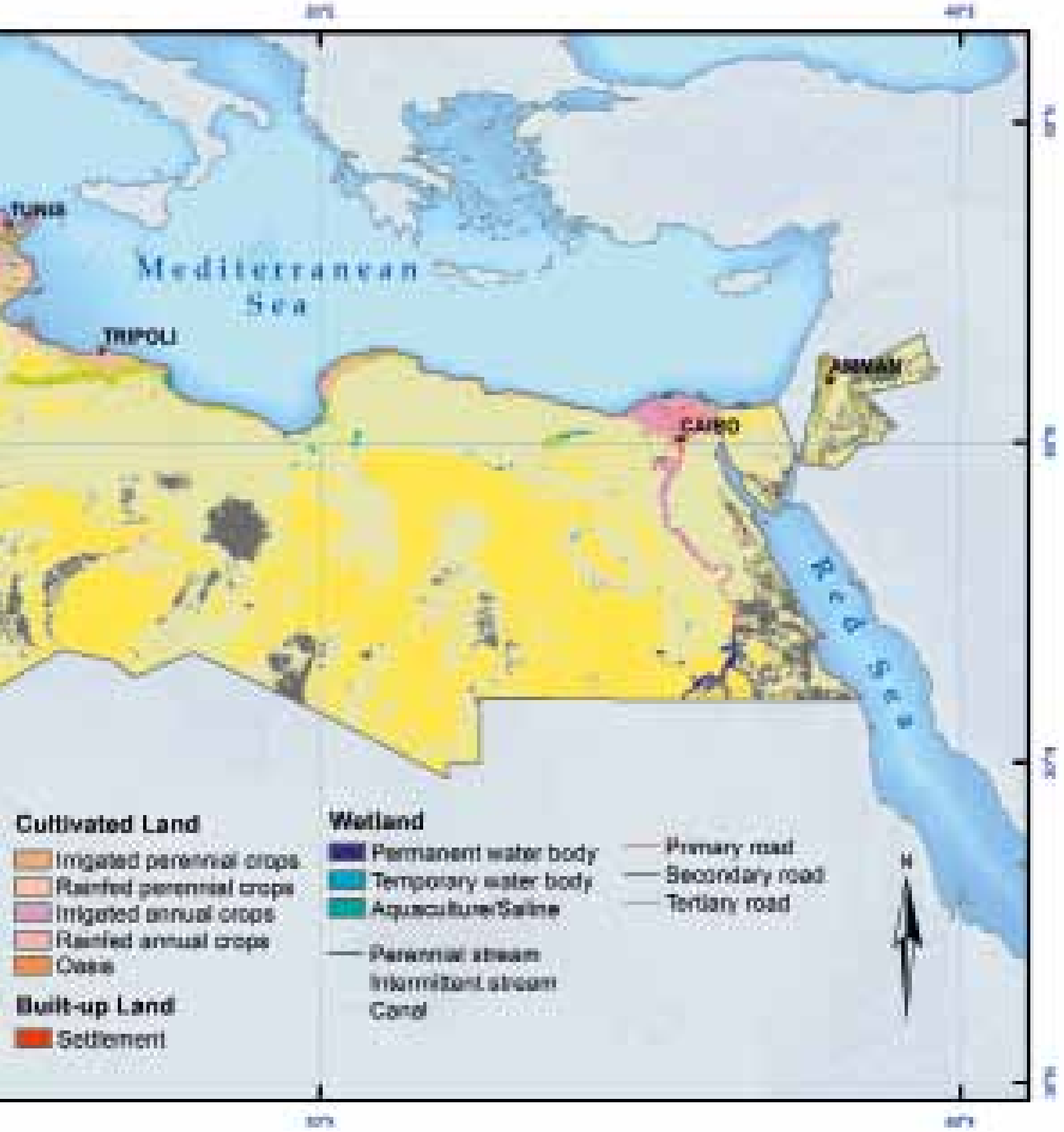
The scale and the map index in this serie is compliant with those of the global topographic map at 1 : 1.000.000, thereby allowing for a better utilisation of these map sheets in the national development programmes and projects. Each map at 1 : 1.000.000 has been divided into two parts (North and South). In this Atlas, and for practical reasons (size and format), the maps have been edited at a scale of 1 : 1.250.000. Map sheets covering desert zones with very sparse vegetation cover have been combined and edited at a reduced scale (1 : 2.500.000).

The scale of the maps determines the minimum size of the mappable objects (Minimum Mapping Unit- MMU). The size of the smallest feature selected is 50 ha, except for the urban, agricultural and water classes, which have a MMU of 25 ha.

The World Geodesic System WGS-84 and the Universal Mercator Transverse (UTM) projection (zones from 28 to37) were adopted for all the map sheets in the Atlas.

LAND COVER MAP: ALGERIA, EGYPT, JORDAN, LIBYA, MAURITANIA, MOROCCO AND TUNISIA




TUNIS
Mediterranean Sea
TRIPOLI
CAIRO
ANNABA
Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Built-up Land
Settlement
Wetland
Permanent water body
Temporary water body
Aquaculture/Saline
Perennial stream
Intermittent stream
Canal
Primary road
Secondary road
Tertiary road
N

PHOTOS ILLUSTRATING LAND COVER MAP LEGEND

Natural vegetation

Forest

Forest species or a group of forest species with a crown density of at least 10% of the wooded area with a minimum width of 15 m and a minimum surface /area of 4 ha or a density of more than 250 young plants per ha (FAO/FRA 2005).

Shrubland

Special vegetation formations that combine certain forest species (pine, oak, etc.) as well as bushes and shrubs (lentisk, arbutus, holm oak, evergreen oaks, rosemary, juniper berry, cedar) in sub-stage with a canopy cover less than 10% (FAO/ FRA 2005).

Steppe/Rangeland

Land covered with low, discontinuous vegetation. Grass species, open, composed of spaced out tufts of Graminae species, sometimes with a few woody plants crossed or not by fires (FAO/ FRA 2005).

Cultivated land

Irrigated perennial crops

Tree crops whose development depends entirely on an artificial supply of water.

Rainfed perennial crops

Tree crops (usually olive trees) whose development depends entirely on rainfall.

Irrigated annual crops

Seasonal cropping whose development depends entirely on an artificial supply of water.

Rainfed annual crops

Seasonal cropping whose development depends entirely on rainfall.

Oasis

Zone with isolated vegetation in a desert near a source of water or groundwater table or sometimes a river bed. The oases presented in this Atlas are mainly covered by date palm trees.

Bare land

Barren soil / Very sparse vegetation

Area that is totally barren or has very little vegetation cover.

Sand dunes

Area of (moving or stable) sand or pebbles in coastal and inland environments. All the ergs are included in this class.

Rock outcrop

Rock outcrop and hardpan zones: plateaux, hills, mountains, fallen rocks, cliffs, rock blocks, and lava are included in this class.

Wetland

Permanent water body

Permanent water bodies, either fresh, salty, or brackish: lakes, streams, reserves and dams, etc.

Temporary water body

Land area that contains water during a limited time stamp of the year and is dry the rest of the time: sebkhas, chotts, swamps, floodplains.

Aquaculture/Saline

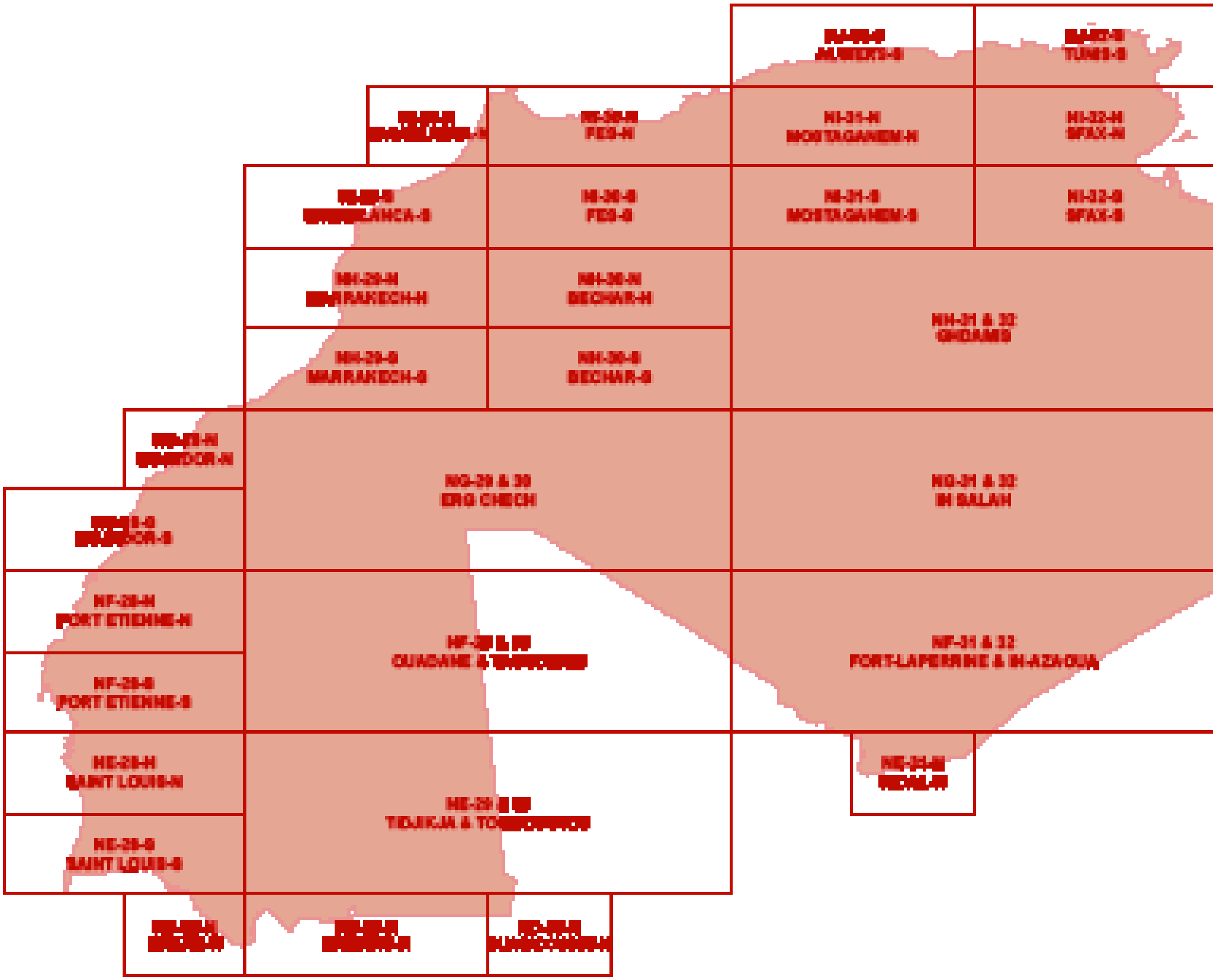
Water body that is developed and reserved for raising aquatic animals or for salt extraction.

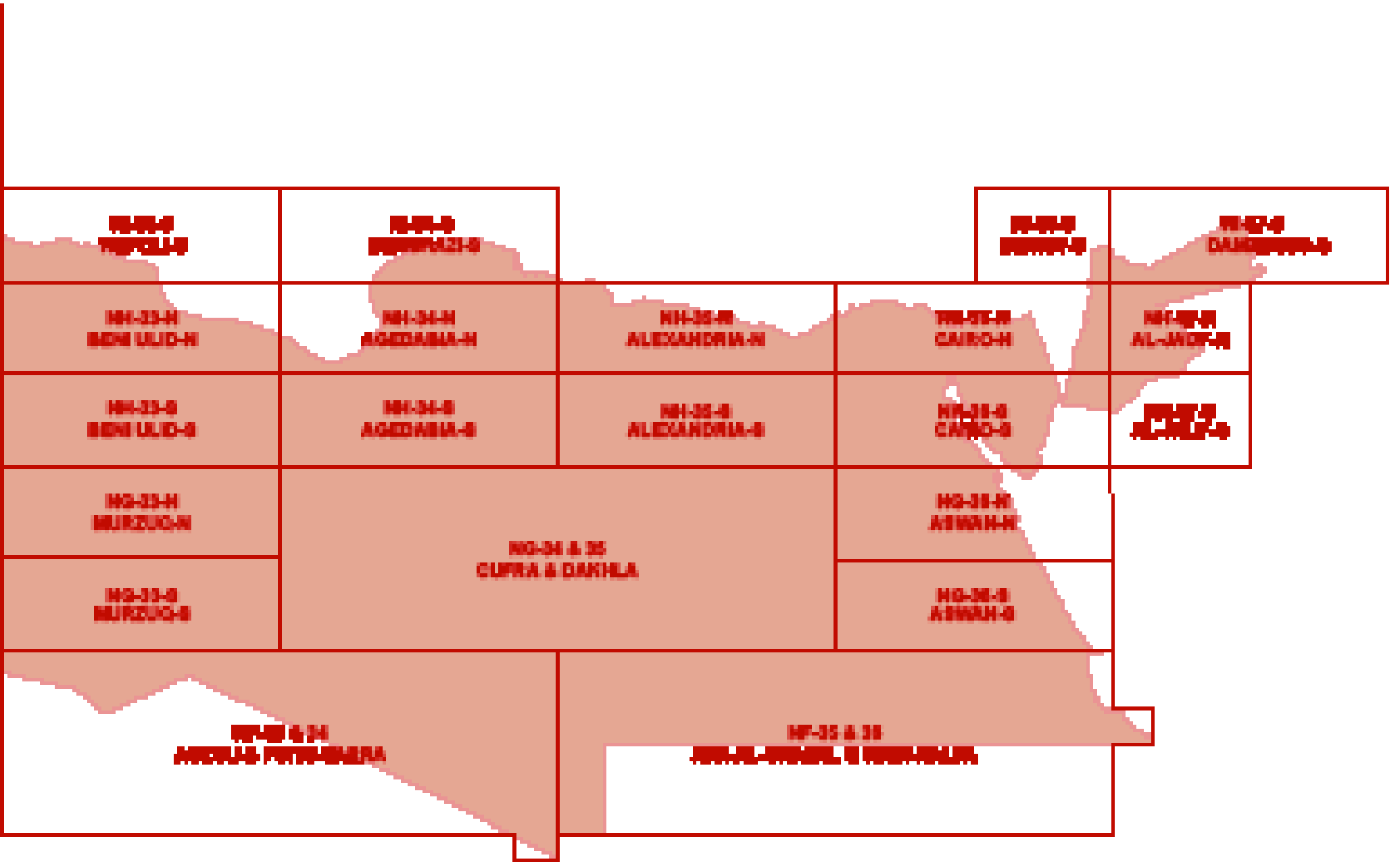
Built-up land

Settlement

Area that is structured, or not, by habitats, in both the urban and the rural zone.

LAND COVER MAPS INDEX

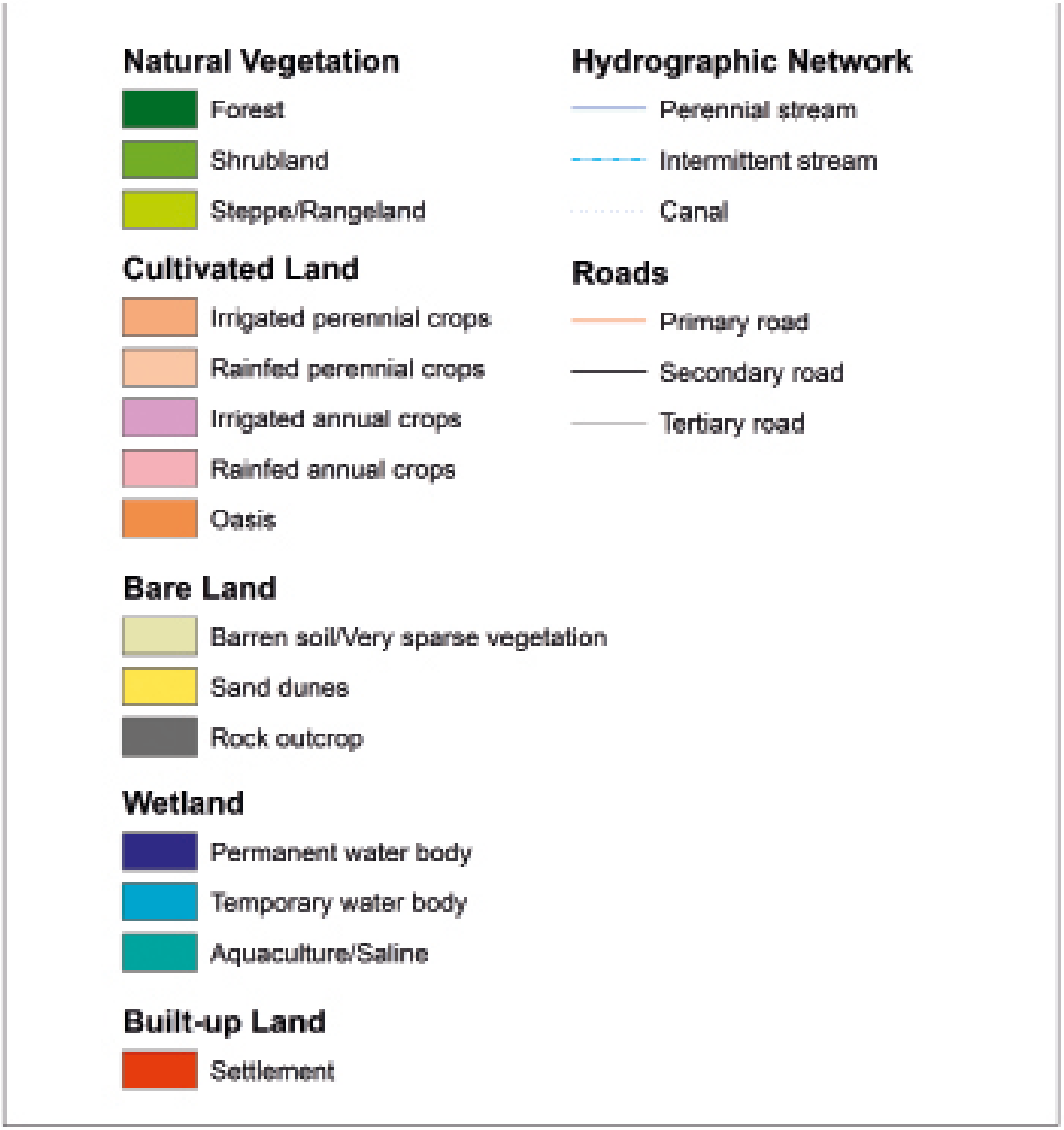


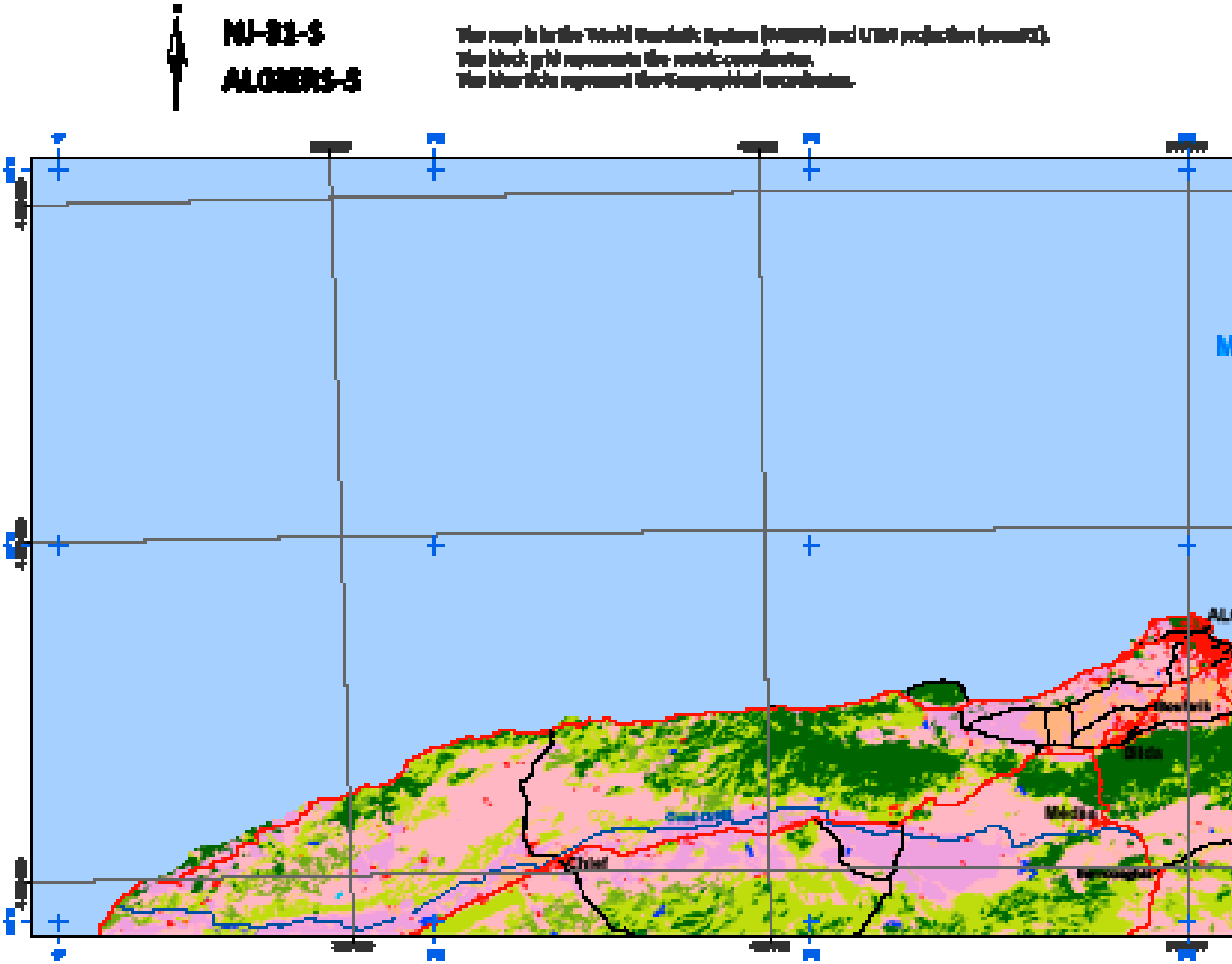


The scale and the map index in this serie is compliant with those of the global topographic map at 1 : 1.000.000, thereby allowing for a better utilisation of these map sheets in the national development programmes and projects. Each map at 1 : 1.000.000 has been divided into two parts (North and South). In this Atlas, and for practical reasons (size and format), the maps have been edited at a scale of 1 : 1.250.000. Map sheets covering desert zones with very sparse vegetation cover have been combined and edited at a reduced scale (1 : 2.500.000).

LAND COVER MAP SHEETS INDEX

LAND COVER MAP LEGEND

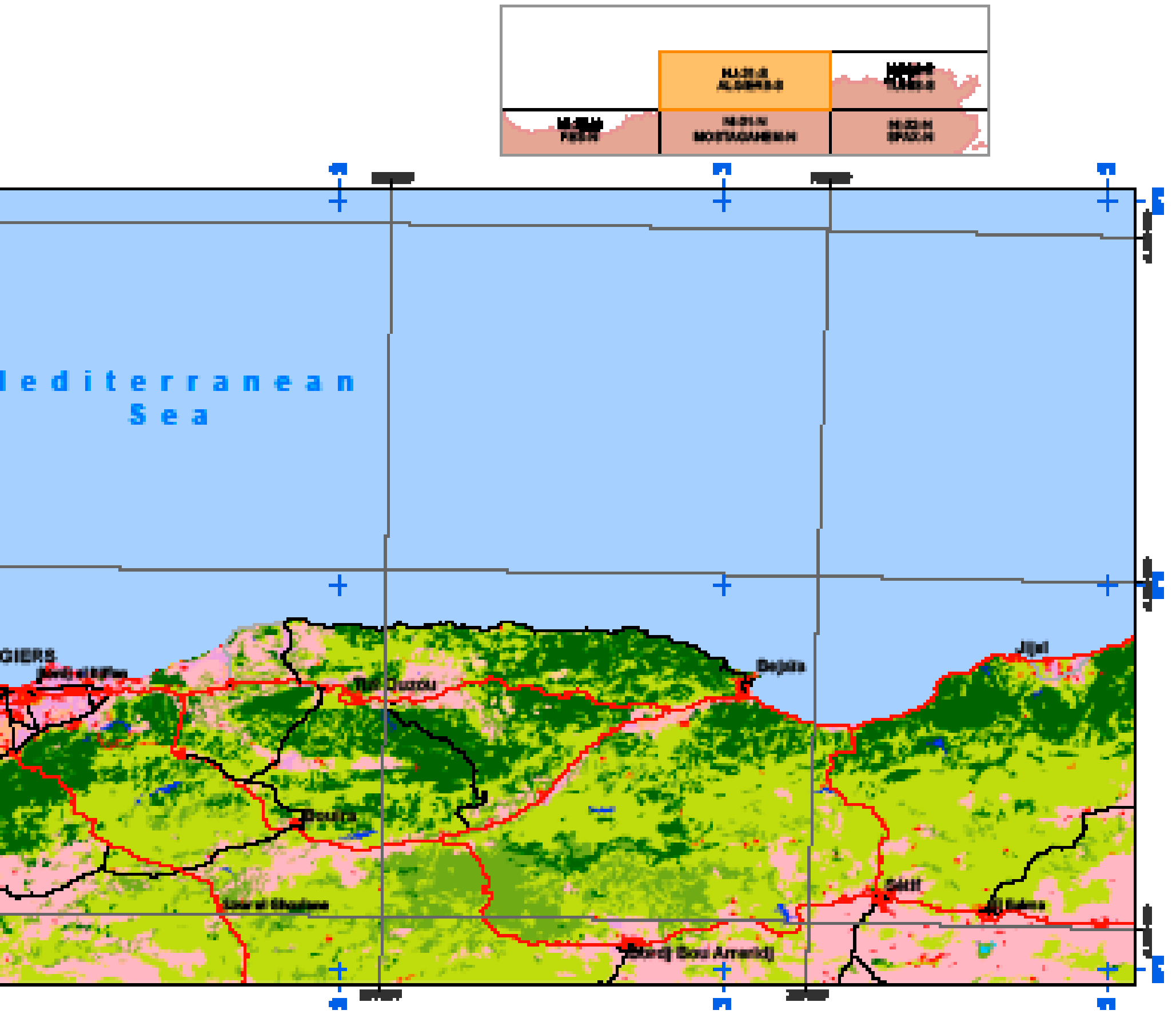


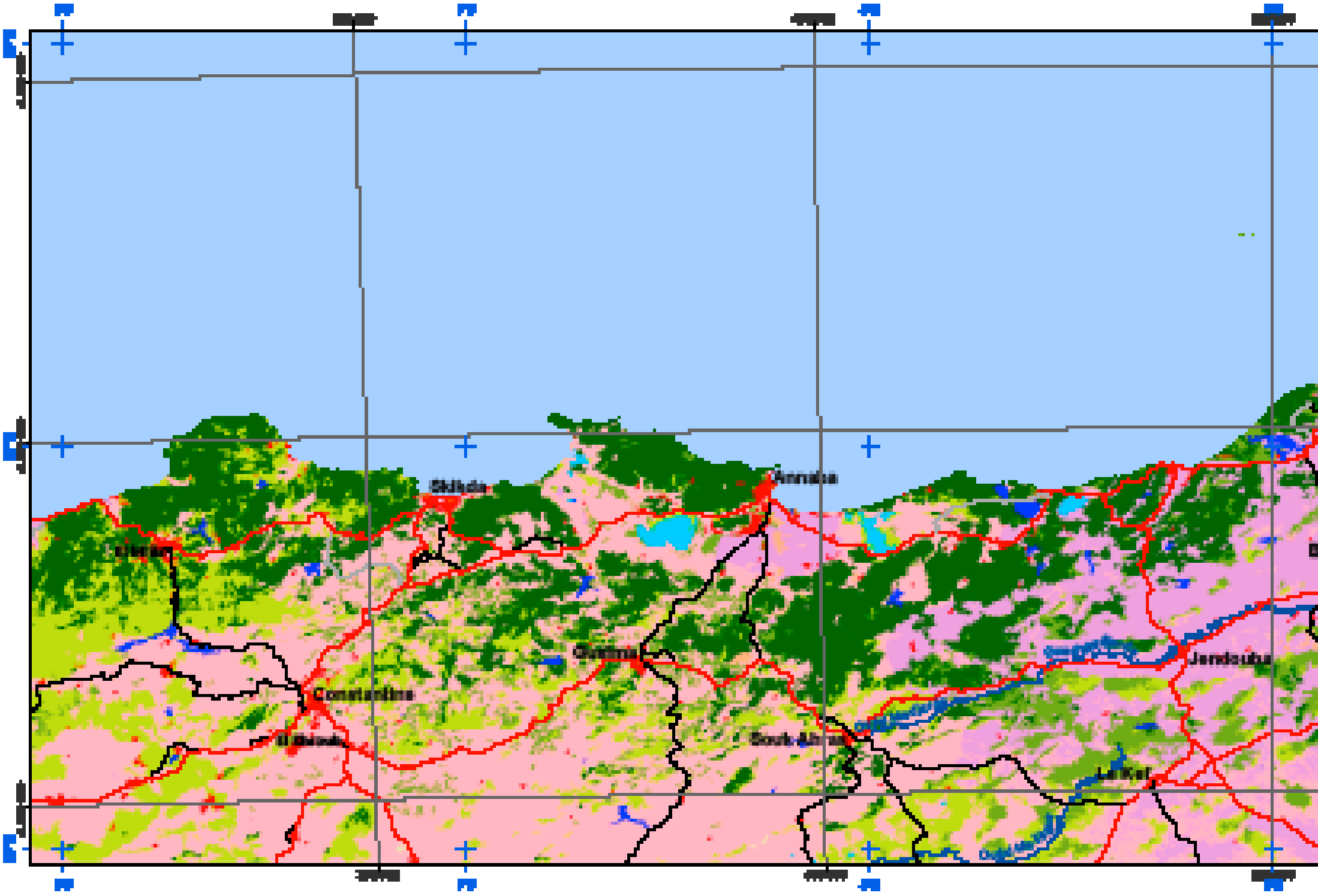


Scale 1:2 500 000

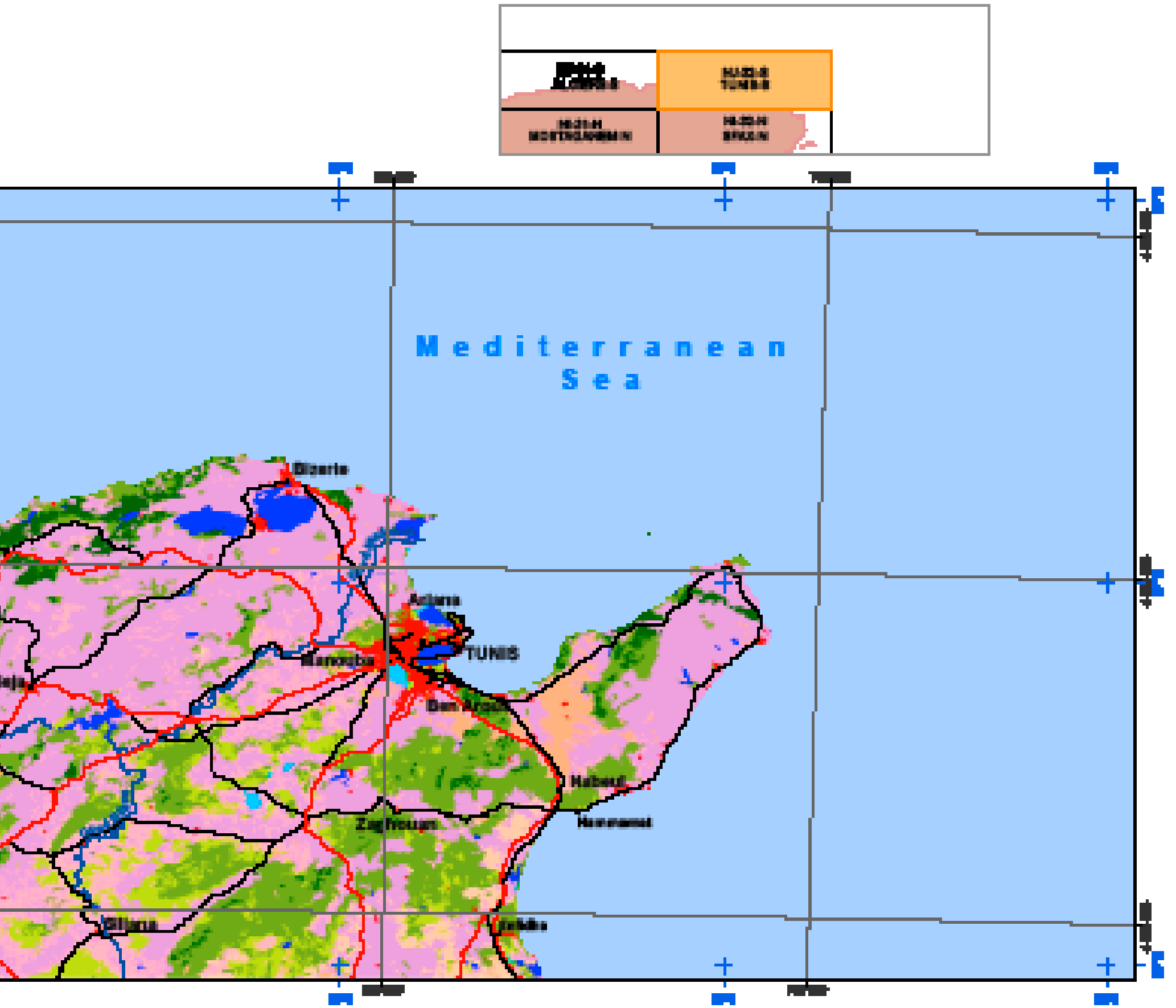
Natural Vegetation
Forest
Shrubland
Steppe/Rangeland

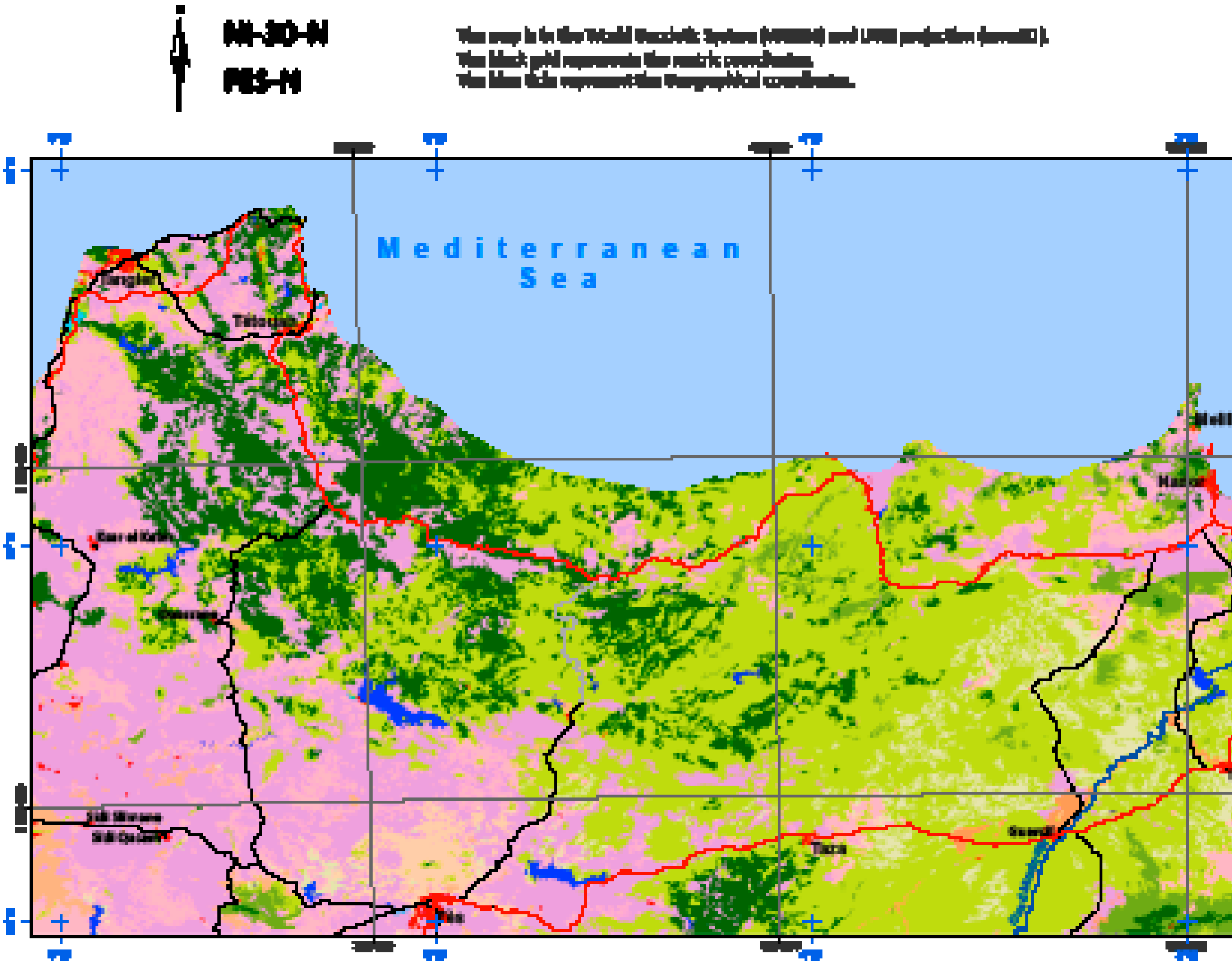
Bare Land
Sand dunes
Rock outcrop

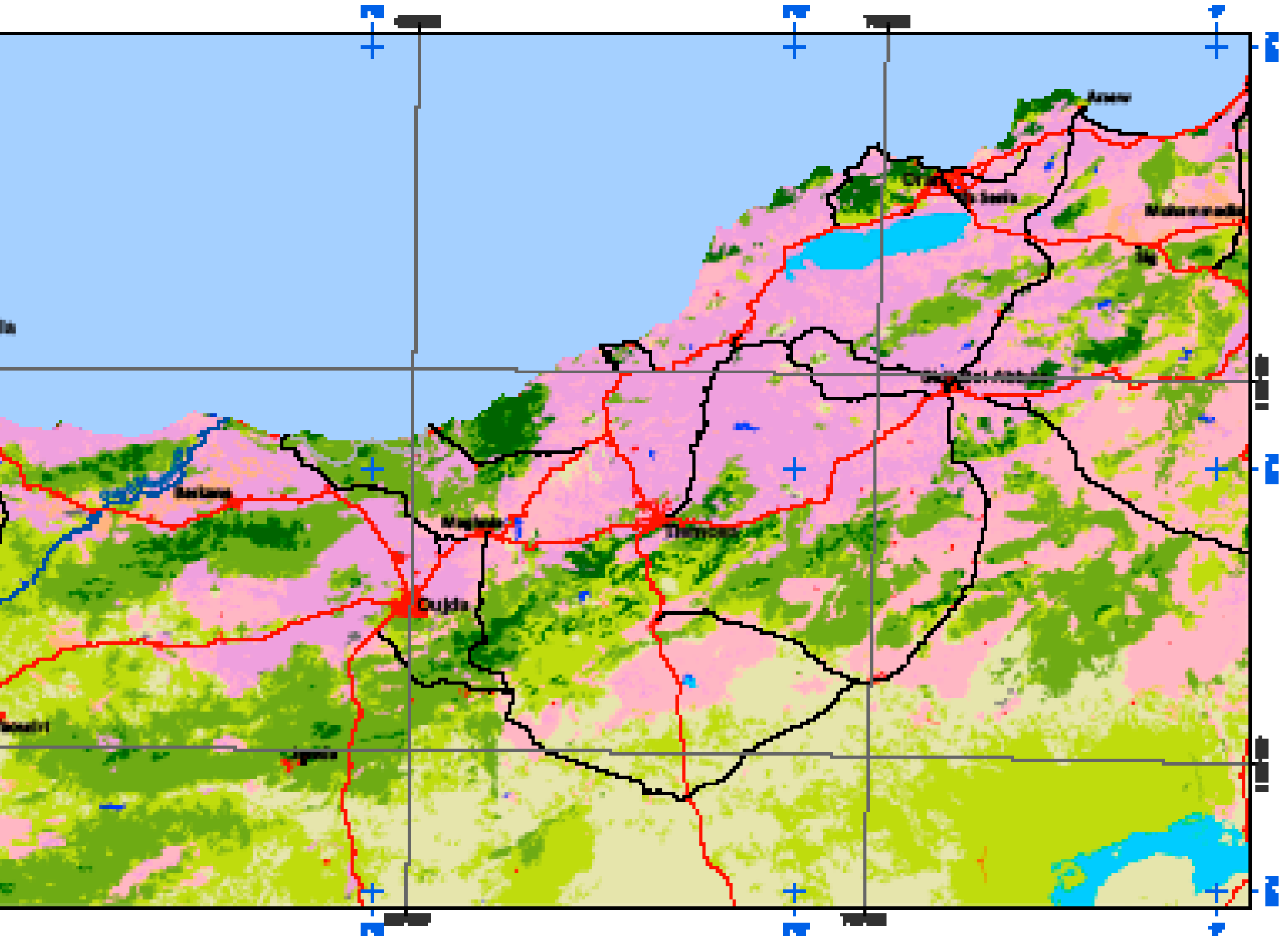

Mediterranean Sea
GIERS
Tlet Ouzou
Bejaia
Jijel
Bouira
Sétif
Bordj Bou Arreridj



page 54


Mediterranean
Sea
Bizerte
Ariana
TUNIS
Nabeul
Hammamet
Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Wetland
Permanent water body
Temporary water body
Built-up Land
Primary road
Secondary road
Tertiary road


Mediterranean
Sea



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

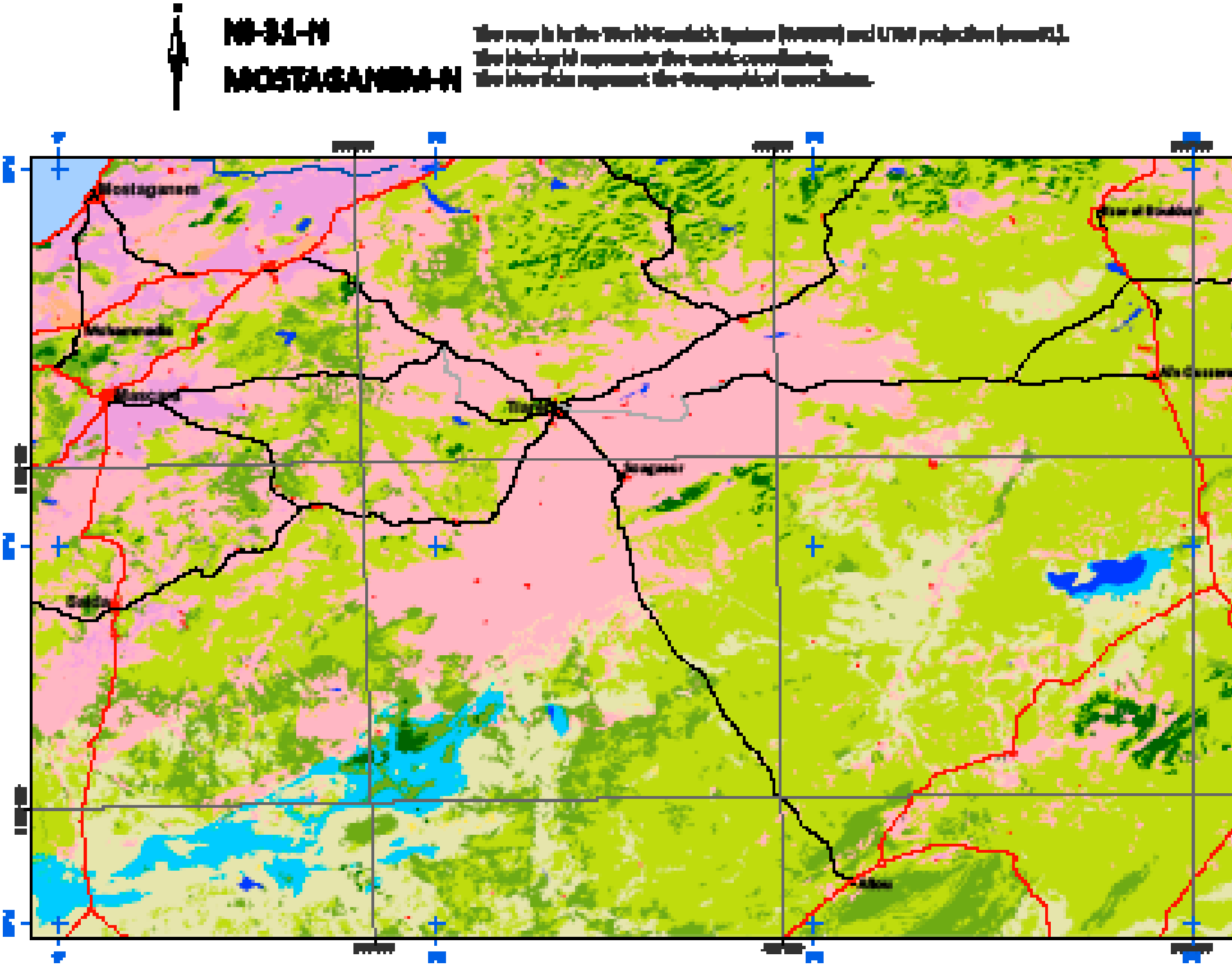
Wetland

- Permanent water body
- Temporary water body
- Agriculture/Wetland

Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road



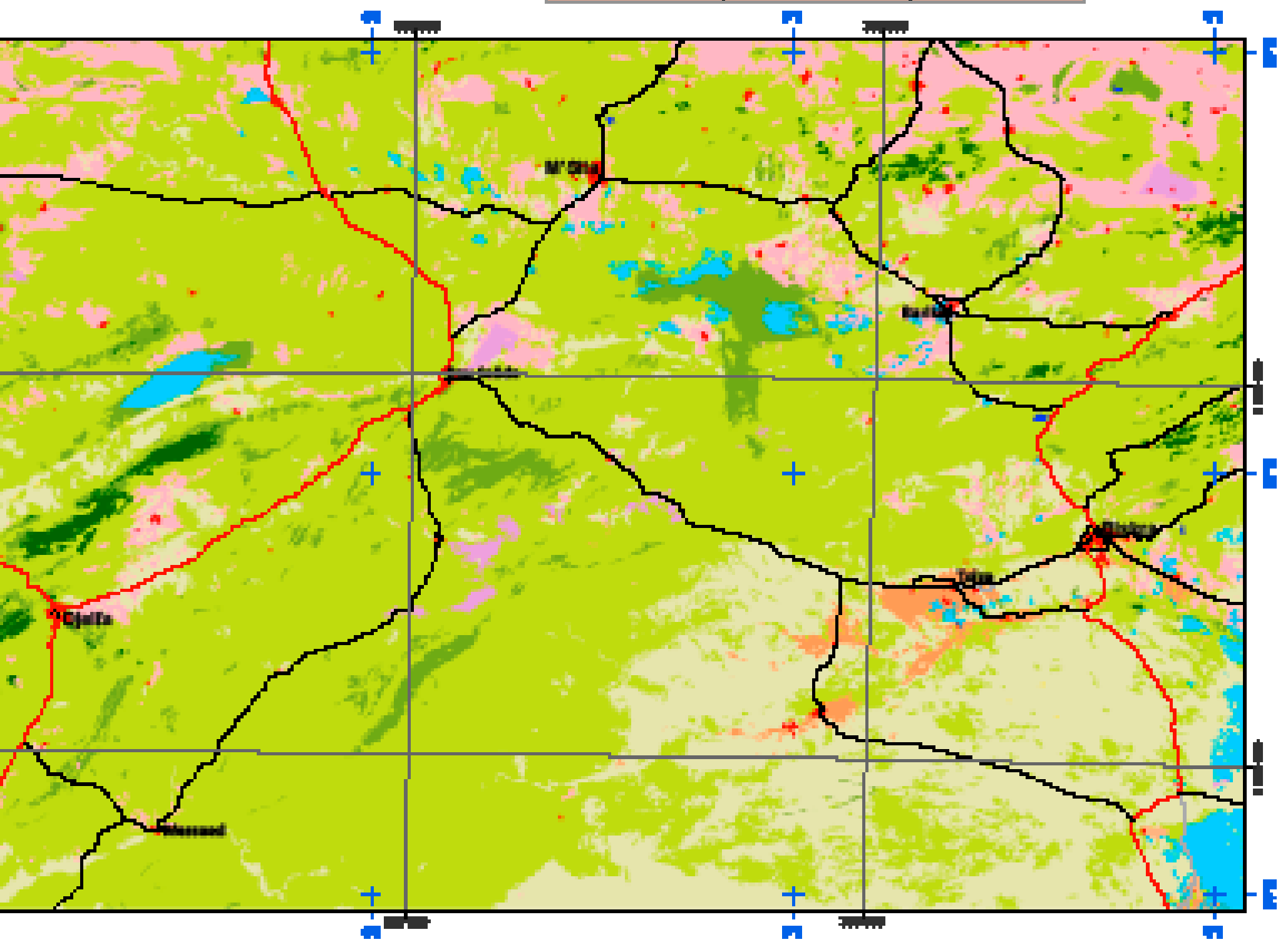
Scale 1:1 000 000

Natural Vegetation

- Forest
- Shrubland
- Steppe/rangeland

Bare Land

- Bare valley/open vegetation
- Sand dunes
- Rock outcrop

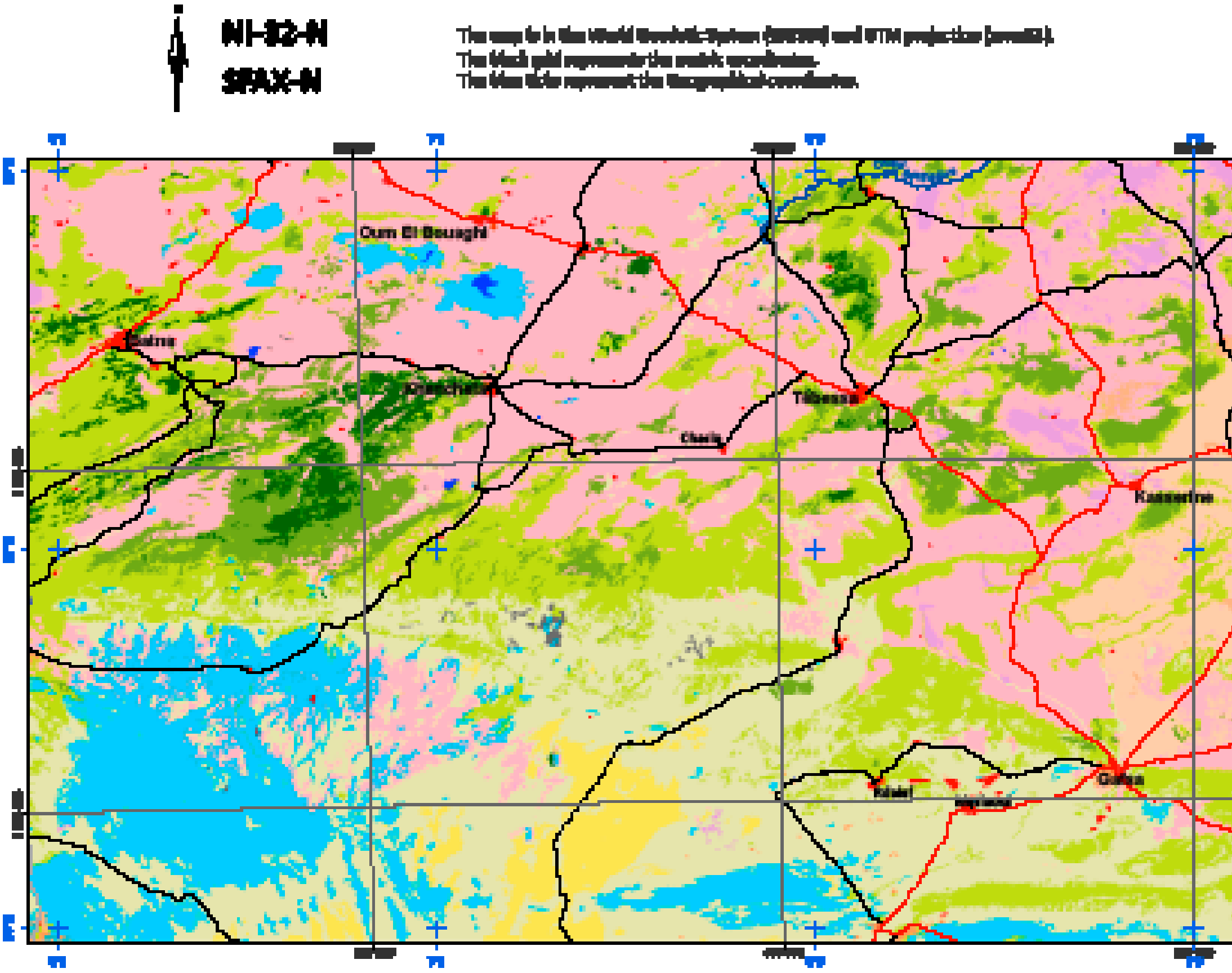


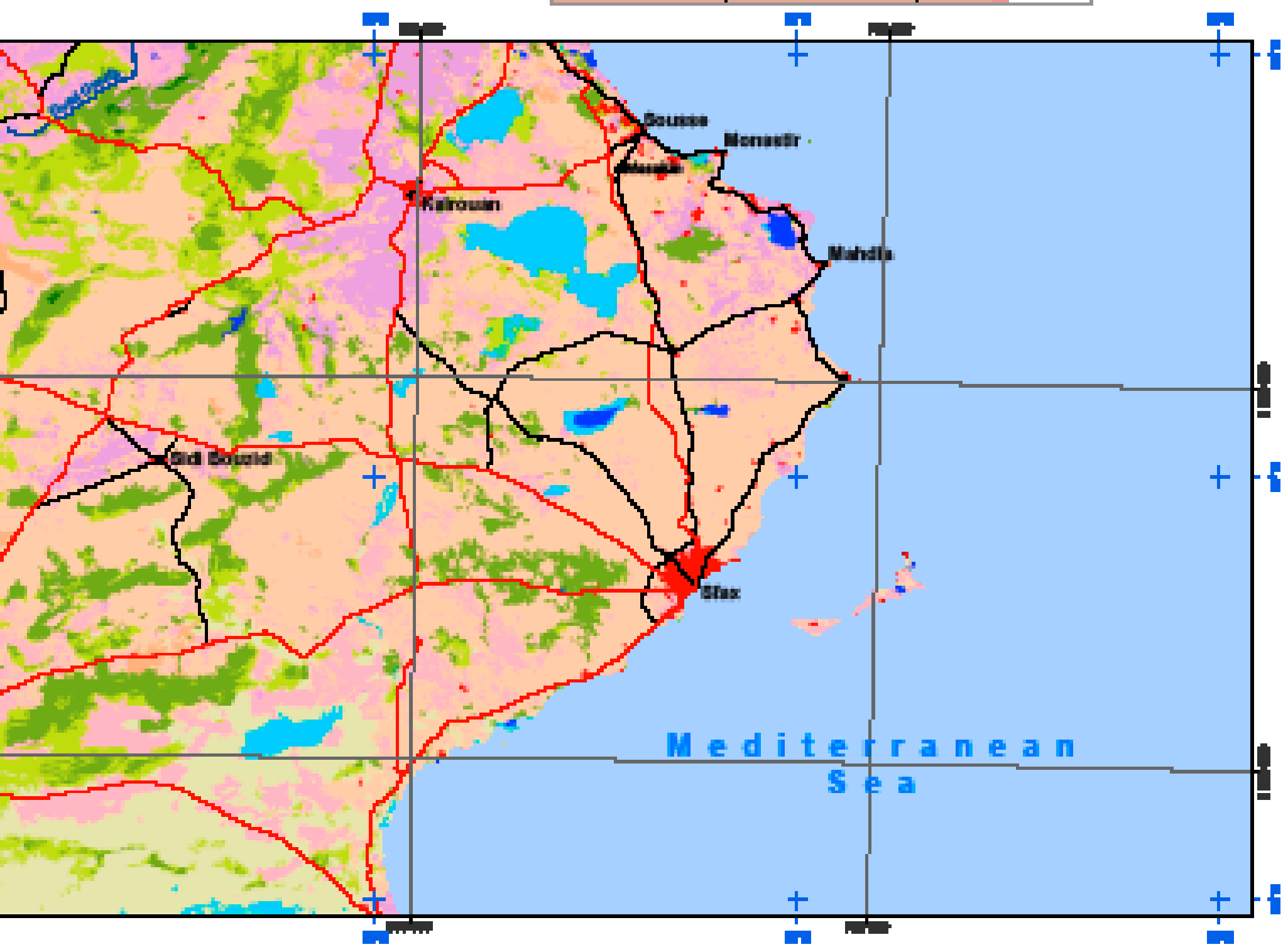
Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Wetland
- Permanent waterbody
- Temporary water body
- Aquaculture/fishery

Built-up Land
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

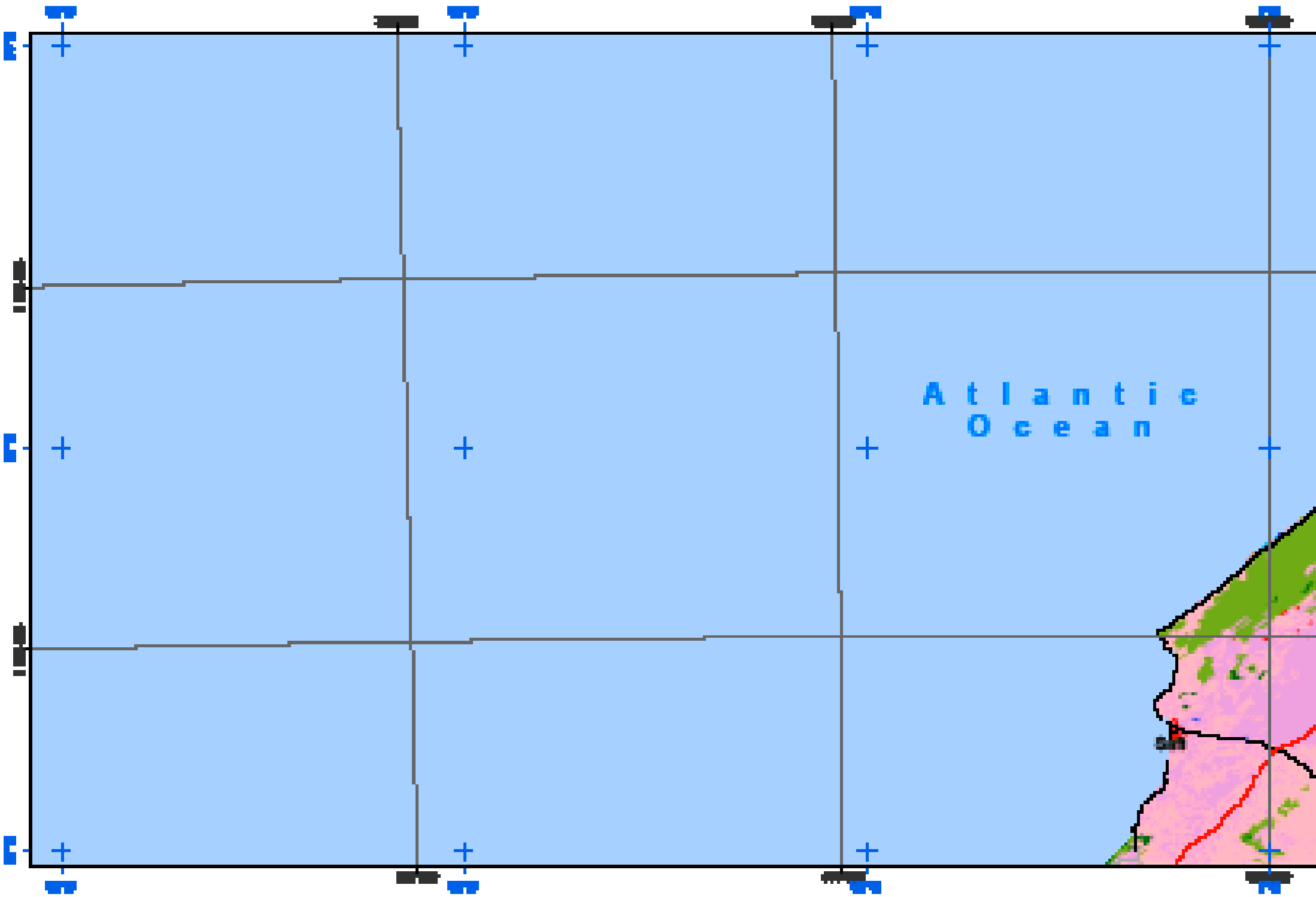

Oum El Bouaghi
Batna
Khenchela
Tébessa
Souk Ahras
Guelma


Sousse
Monastir
Kairouan
Mahdia
Sidi Bouzid
Sfax
Mediterranean
Sea

NA-29-5

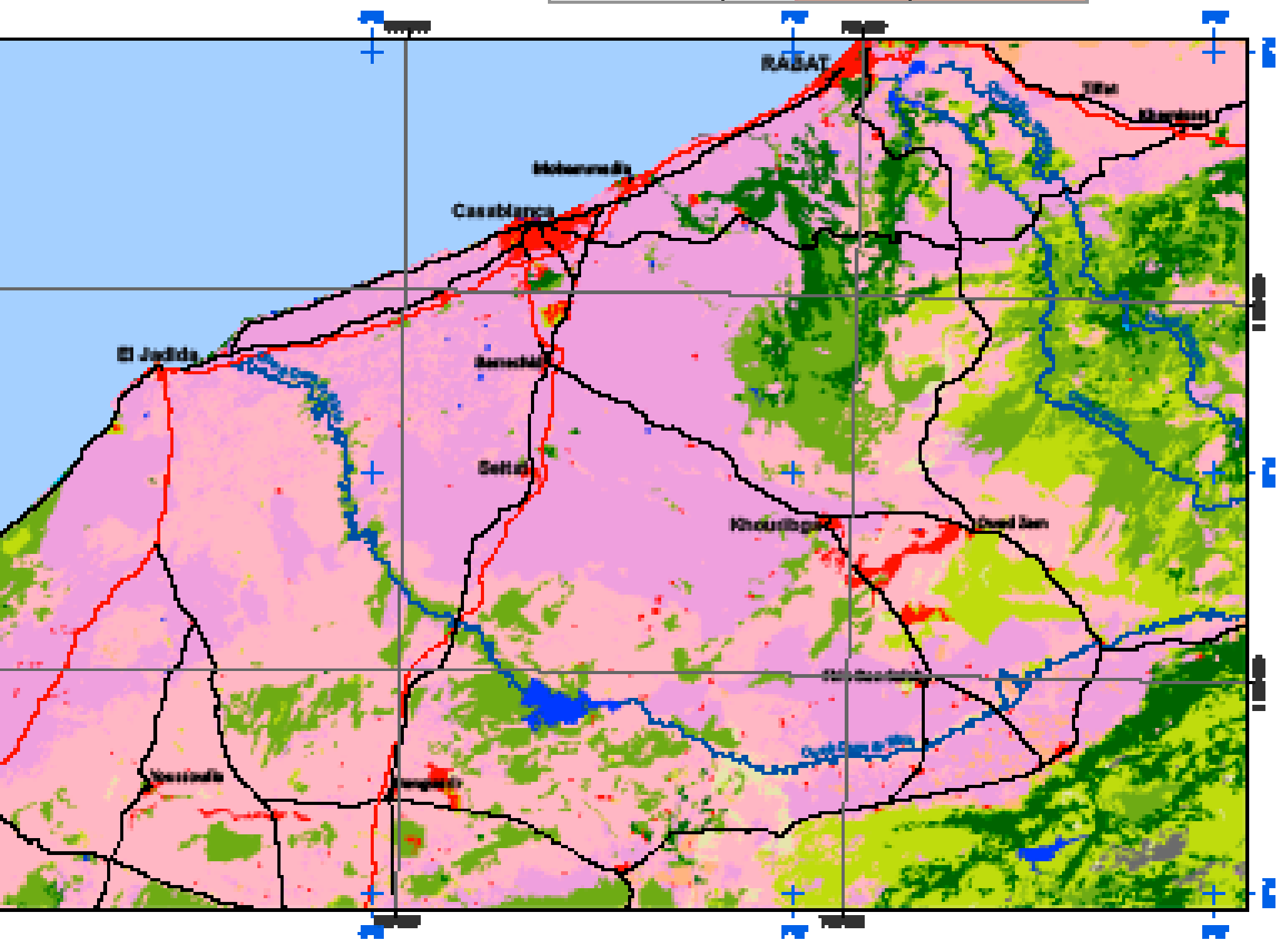
CASABLANCA-5

The map is in the World Geodetic System (WGS84) and UTM projection (zone 29N).
The black grid represents the metric coordinates.
The blue lines represent the geographical coordinates.



Natural Vegetation
Forest
Shrubland
Steppe/Rangeland

Bare Land
Desert with very sparse vegetation
Sand dunes
Rock outcrop

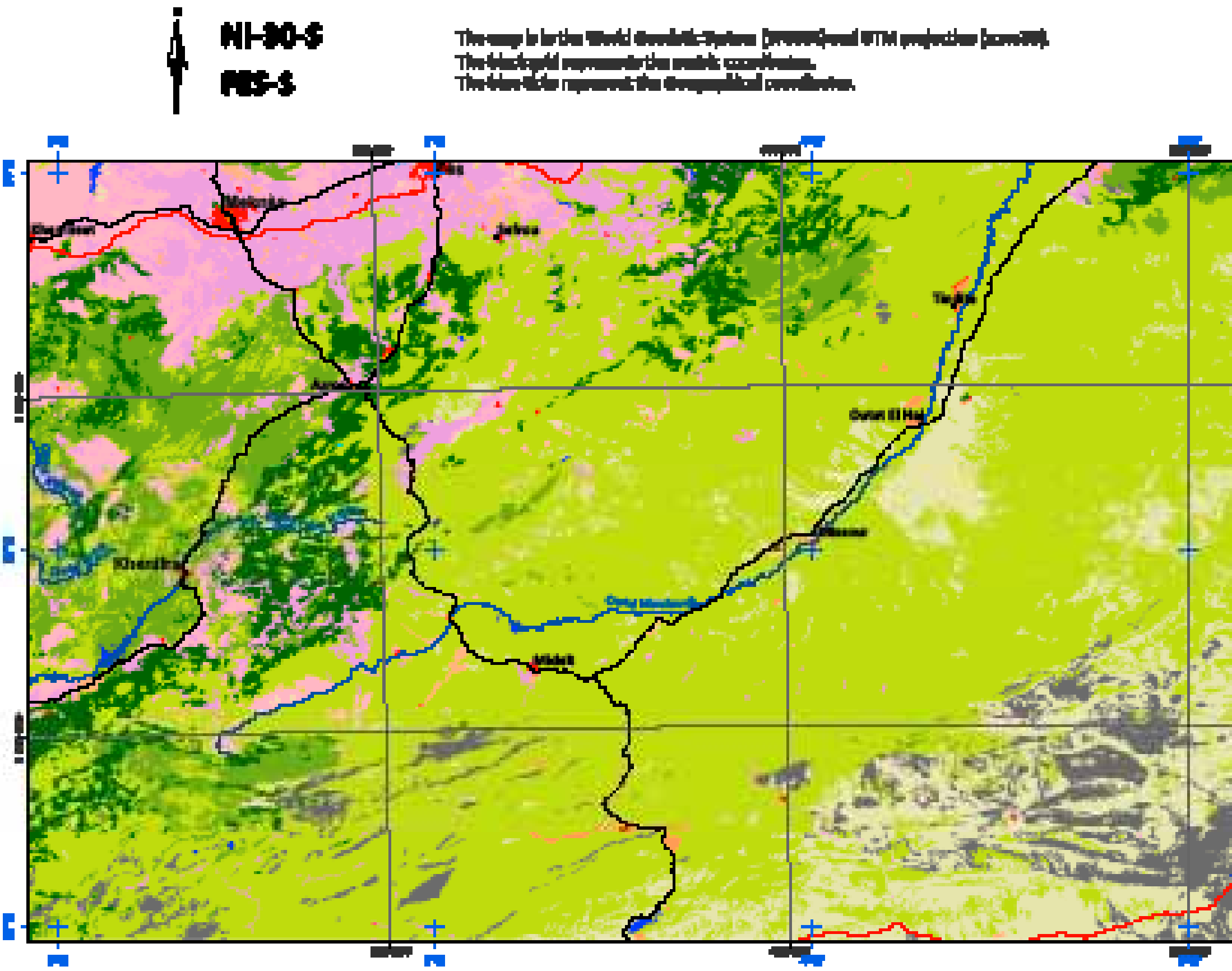


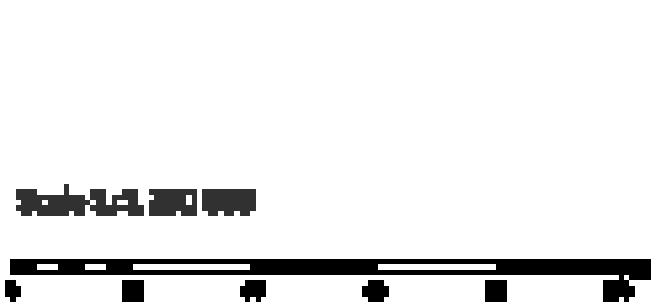
Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

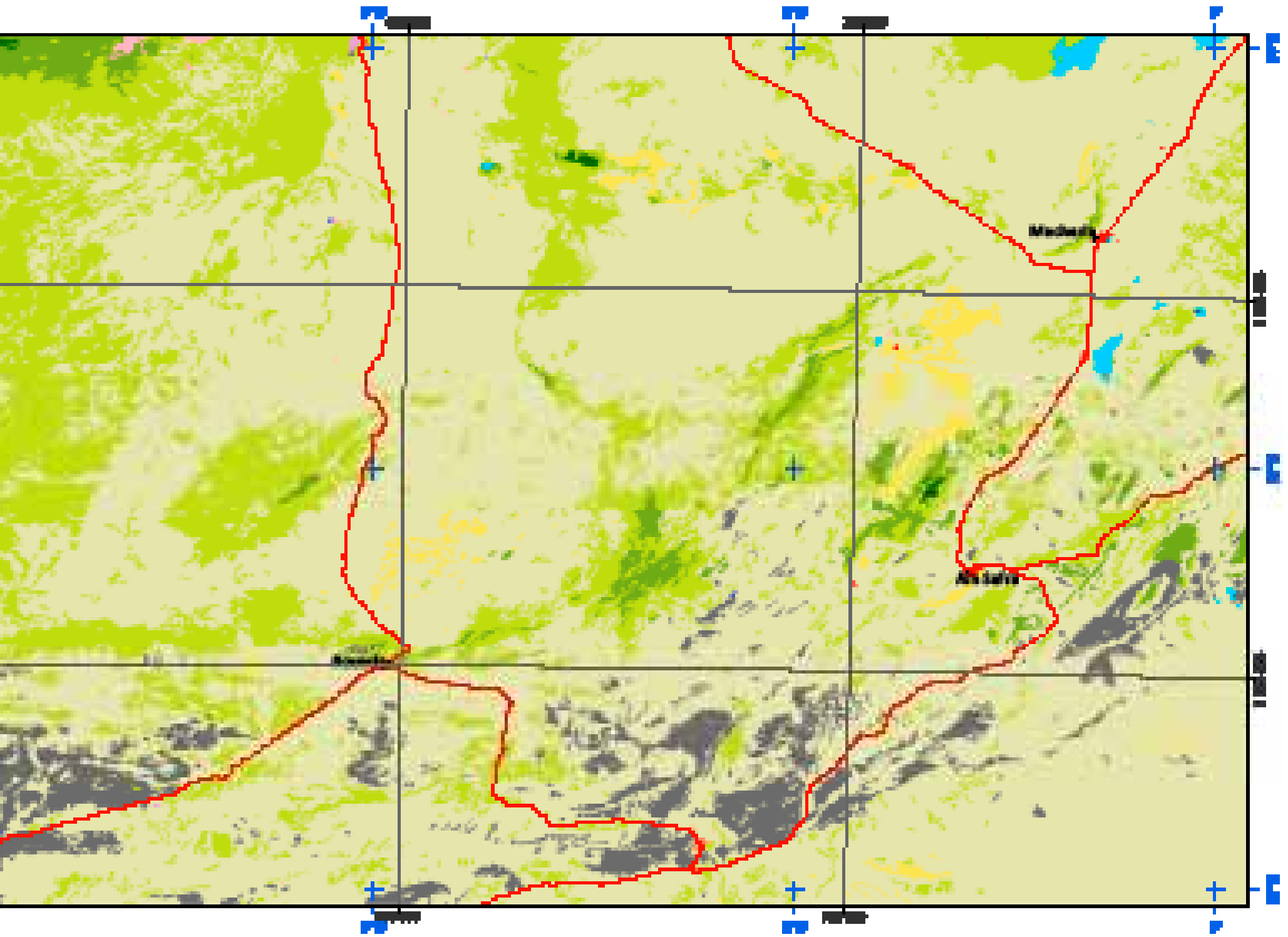
Wetland
- Permanent water body
- Temporary water body
- Aquaculture/saltpan

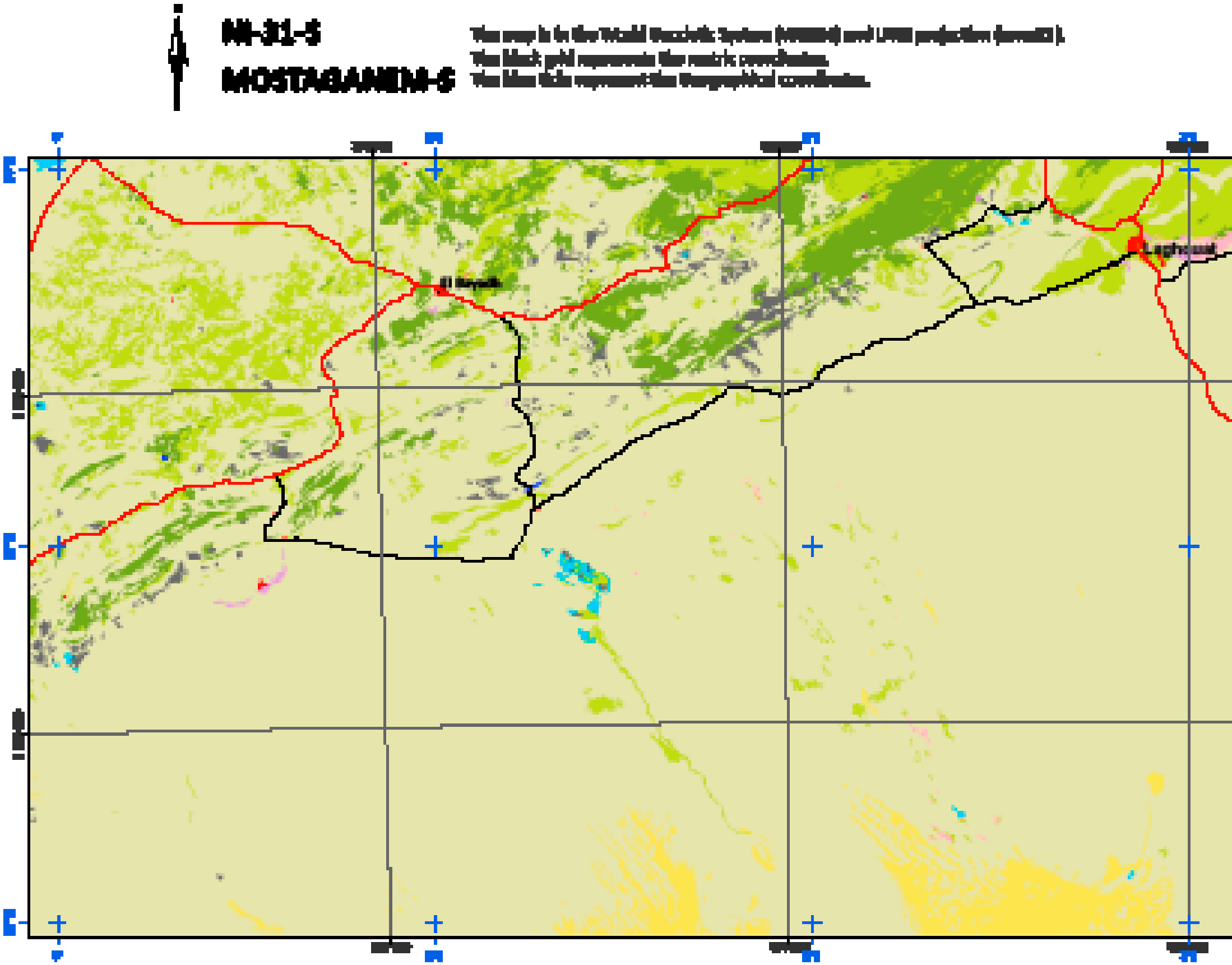
Built-up Land
- Settlement

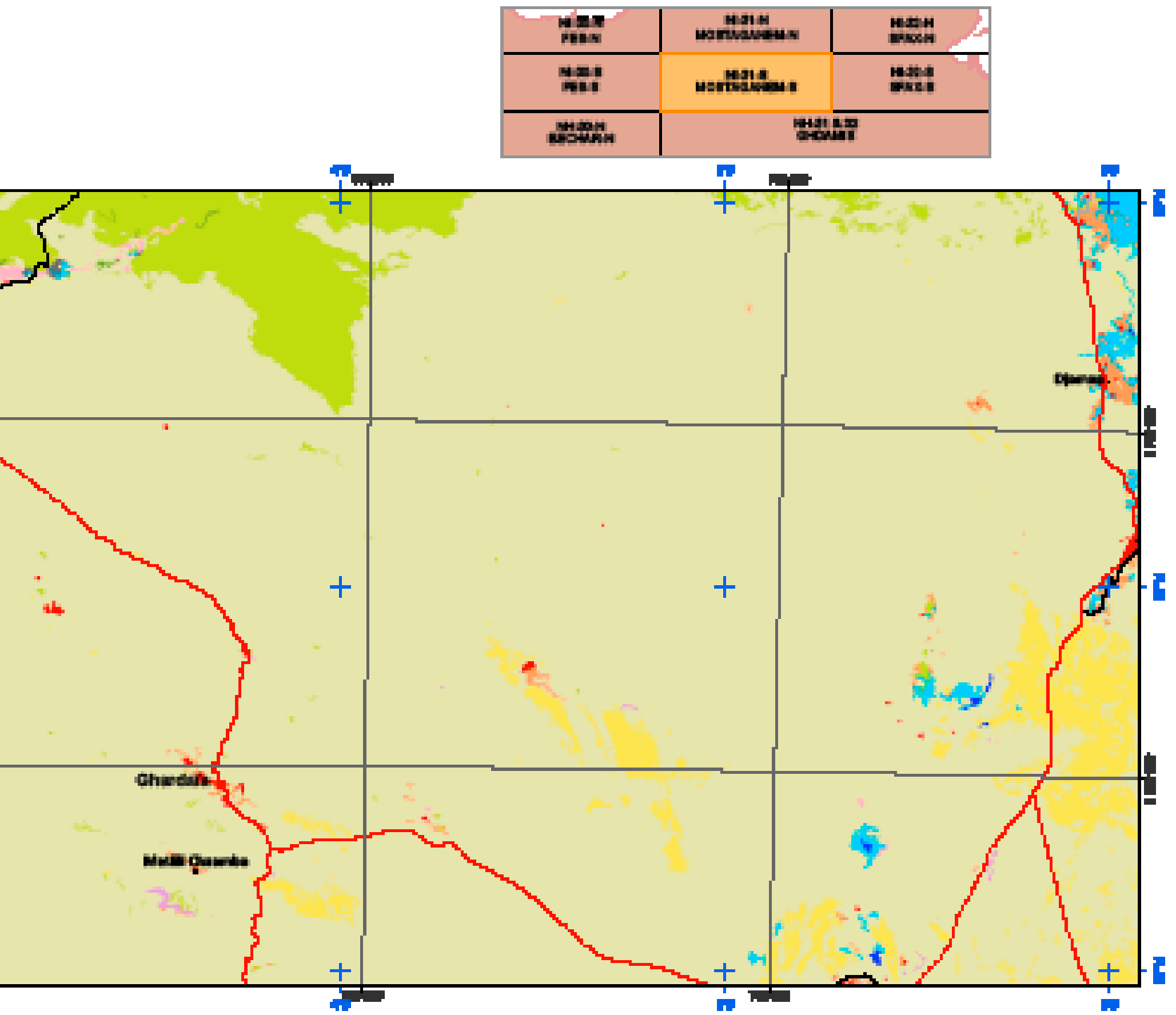
- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


N
W
E
S




Mwimbi
Mwanza
Kahama
Kwimba
Misungwi
Sengerema
Geita


Natural Vegetation
Forest
Shrubland
Grass/Rangeland
Bare Land
Sand dunes
Rock outcrop

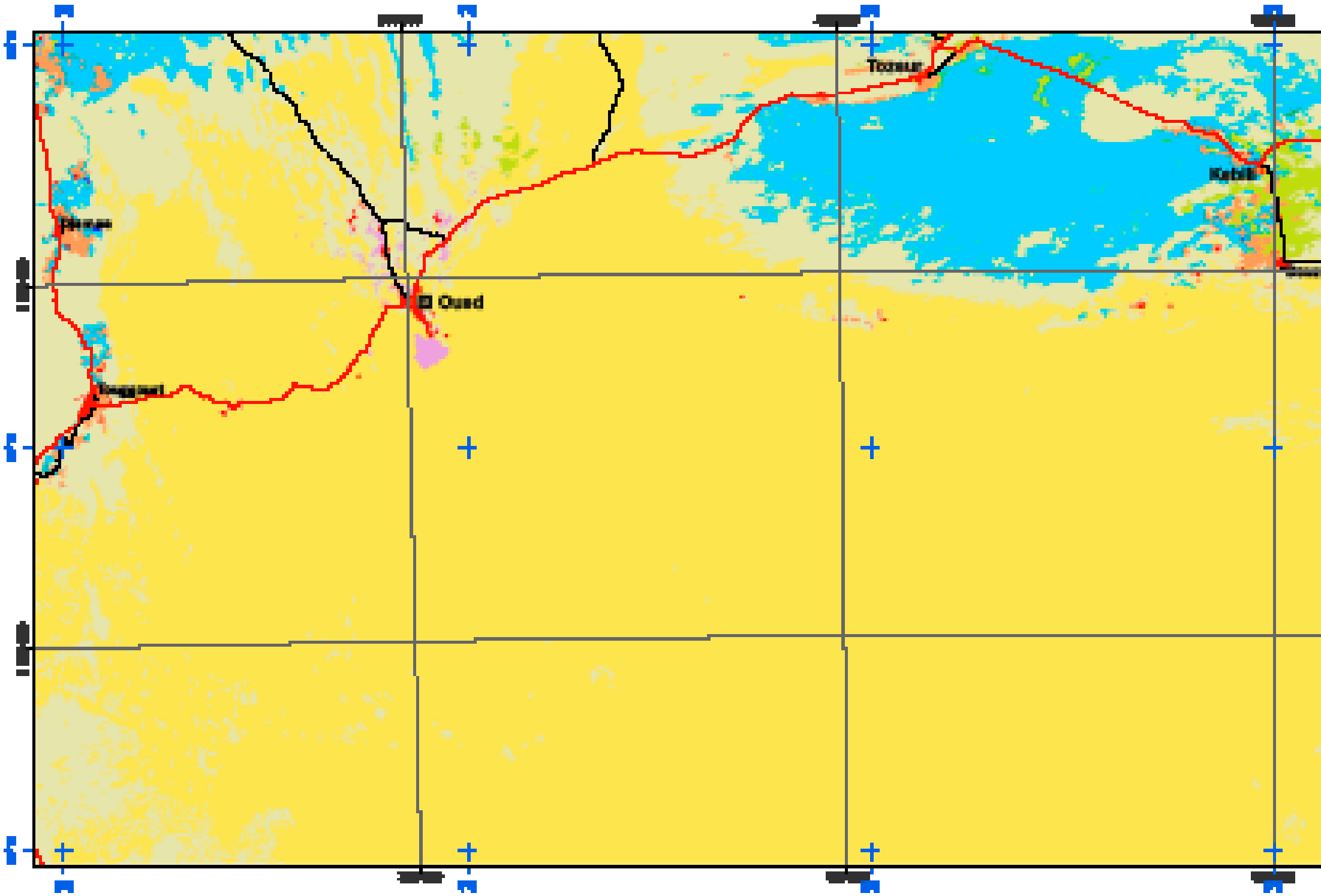


Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Wetland
- Permanent water body
- Temporary water body
- Aquaculture/Saline

Built-up Land
- Settlement

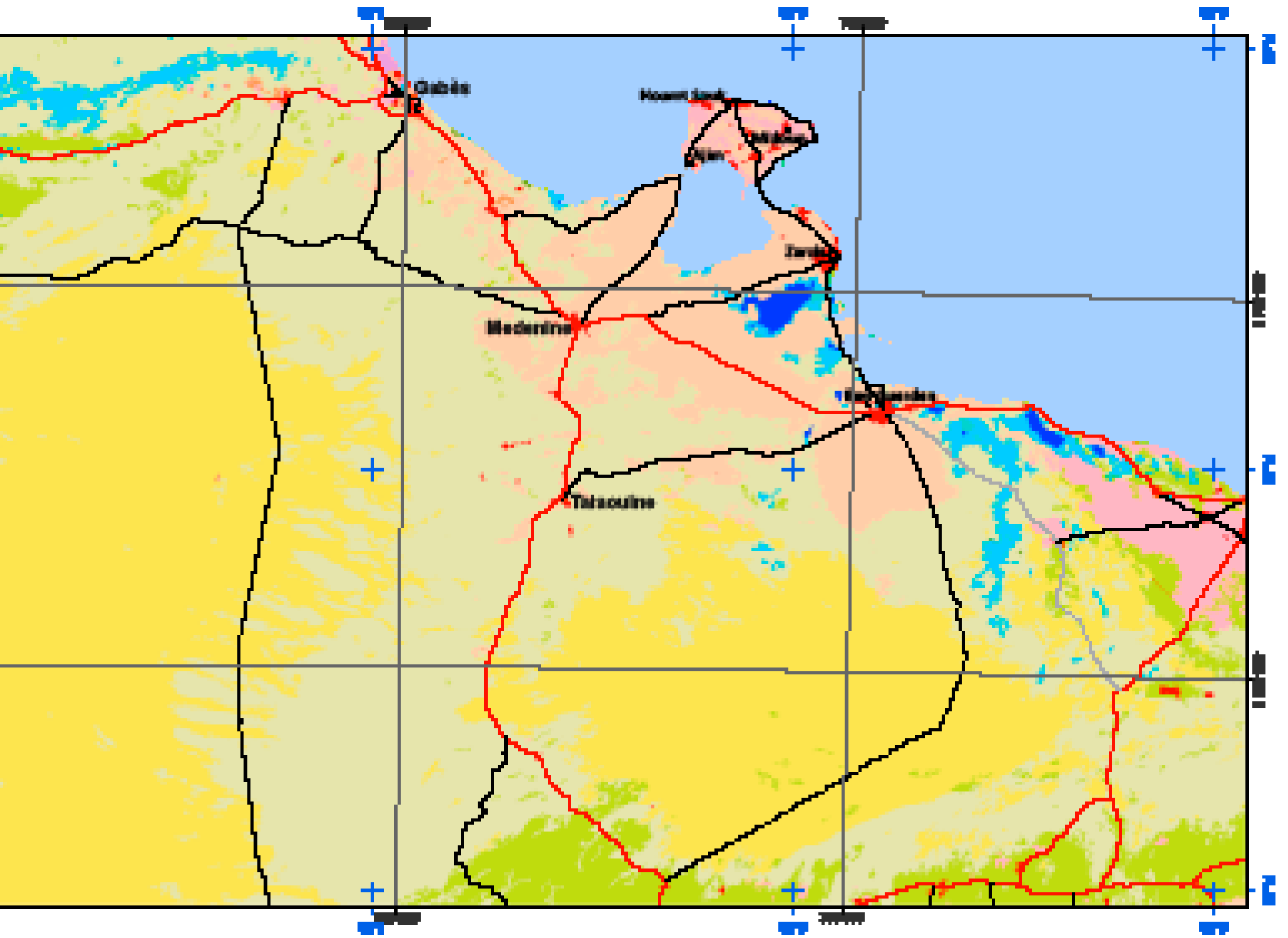
- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road



Scale 1:1 000 000

Natural Vegetation
Forest
Shrubland
Steppe/Rangeland

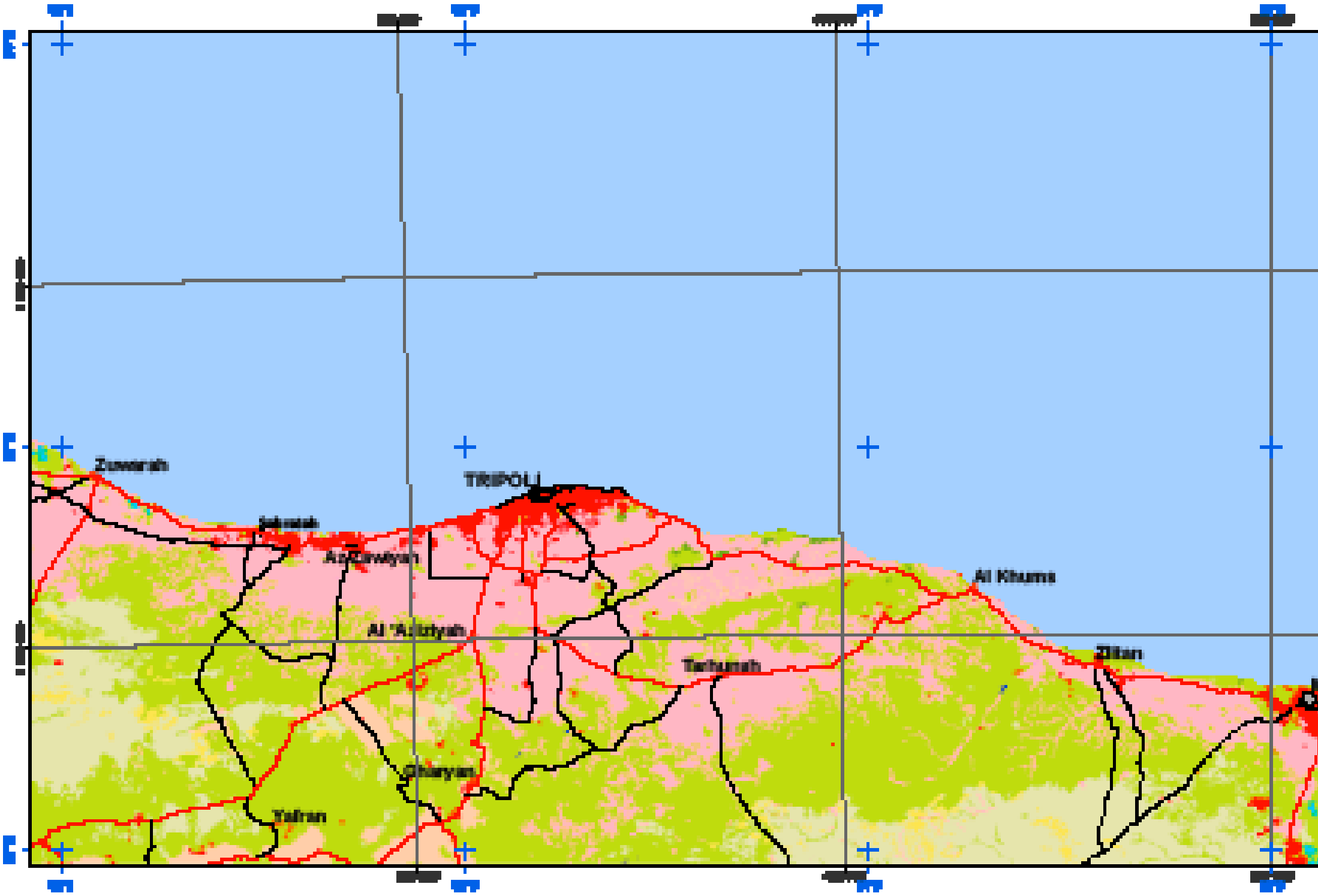
Bare Land
Sparse cultivated/sparse vegetation
Desert dunes
Rock outcrop


Gabès
Medenine
Tataouine

NI-33-5

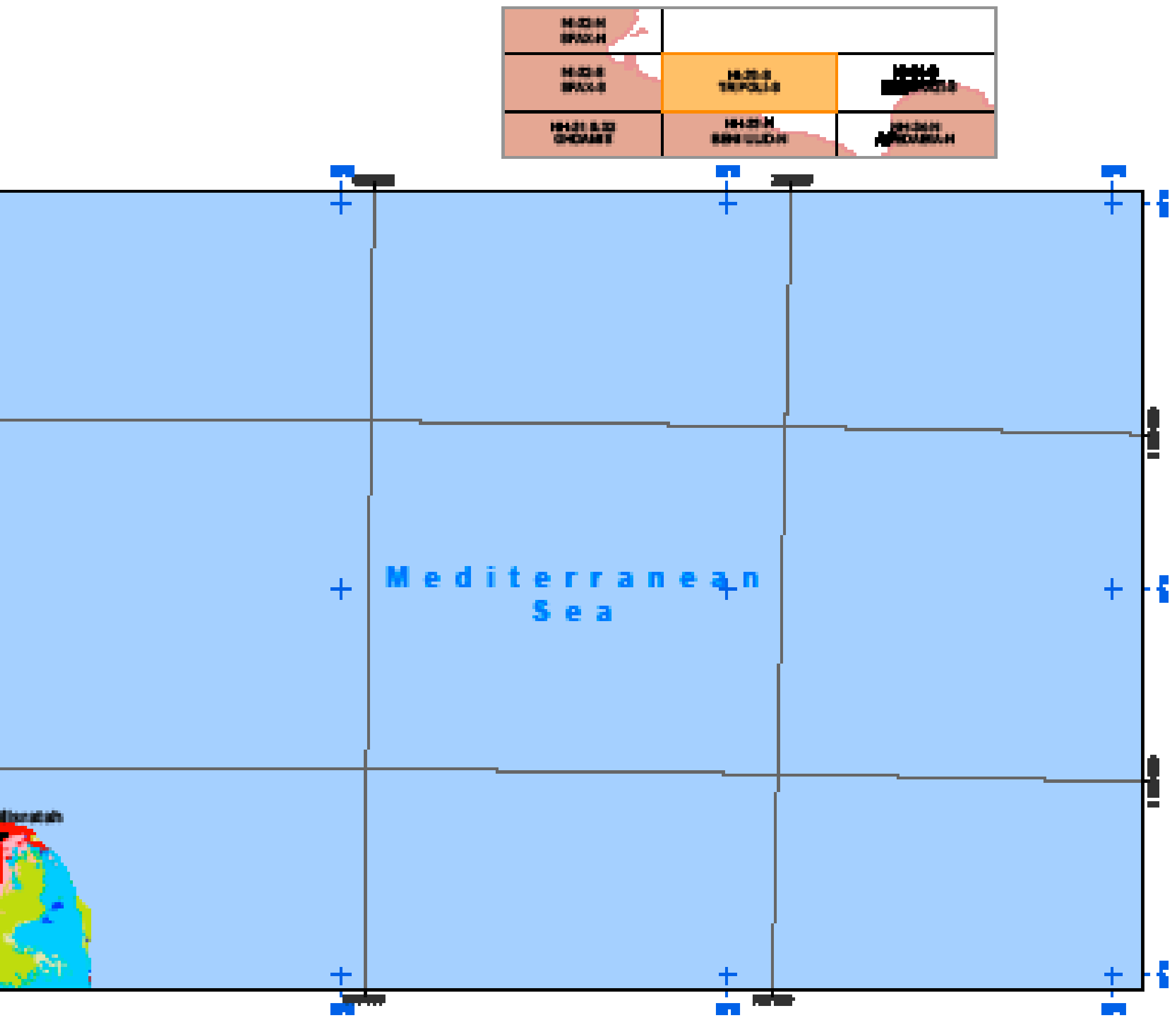
TRIPOLI-5

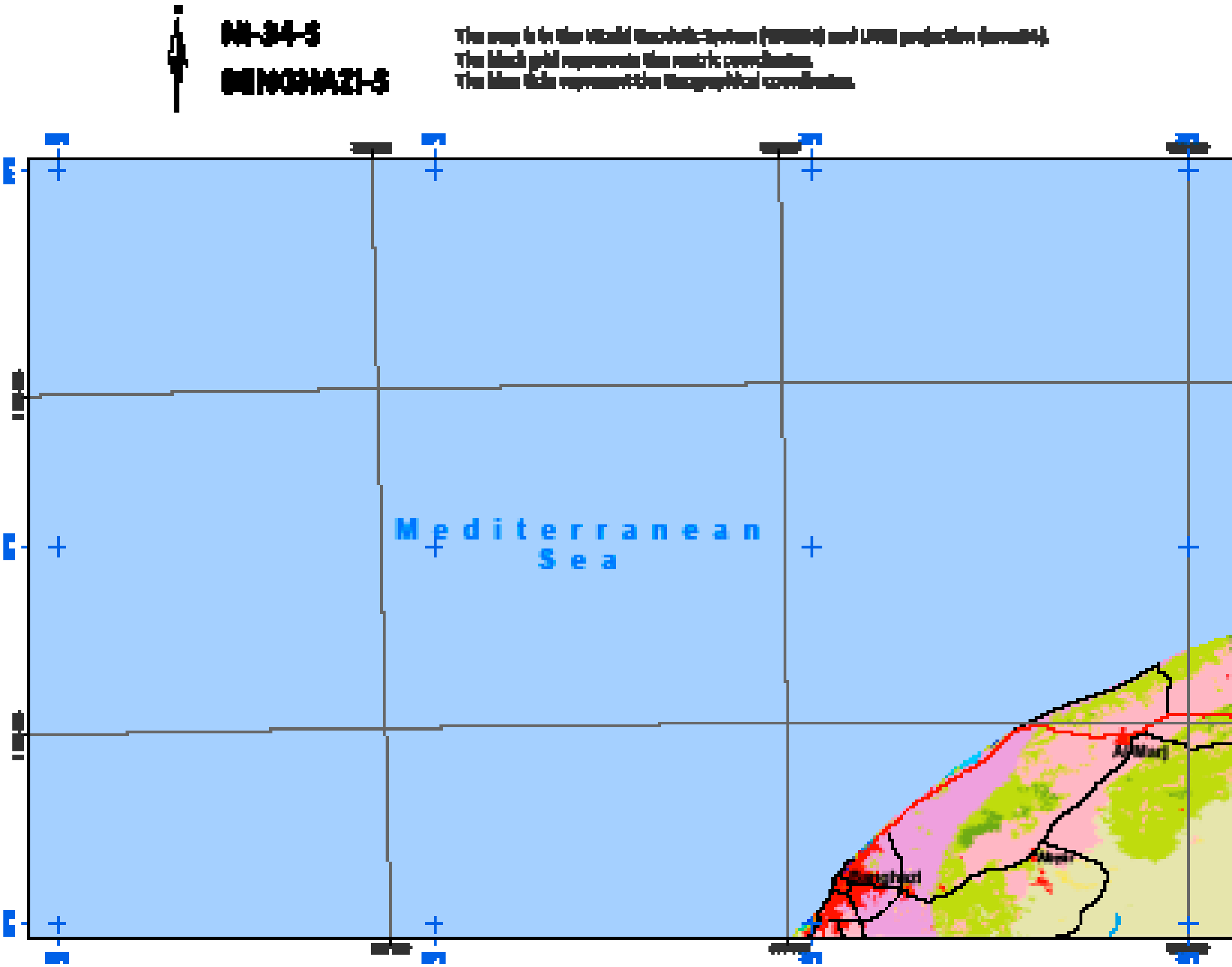
The map is in the World Geodetic System (1984) and UTM projection (zone 33).
The black grid represents the metric coordinates.
The blue dots represent the Geographical coordinates.

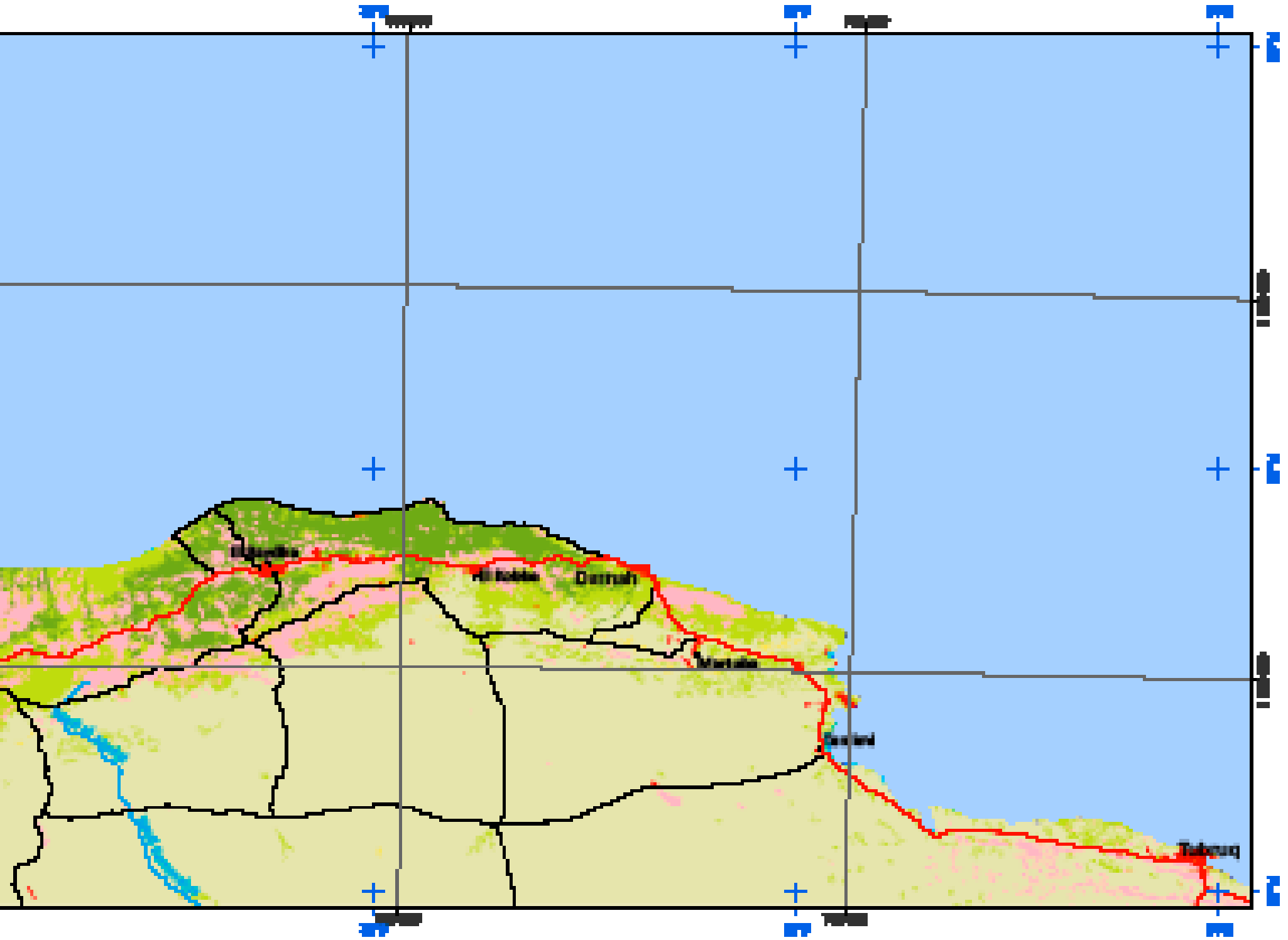


Natural Vegetation
Forest
Shrubland
Steppe/Rangeland

Bare Land
Barren soil/very sparse vegetation
Sand dunes
Rock outcrop


Mediterranean
Sea


Mediterranean
Sea



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Wetland

- Permanent water body
- Temporary water body
- Agriculture/Wetland

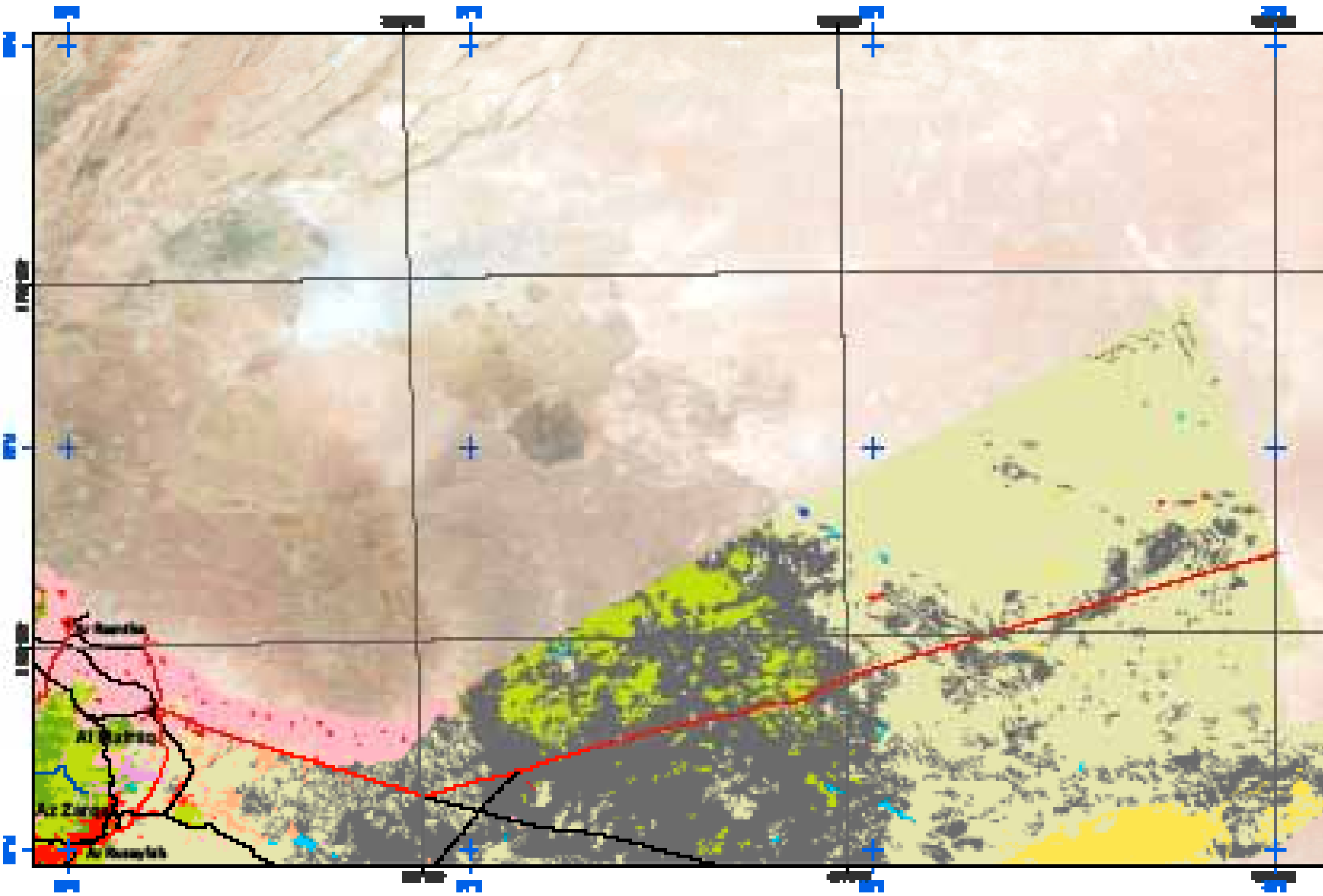
Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

NI-37-5

DAMASCUS-5



Scale 1:1 000 000

Natural Vegetation

Forest

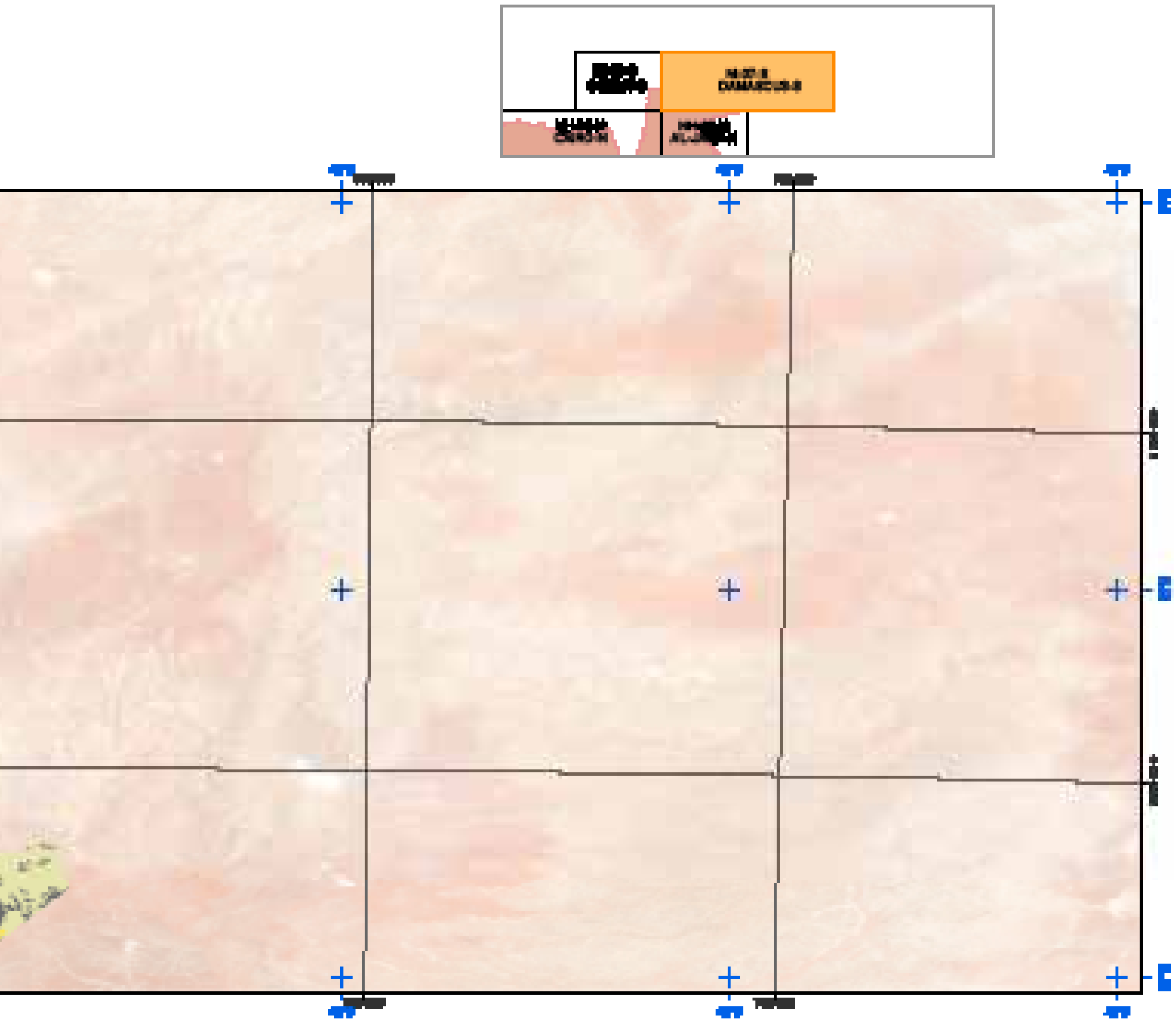
Shrubland

Grassland/Steppeland

Bare Land

Sand dunes

Rock outcrop



Cultivated Land

Irrigated perennial crops

Rainfed perennial crops

Irrigated annual crops

Rainfed annual crops

Oasis

Wetland

Permanent waterbody

Temporary water body

Aquaculture/saltpans

Built-up Land

Settlement

Perennial rivers

Intermittent rivers

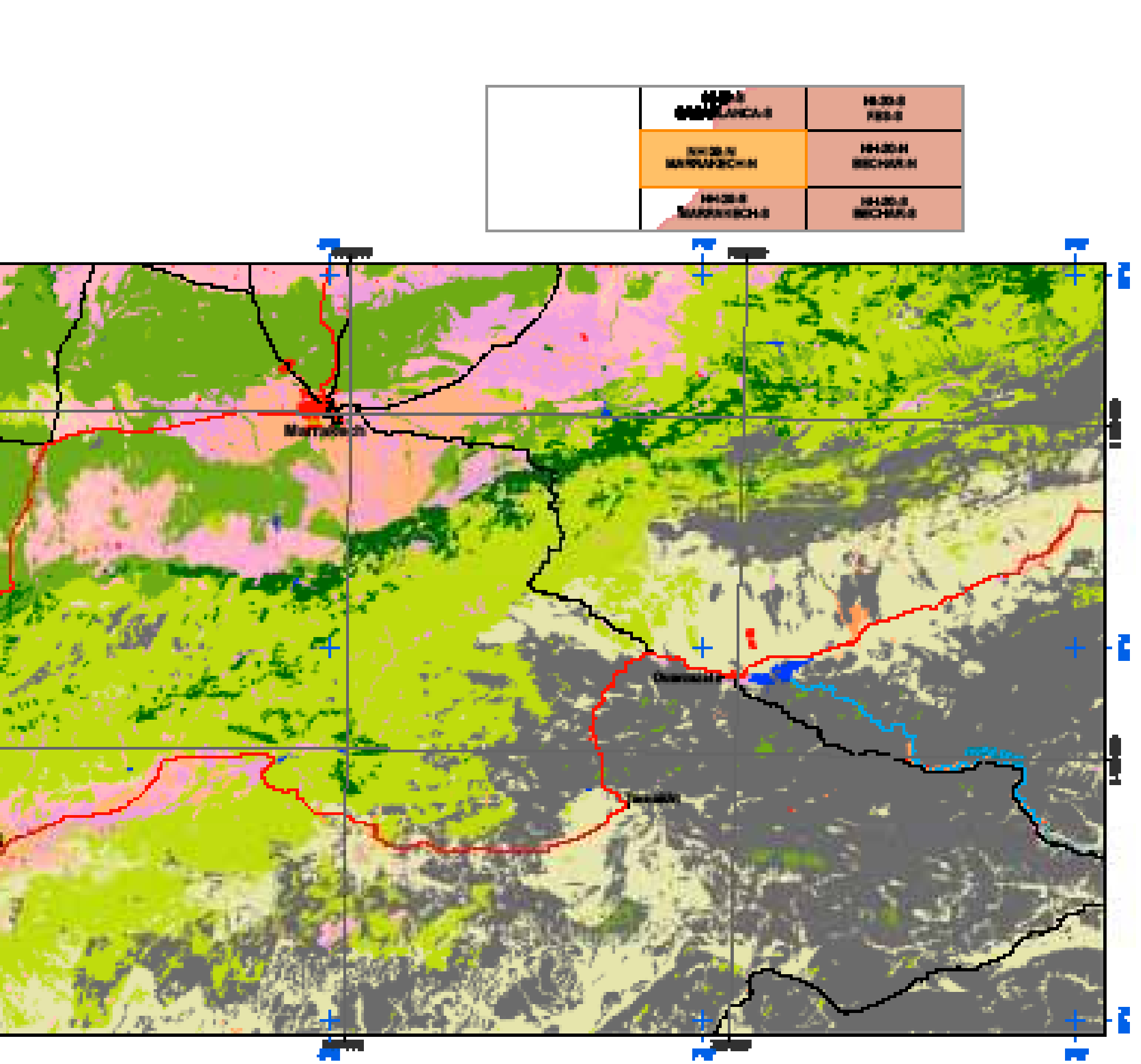
Canal

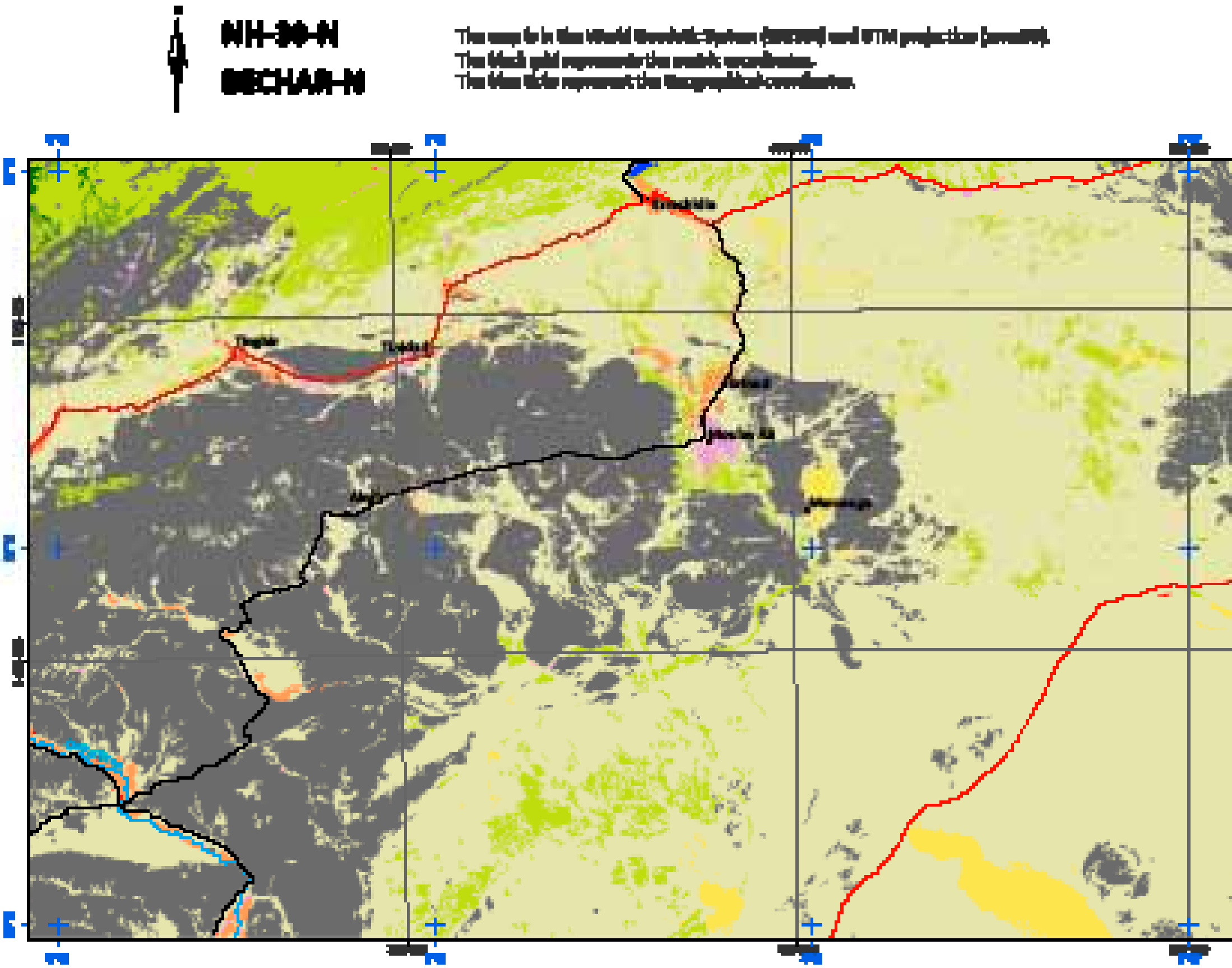
Primary road

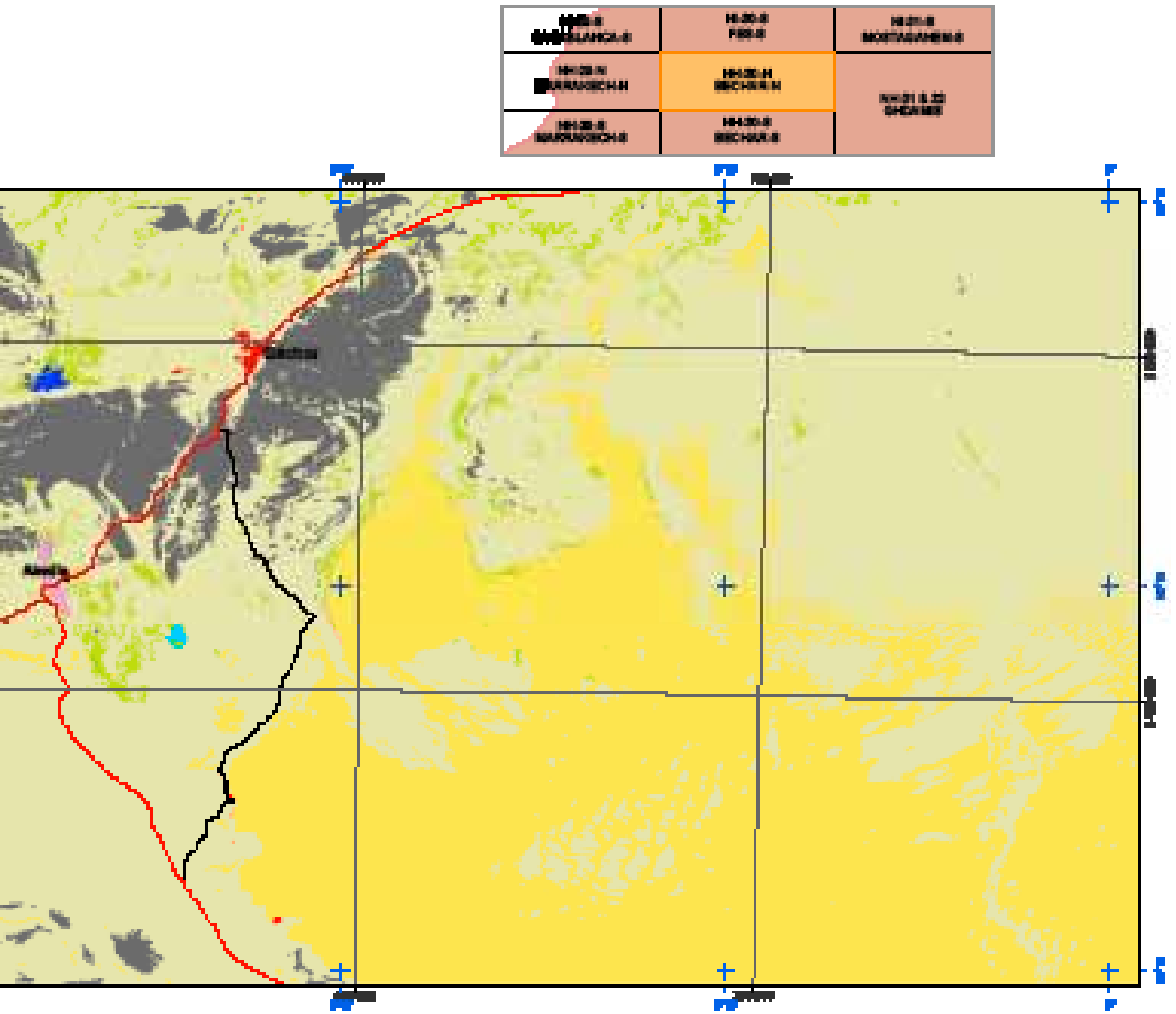
Secondary road

Tertiary road


Atlantic
Ocean


Marrakech
Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Natural
Permanent water body
Temporary water body
Agricultural water
Built-up Land
Settlement
Perennial stream
Intermittent stream
Canal
Primary road
Secondary road
Tertiary road


Natural Vegetation
Forest
Shrubland
Grass/Rangeland
Bare Land
Barren or sparsely vegetated
Sand dunes
Rock outcrop



Cultivated Land

Irrigated perennial crops

Rainfed perennial crops

Irrigated annual crops

Rainfed annual crops

Oasis

Wetland

Permanent water body

Temporary waterbody

Aquaculture/Saline

Built-up Land

Settlement

Perennial stream

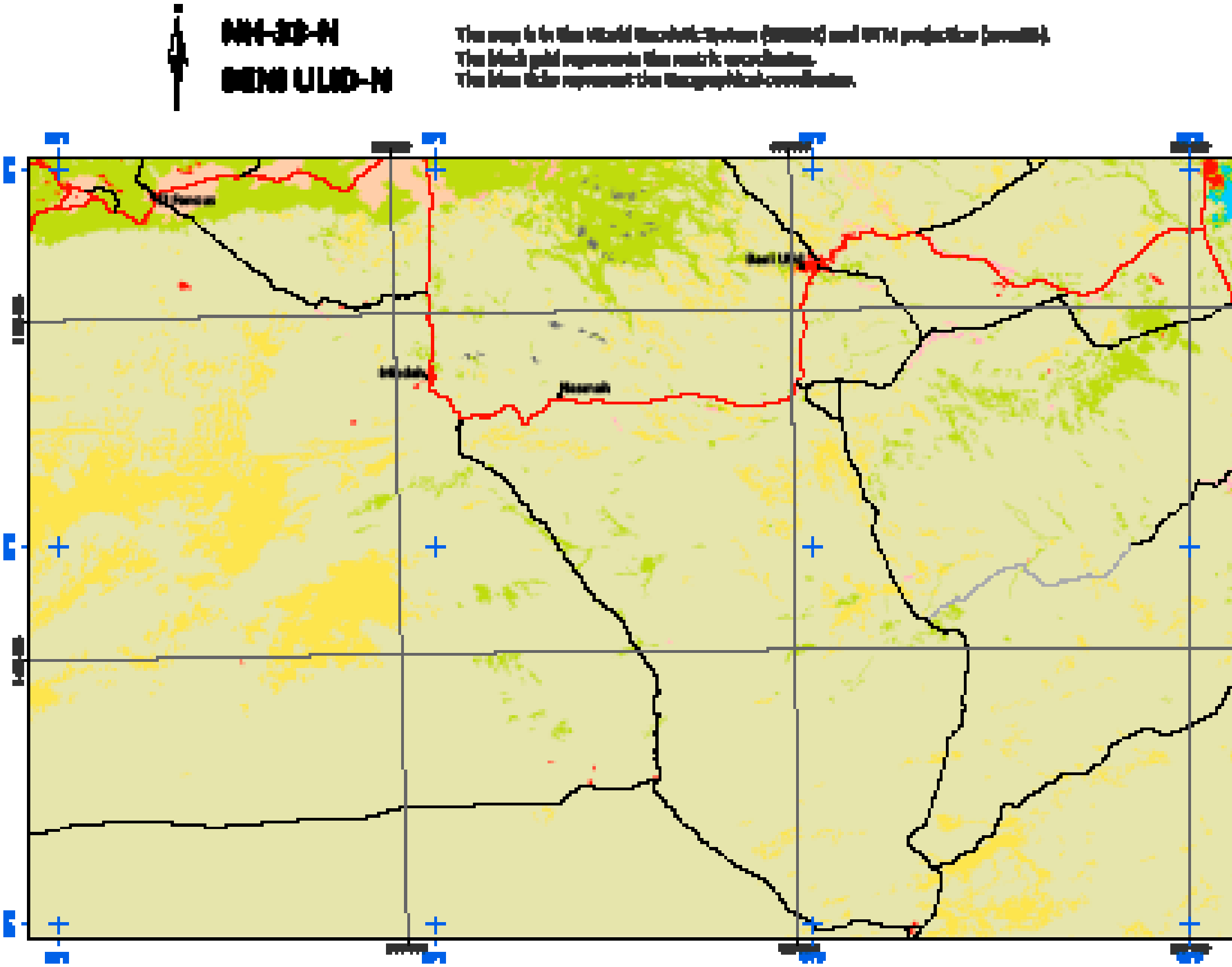
Intermittent stream

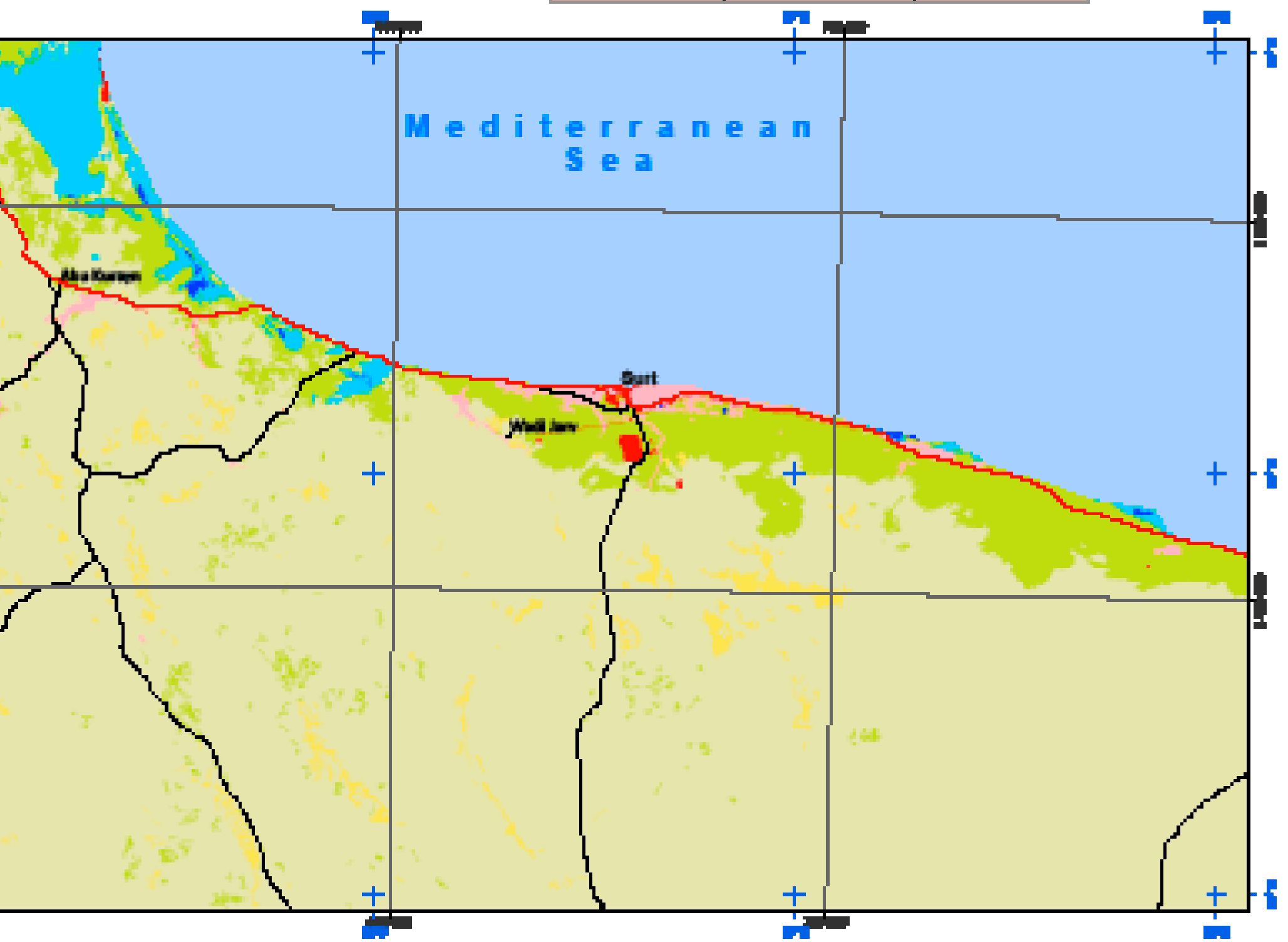
Canal

Primary road

Secondary road

Tertiary road


Natural Vegetation
Forest
Shrubland
Grassland
Bare Land
Sparse vegetation
Sand dunes
Rock outcrop



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

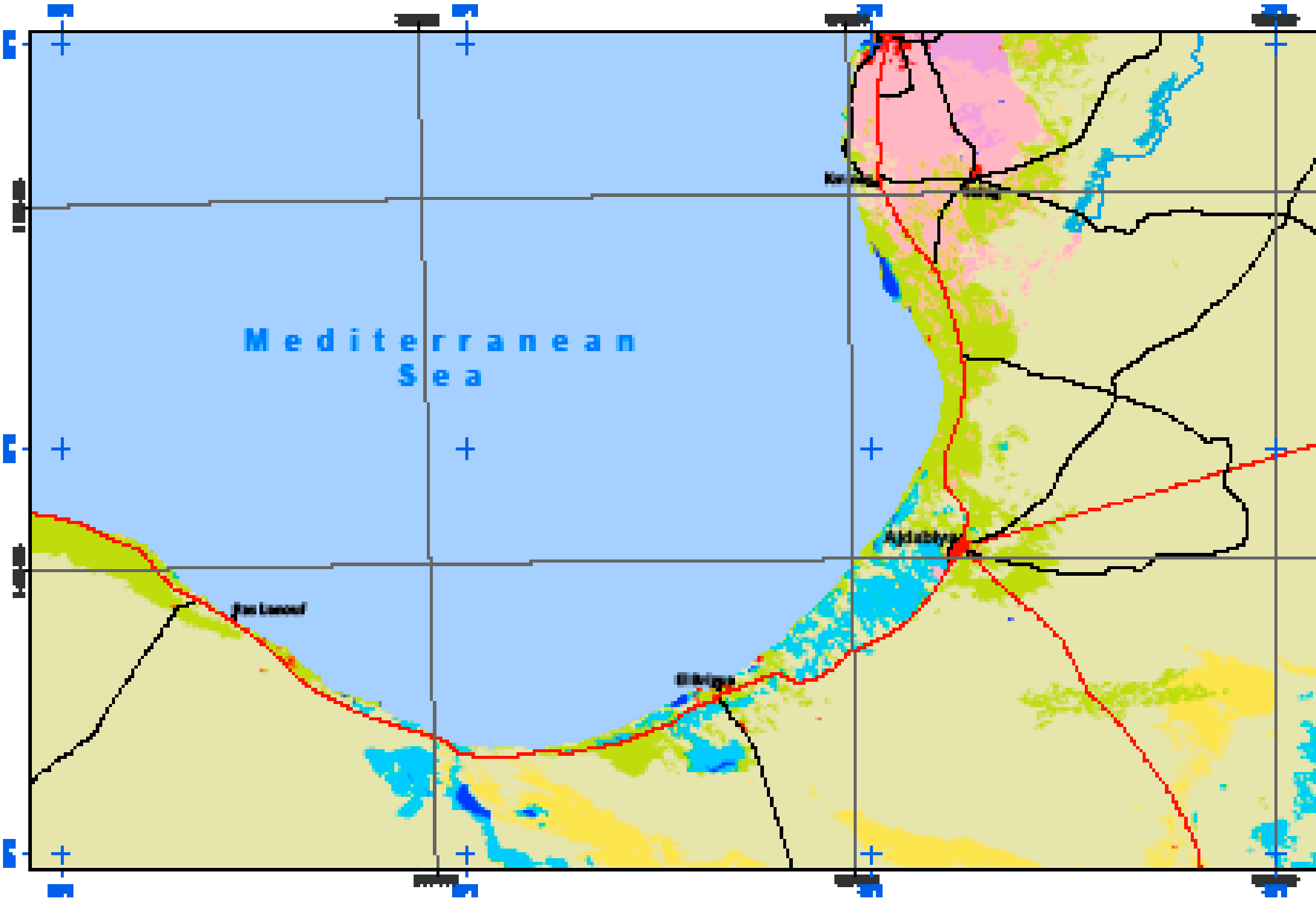
Wetland

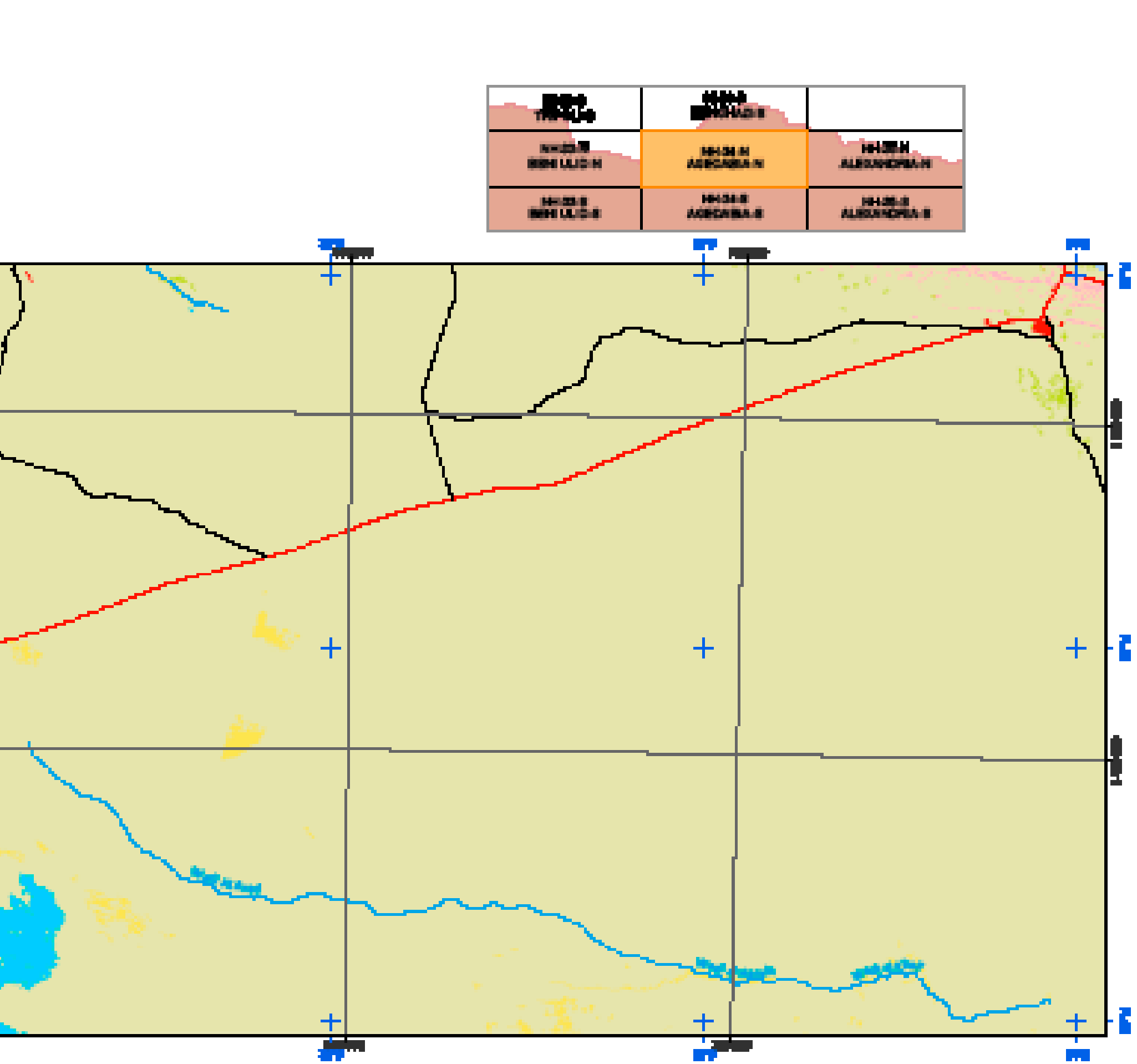
- Permanent water body
- Temporary waterbody
- Aquaculture/saline

Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


Mediterranean
Sea



Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Clouds

Wetland
- Permanent water body
- Temporary water body
- Agricultural wetland

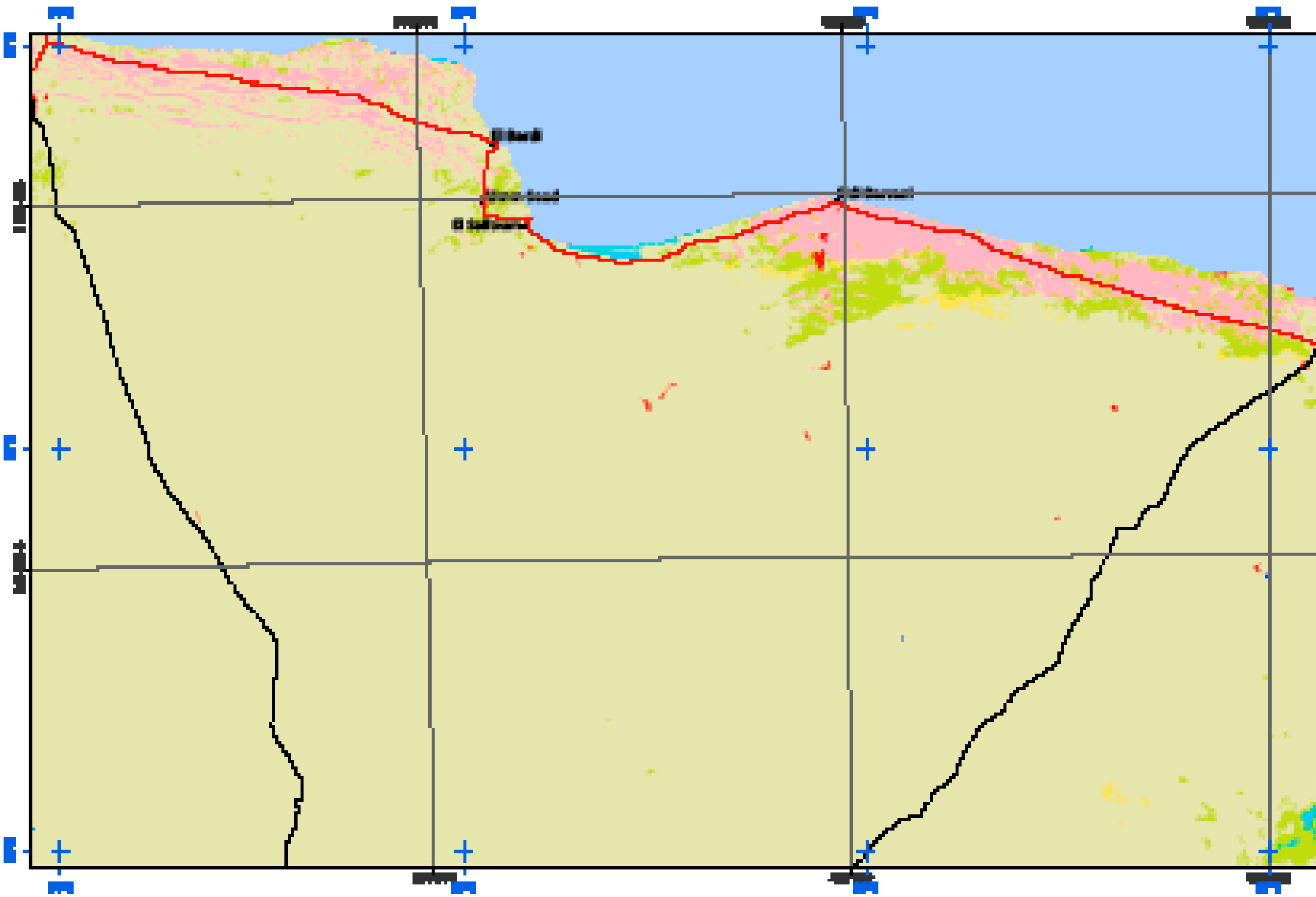
Built-up Land
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

NH-35-N

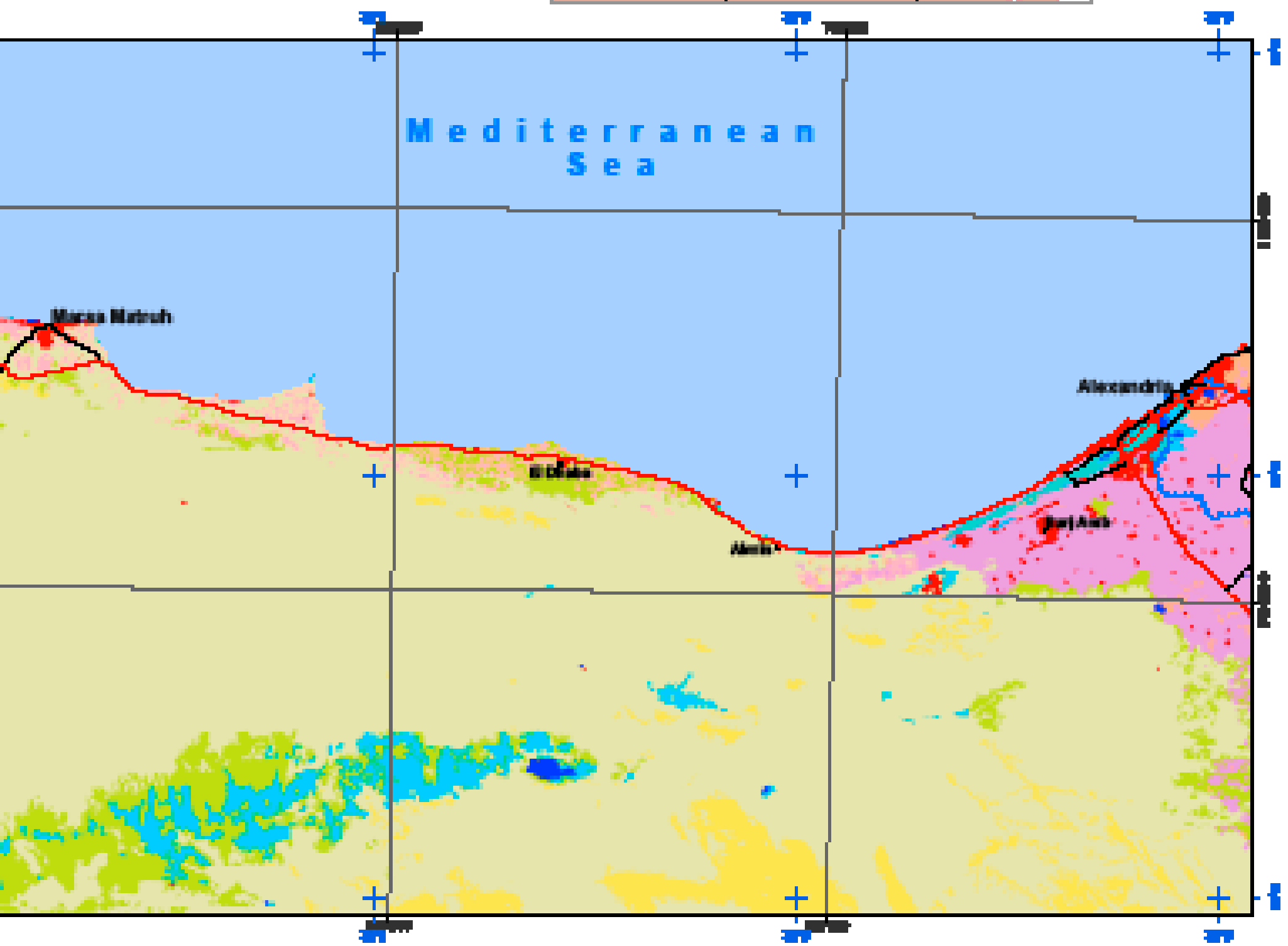
ALEXANDRIA-N

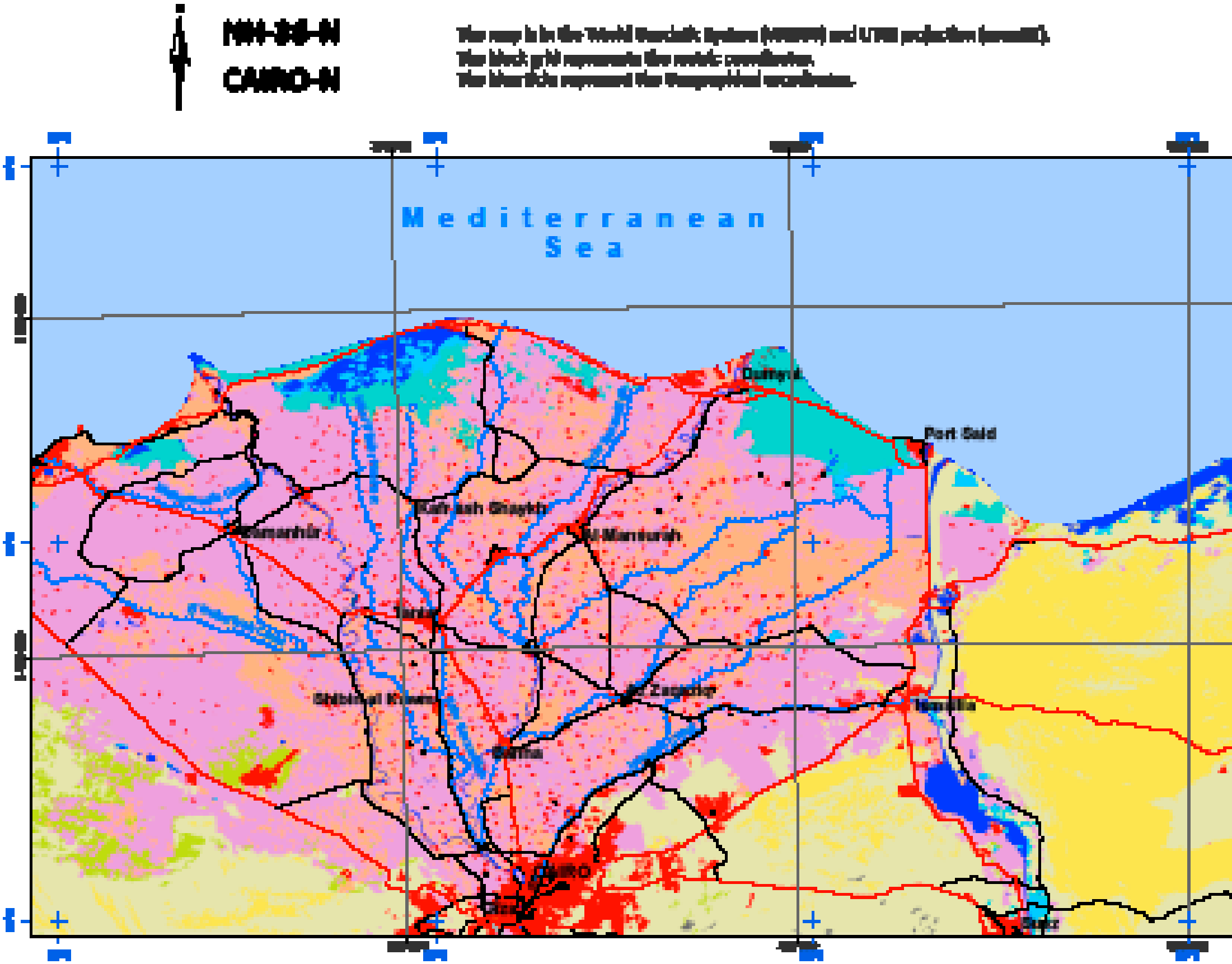
The map is in the World Geodetic System (WGS84) and UTM projection (zone 36).
The black grid represents the metric coordinates.
The blue dots represent the Geographic coordinates.

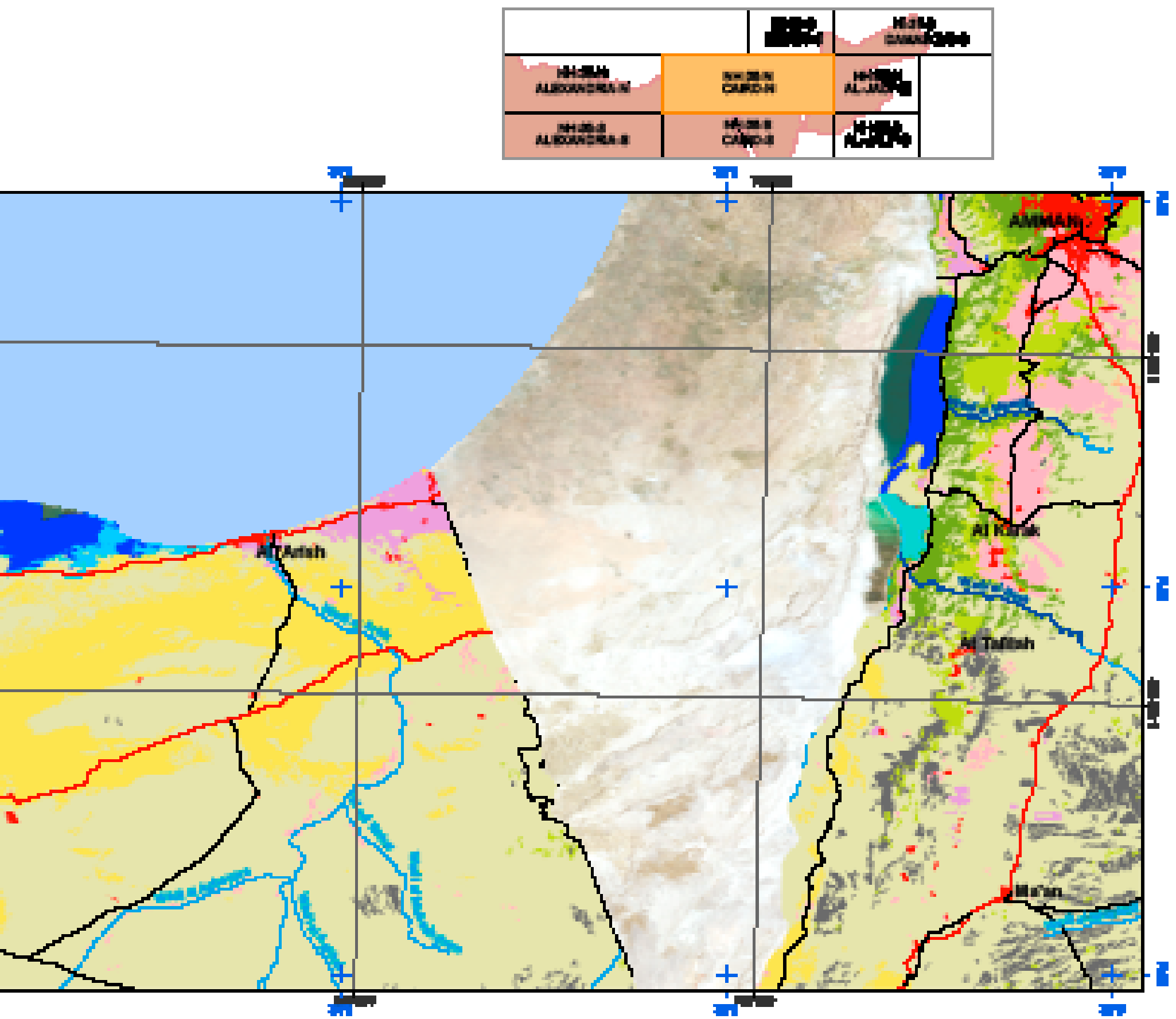


Natural Vegetation
- Forest
- Shrubland
- Steppe/Rangeland

Bare Land
- Barren soil/very sparse vegetation
- Sand dunes
- Rock/outcrop


Mediterranean Sea
Marsa Matruh
Alexandria
Burj Arab


Mediterranean Sea
Damietta
Port Said
Kafr ash Shaykh
Al Mansurah
Tanta
Shibin al Kawm
Banha
Cairo
Giza



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Wetland

- Permanent waterbody
- Temporary water body
- Agriculture/Saline

Built-up Land

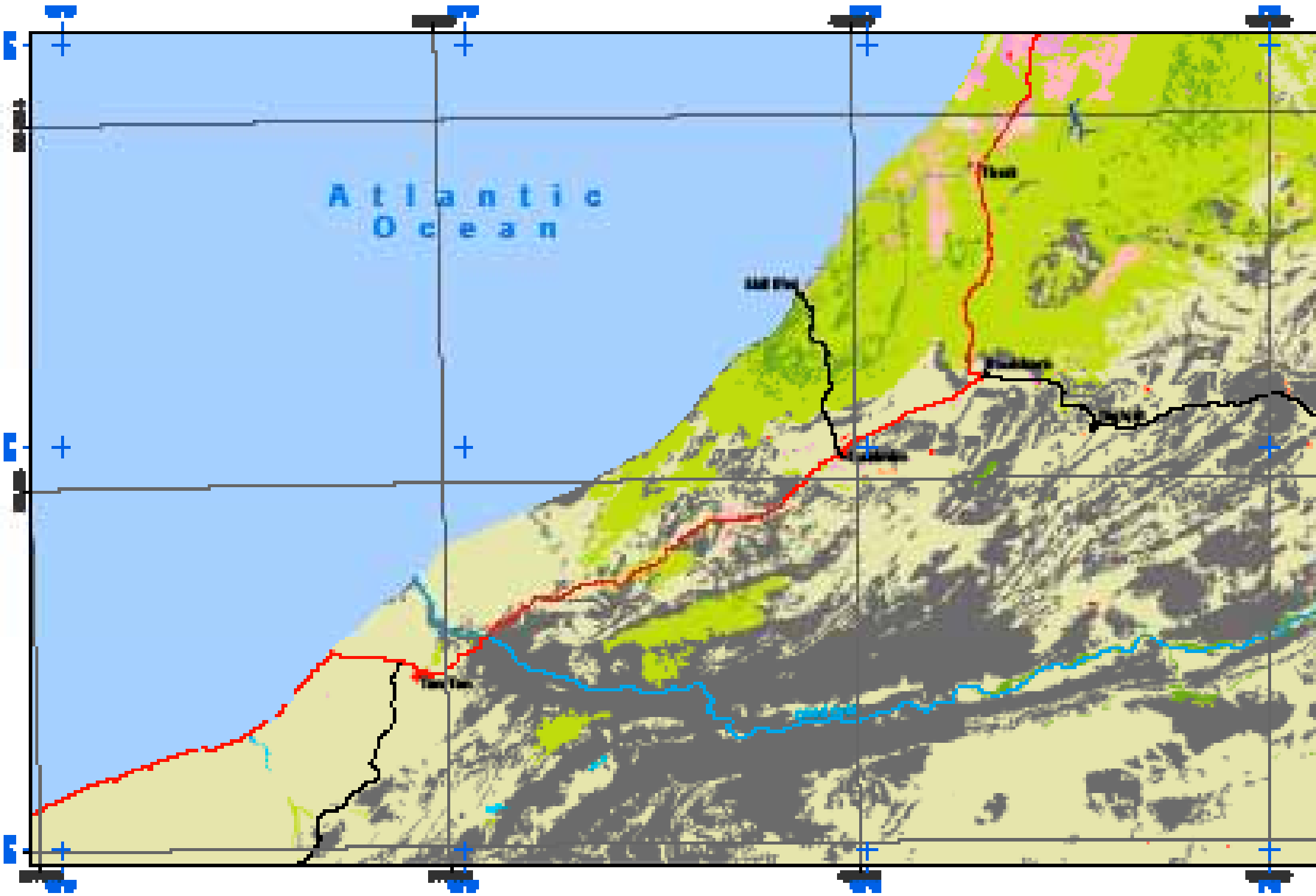
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

NM-29-8

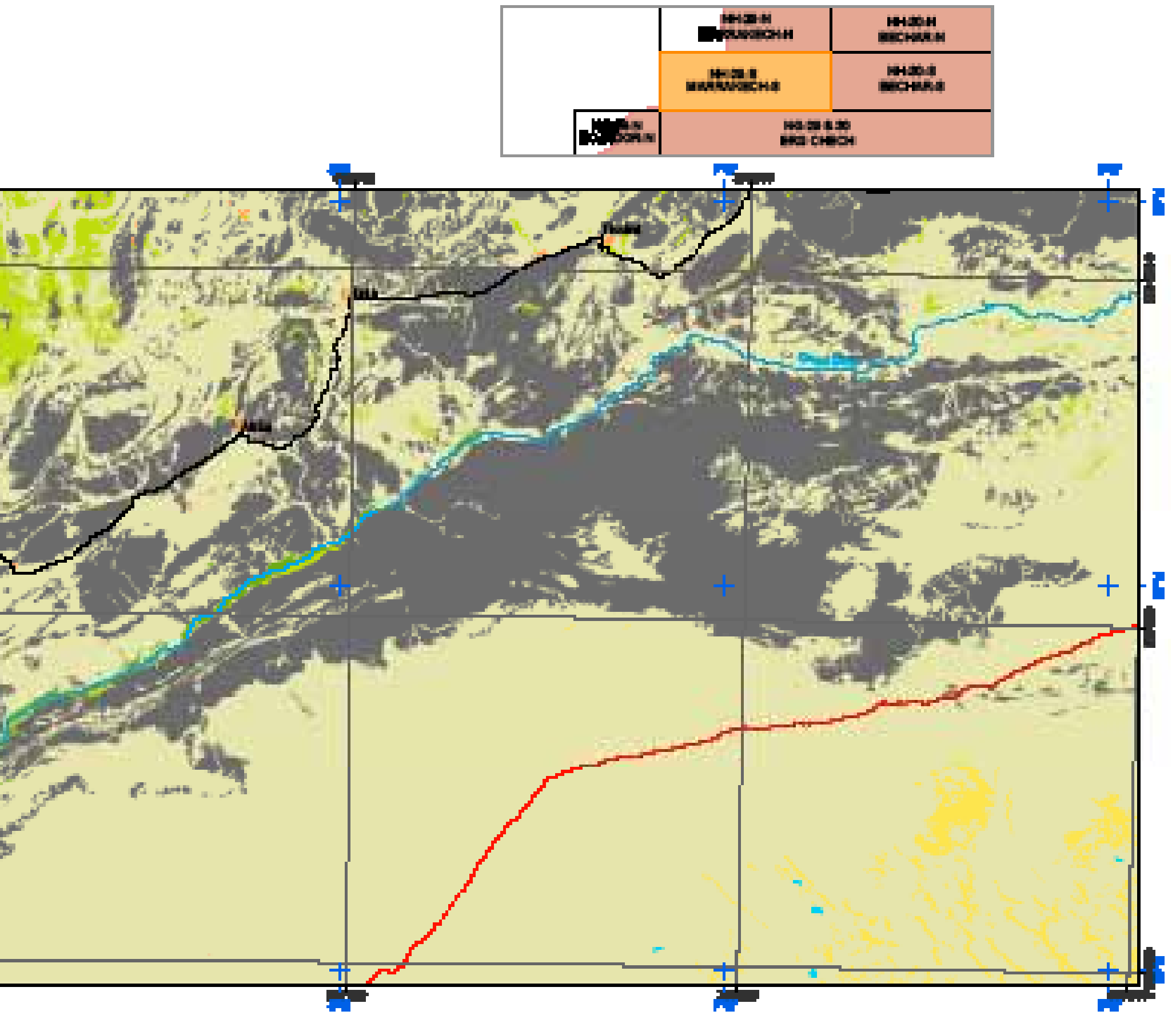
MARRAKECH-S

The map is in the World Geodetic System (WGS84) and UTM projection (zone 29N).
The black grid represents the metric coordinates.
The blue lines represent the longitude/latitude coordinates.



Natural Vegetation
- Forest
- Shrubland
- Steppe/rangeland

Bare Land
- Barren soil/dry sparse vegetation
- Sand dunes
- Rock outcrop

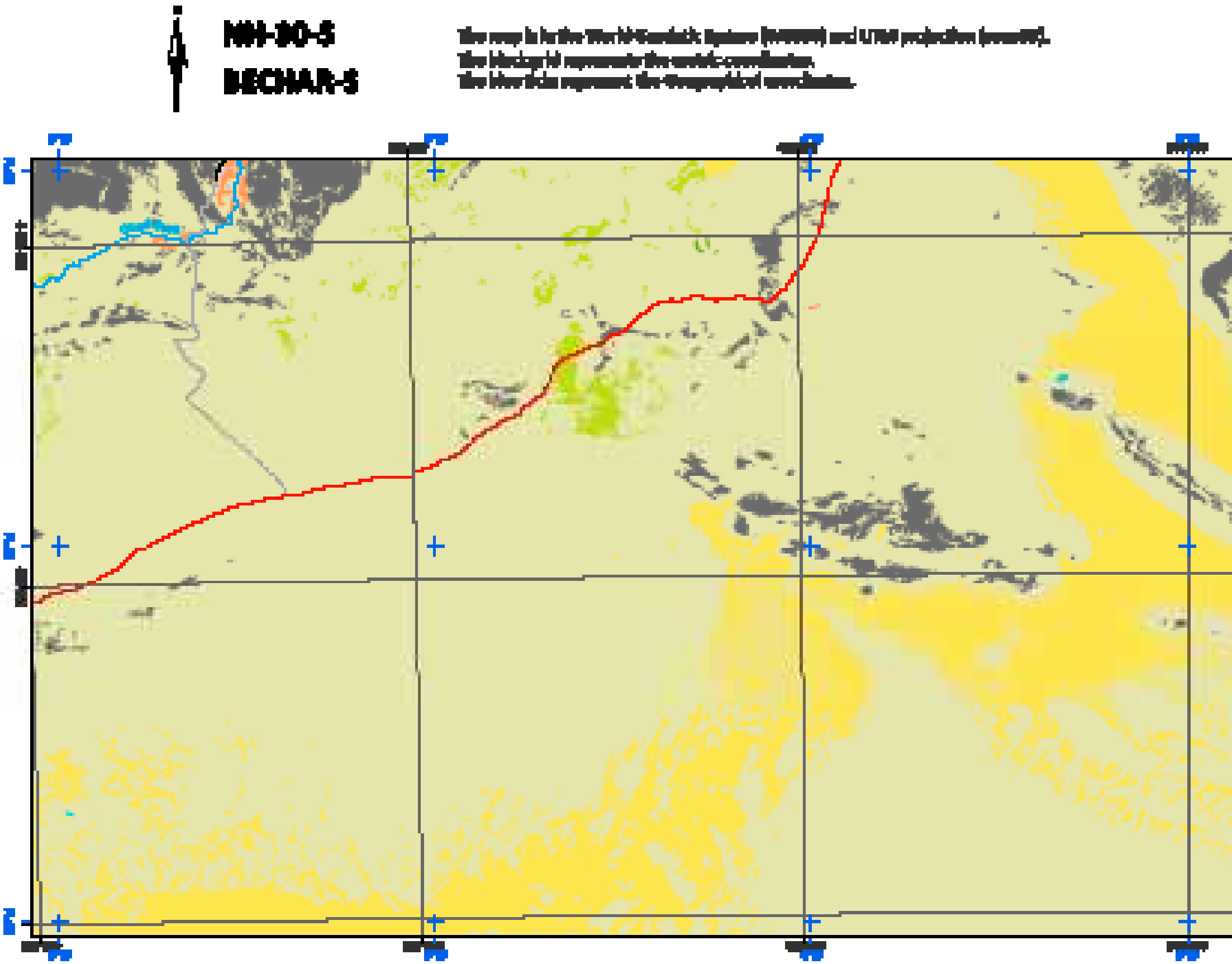


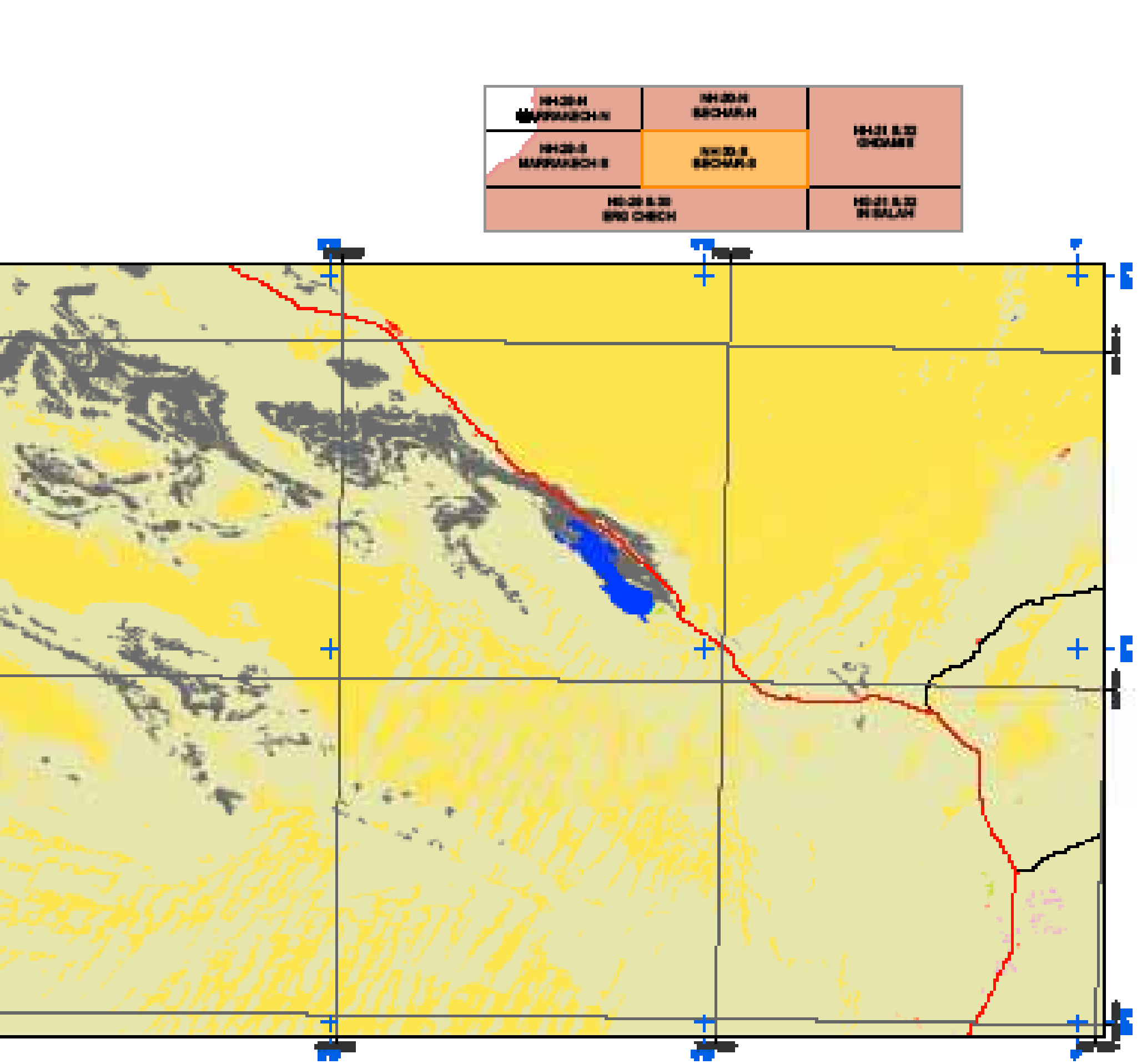
Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Wetland
- Permanent water body
- Temporary water body
- Agricultural field

Built-up Land
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


NW-SO-S
NECHAR-S
The map is in the World Geodetic System (WGS84) and UTM projection (zone 29).
The black grid represents the metric coordinates.
The blue lines represent the Geographical coordinates.
Natural Vegetations
Forest
Shrubland
Steppe/Rangeland
Bare Land
Bare soil/dry/sparse vegetation
Sand dunes
Rock outcrop



Cultivated Land

Irrigated perennial crops

Rainfed perennial crops

Irrigated annual crops

Rainfed annual crops

Oasis

Wetland

Permanent waterbody

Temporary water body

Aquaculture/fishpond

Built-up Land

Settlement

Perennial stream

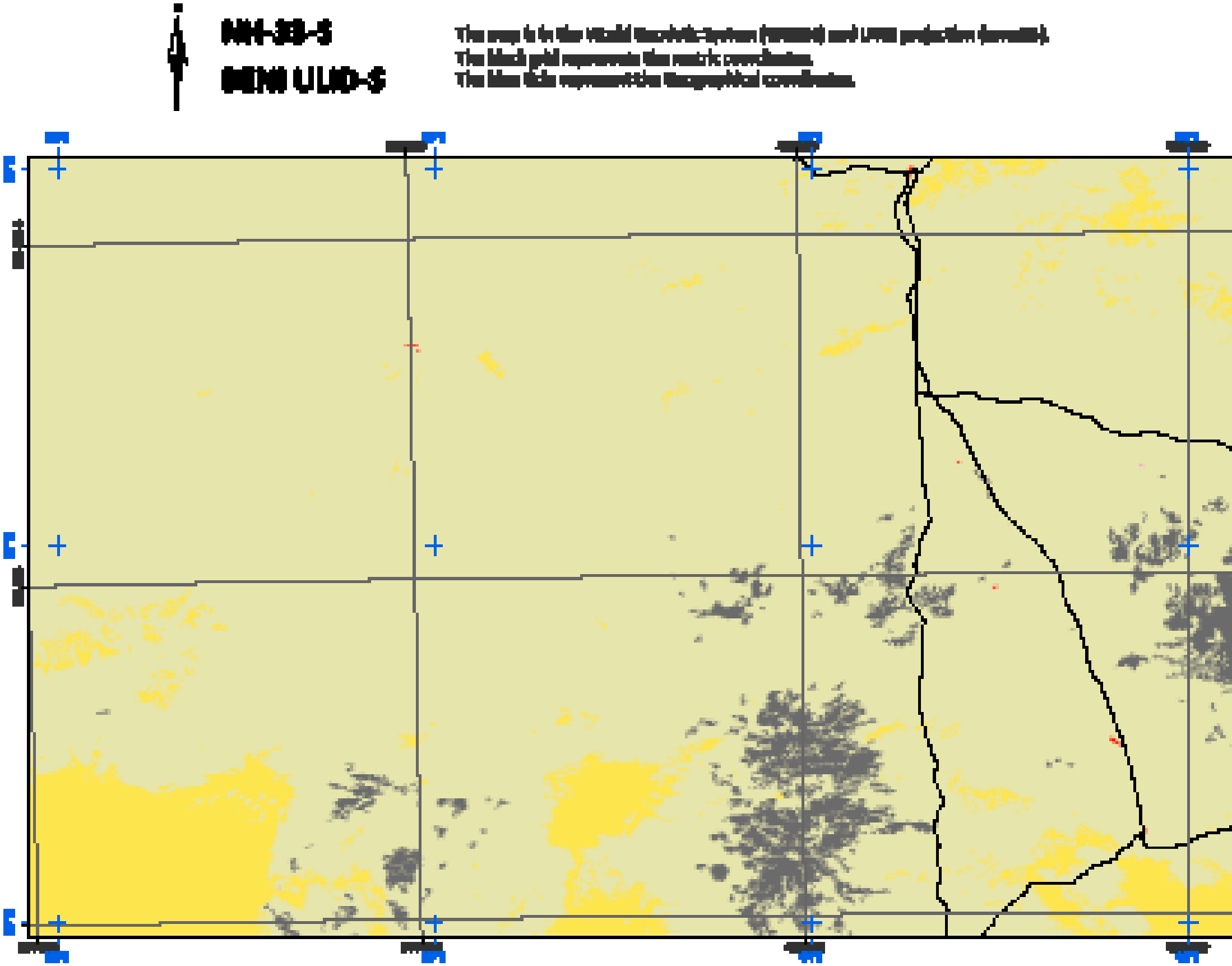
Intermittent stream

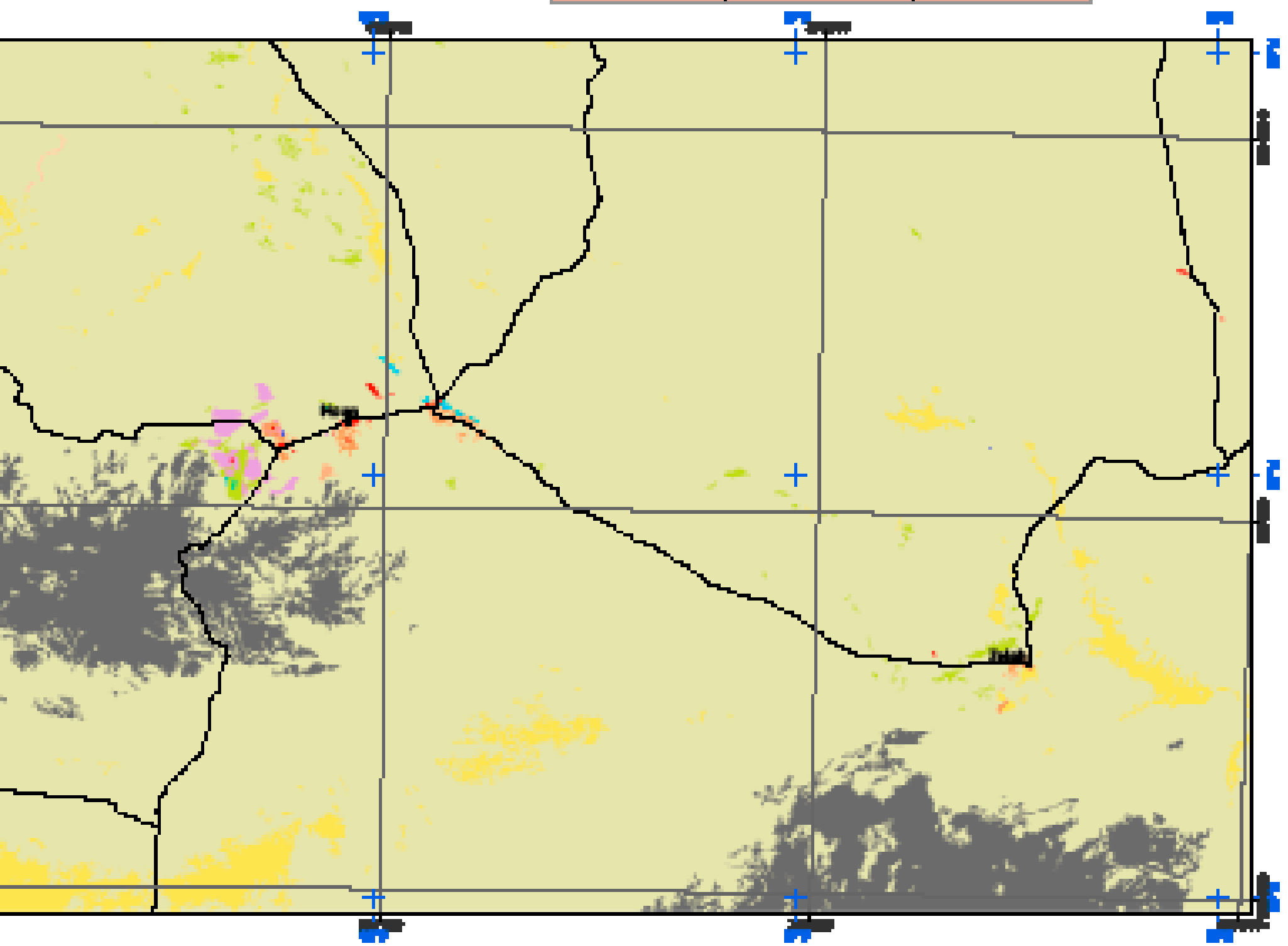
Canal

Primary road

Secondary road

Tertiary road


Natural Vegetation
Forest
Shrubland
Rangeland
Bare Land
Barren salisbury sparse vegetation
Hard dunes
Rock outcrop

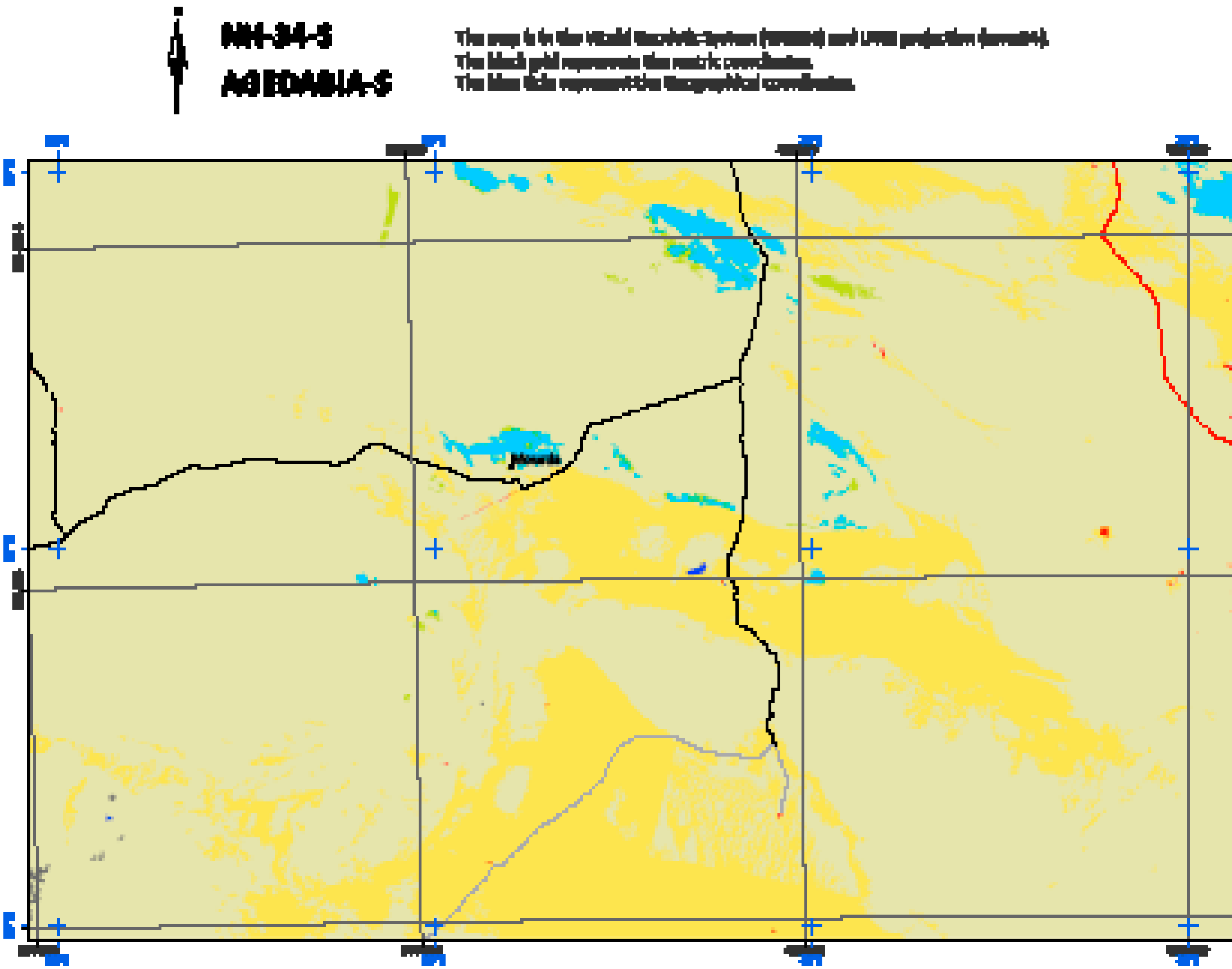


Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Wetland
- Permanent water body
- Temporary water body
- Aquaculture/saltpan

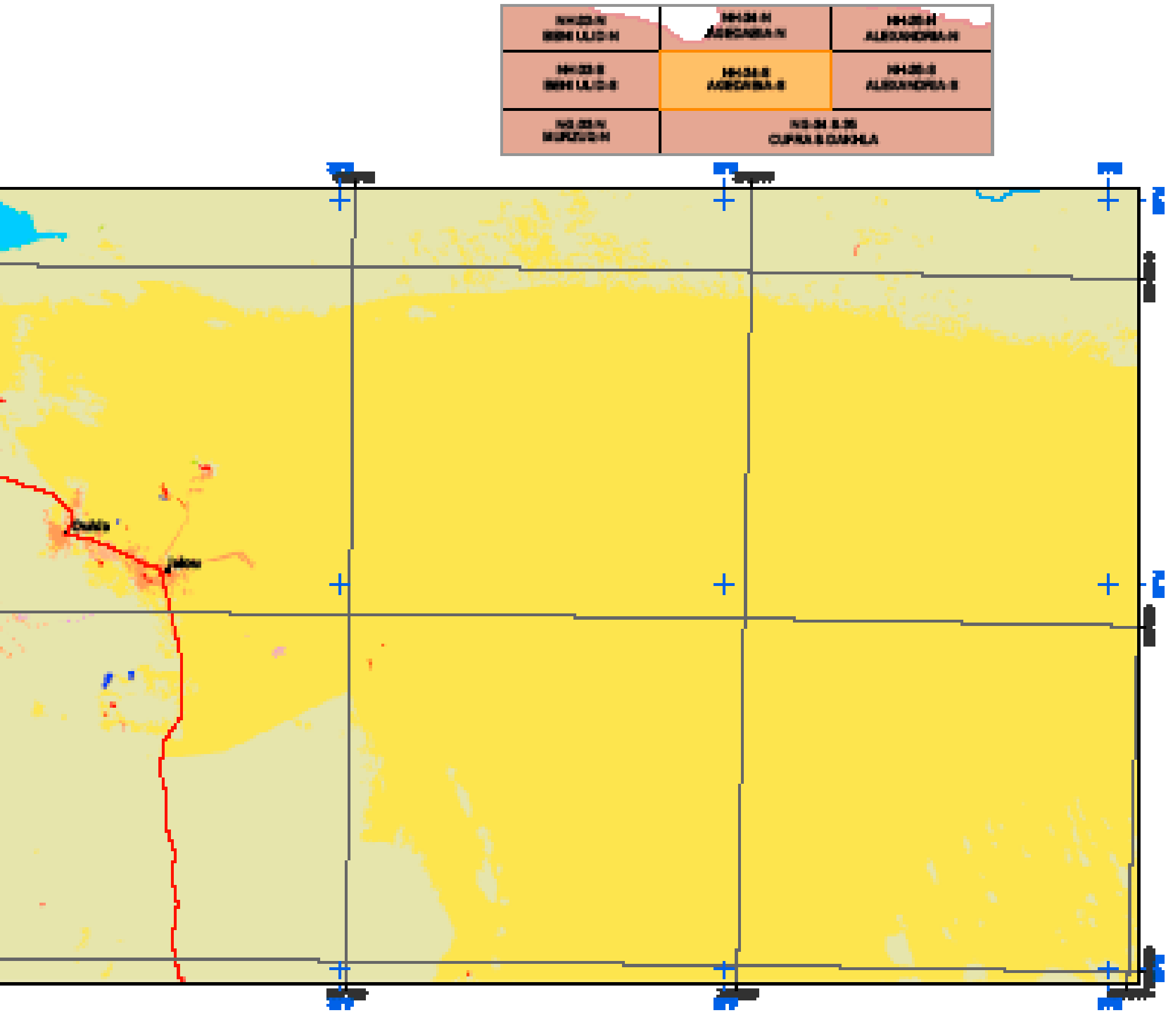
Built-up Land
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road



Natural Vegetation
Forest
Shrubland
Rangeland

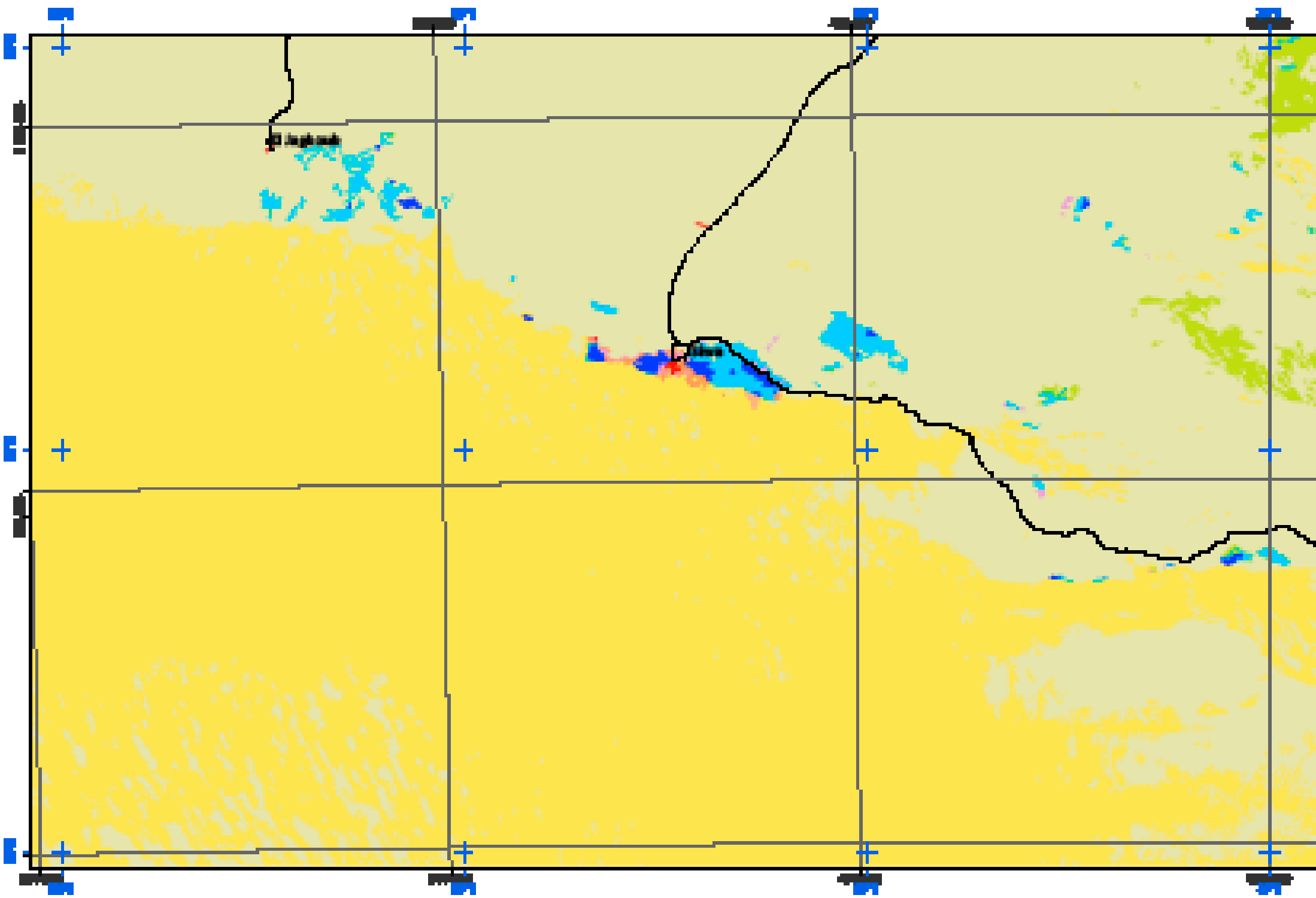
Base Land
Barren (Mostly Sparse Vegetation)
Sand Dunes
Rock Outcrop


Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Wetland
Permanent water body
Temporary water body
Agricultural fields
Built-up Land
Settlement
Primary road
Secondary road
Tertiary road

NH-35-5

ALEXANDRIA-5

The map is in the World Geodetic System (Sphere) and UTM projection (zone 35).
The black grid represents the metric coordinates.
The blue dots represent the Geographical coordinates.



Natural Vegetation

Forest

Shrubland

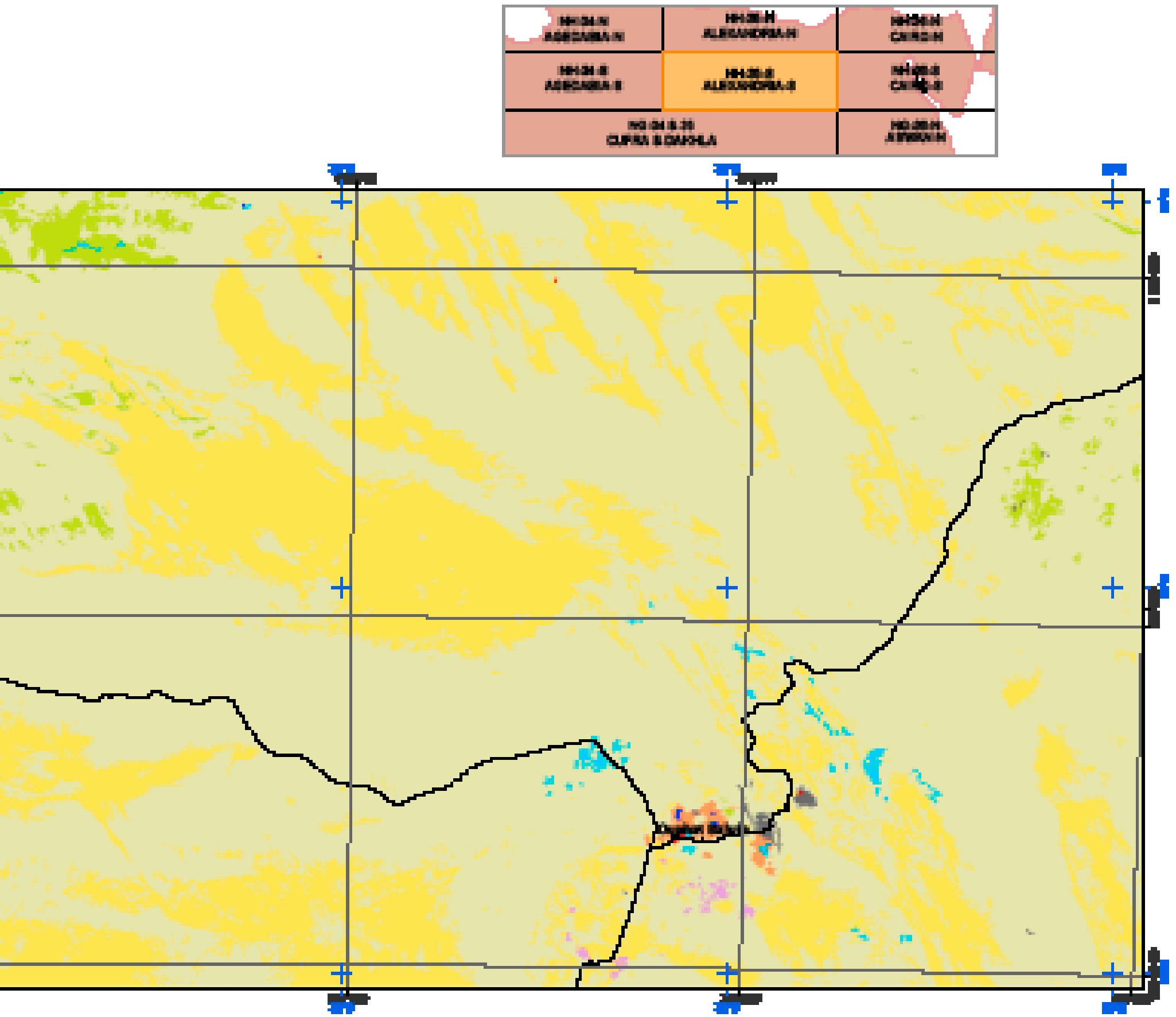
Grassland/cropland

Base Level

Barren or sparsely vegetated

Sand dunes

Rock outcrop



Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Chalo

Wetland
- Permanent water body
- Temporary waterbody
- Aquaculture/Marine

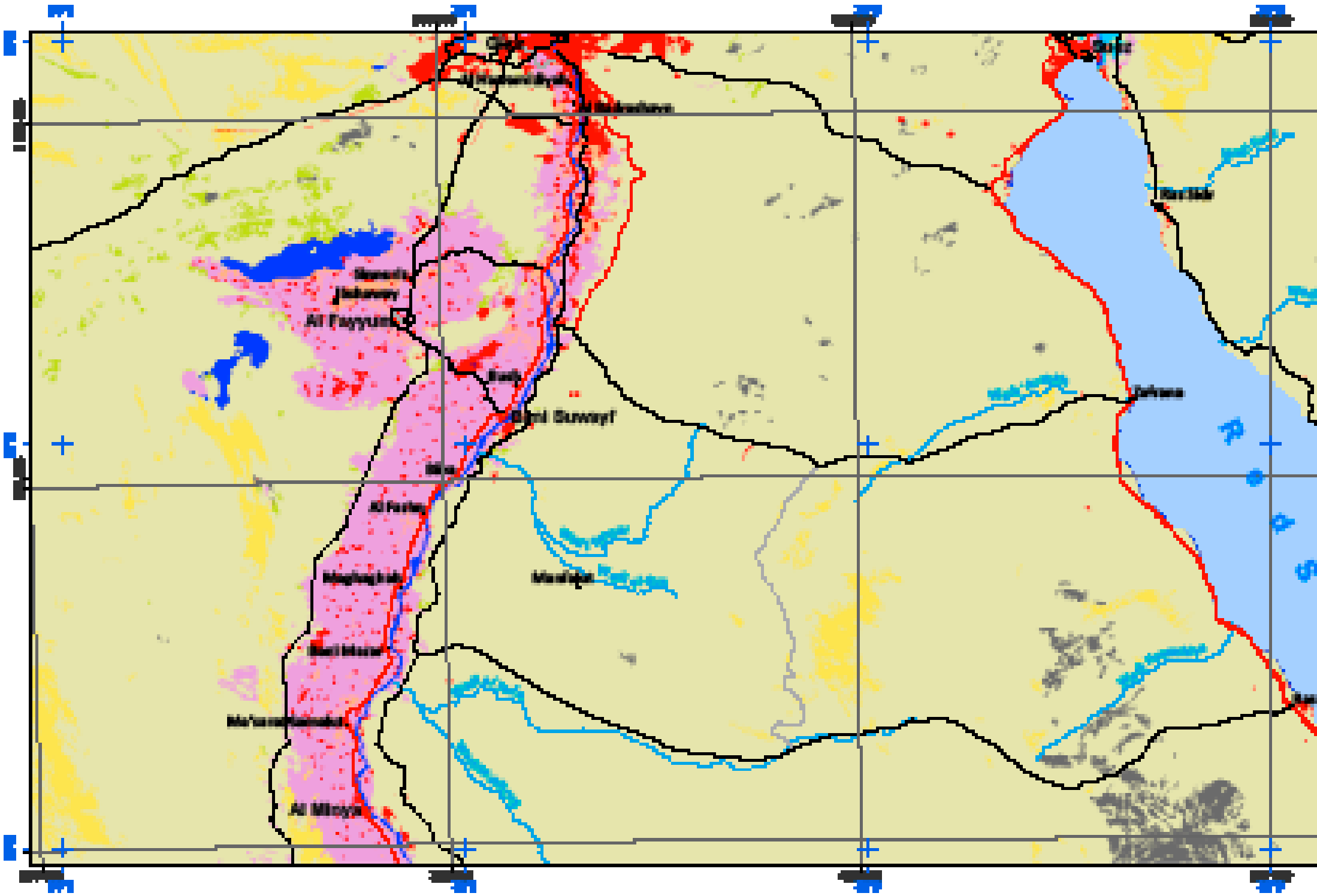
Built-up Land
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

NH-36-5

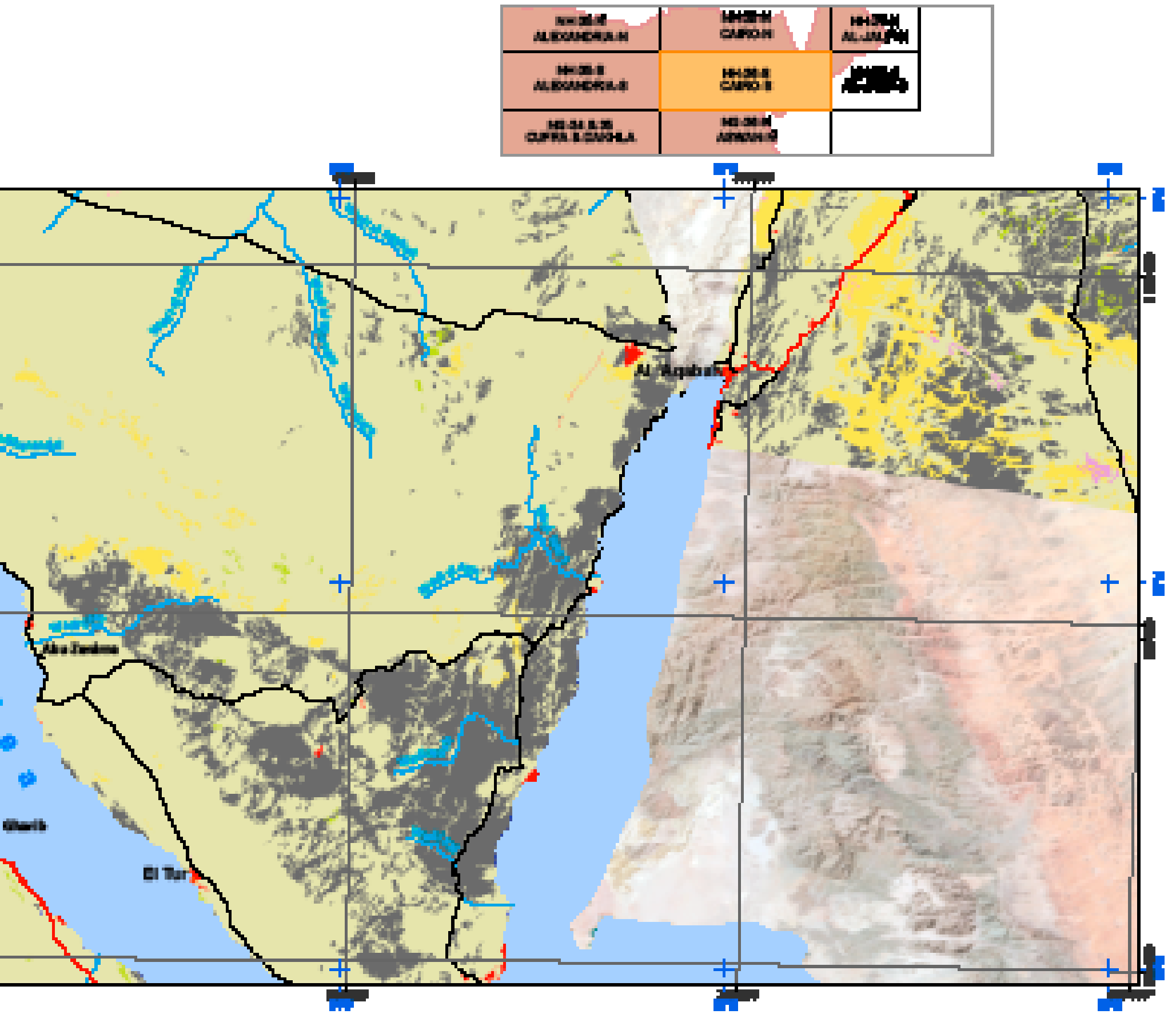
CAIRO-5

The map is in the World Geodetic System (WGS84) and UTM projection (zone 36N).
The black grid represents the metric coordinates.
The blue tick represents the Geographical coordinates.



Natural Vegetation
Forest
Shrubland
Rangeland

Bare Land
Desert, rocky or sandy areas vegetation
Sand dunes
Rock outcrop



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

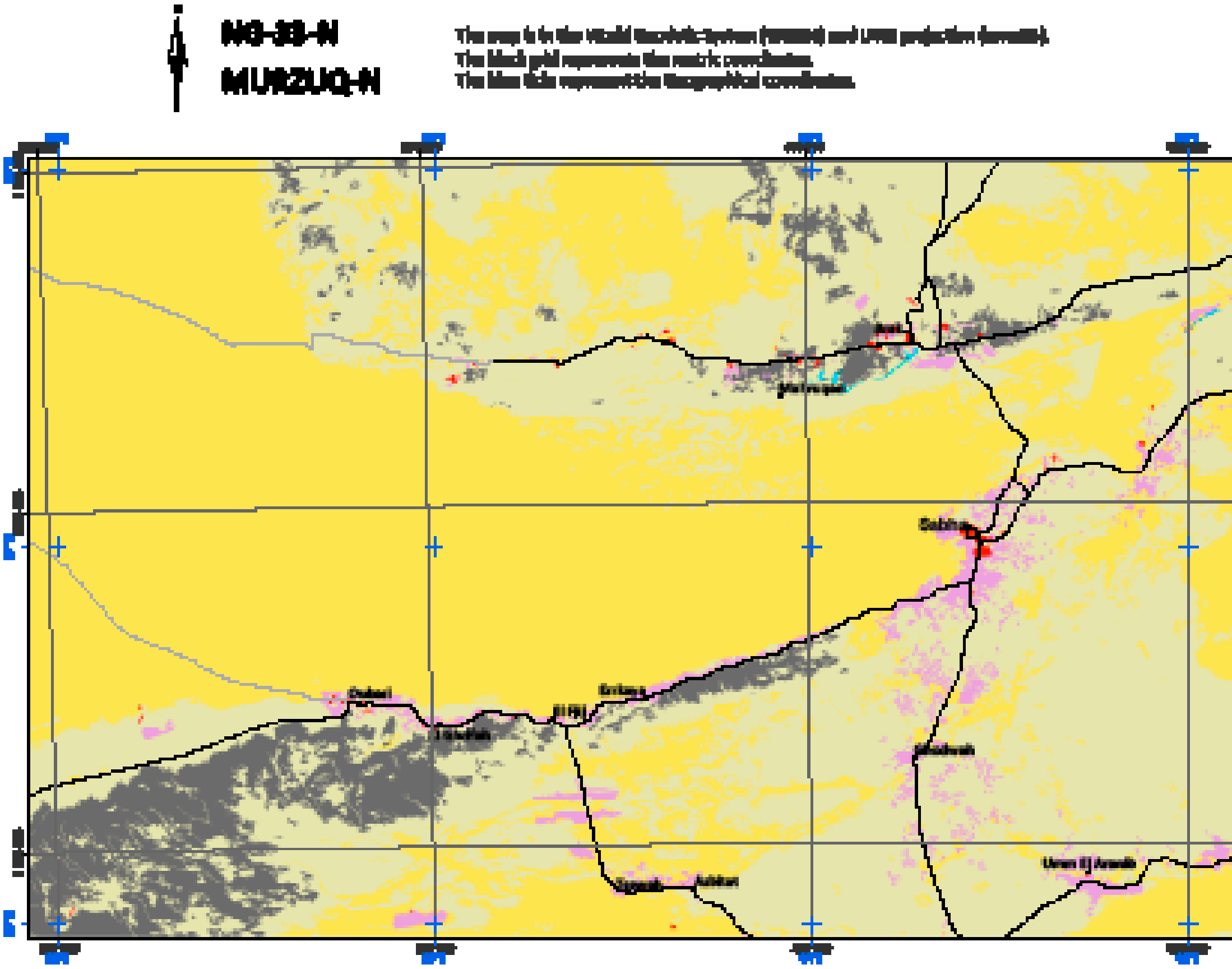
Wetland

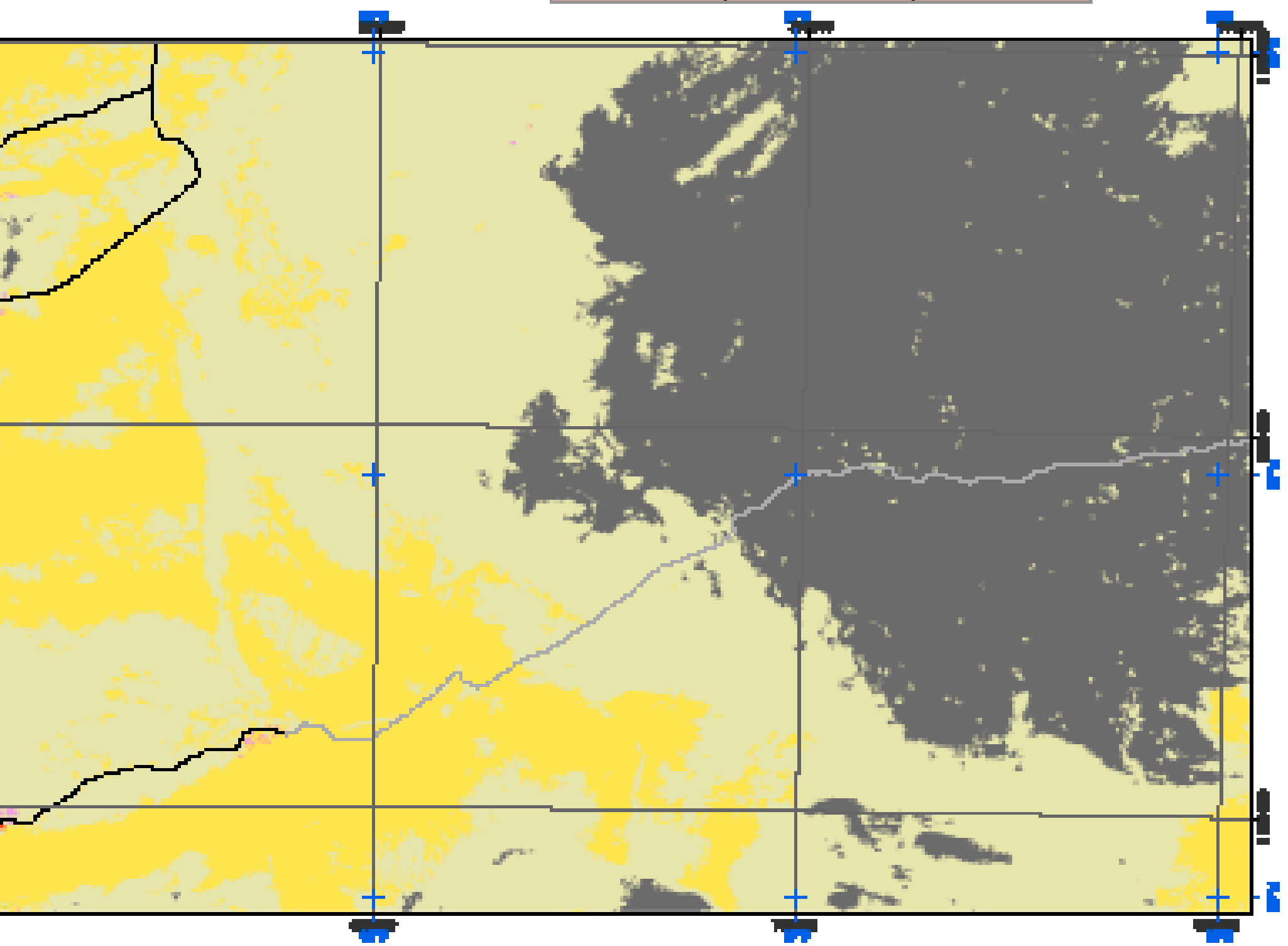
- Permanent water body
- Temporary water body
- Aquaculture/saltpan

Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


N
Natural Vegetation
Forest
Grassland
Rangeland/Cropland
Shore Land
Desert salt/dry sparse vegetation
Sand dunes
Rock outcrop



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

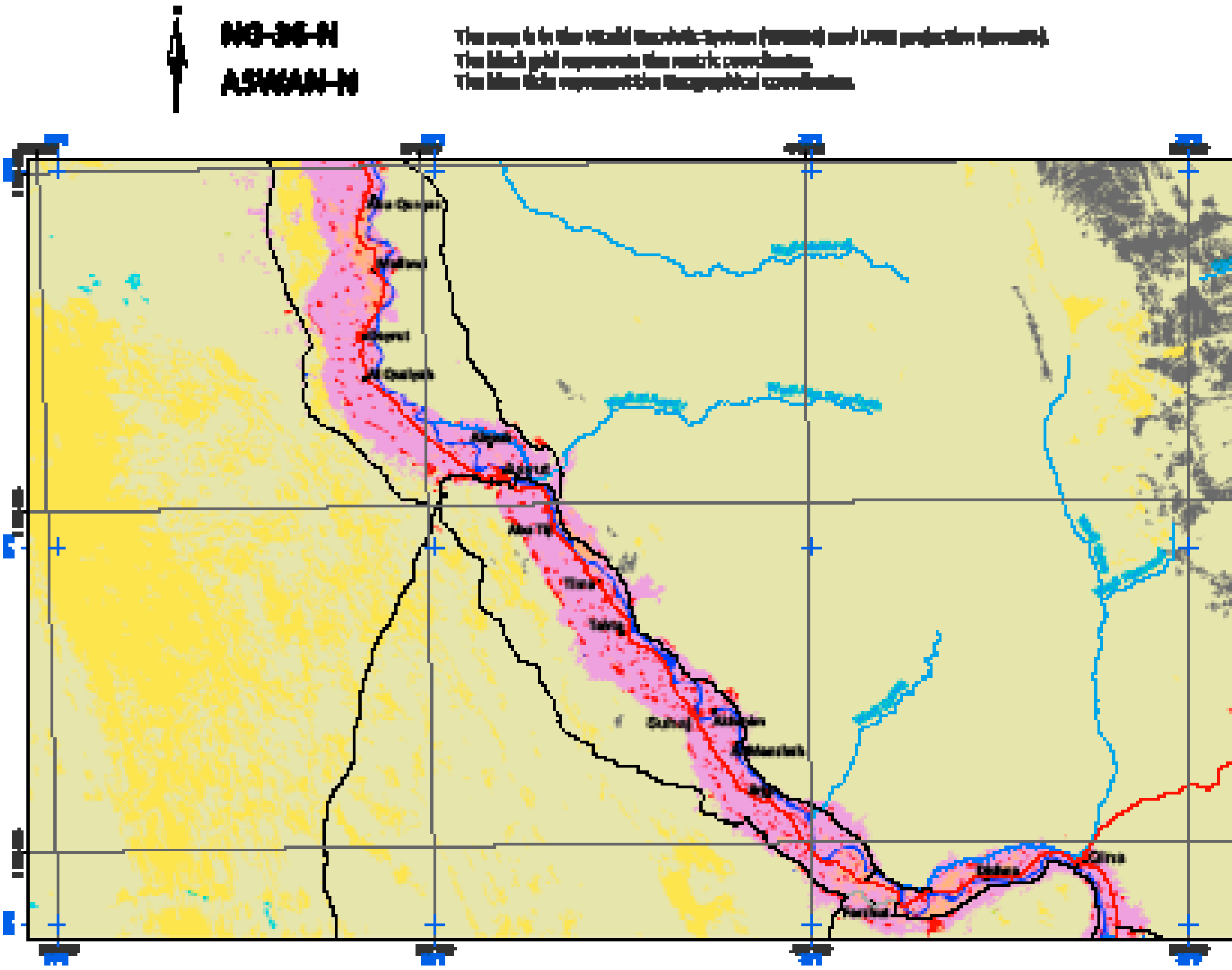
Wetland

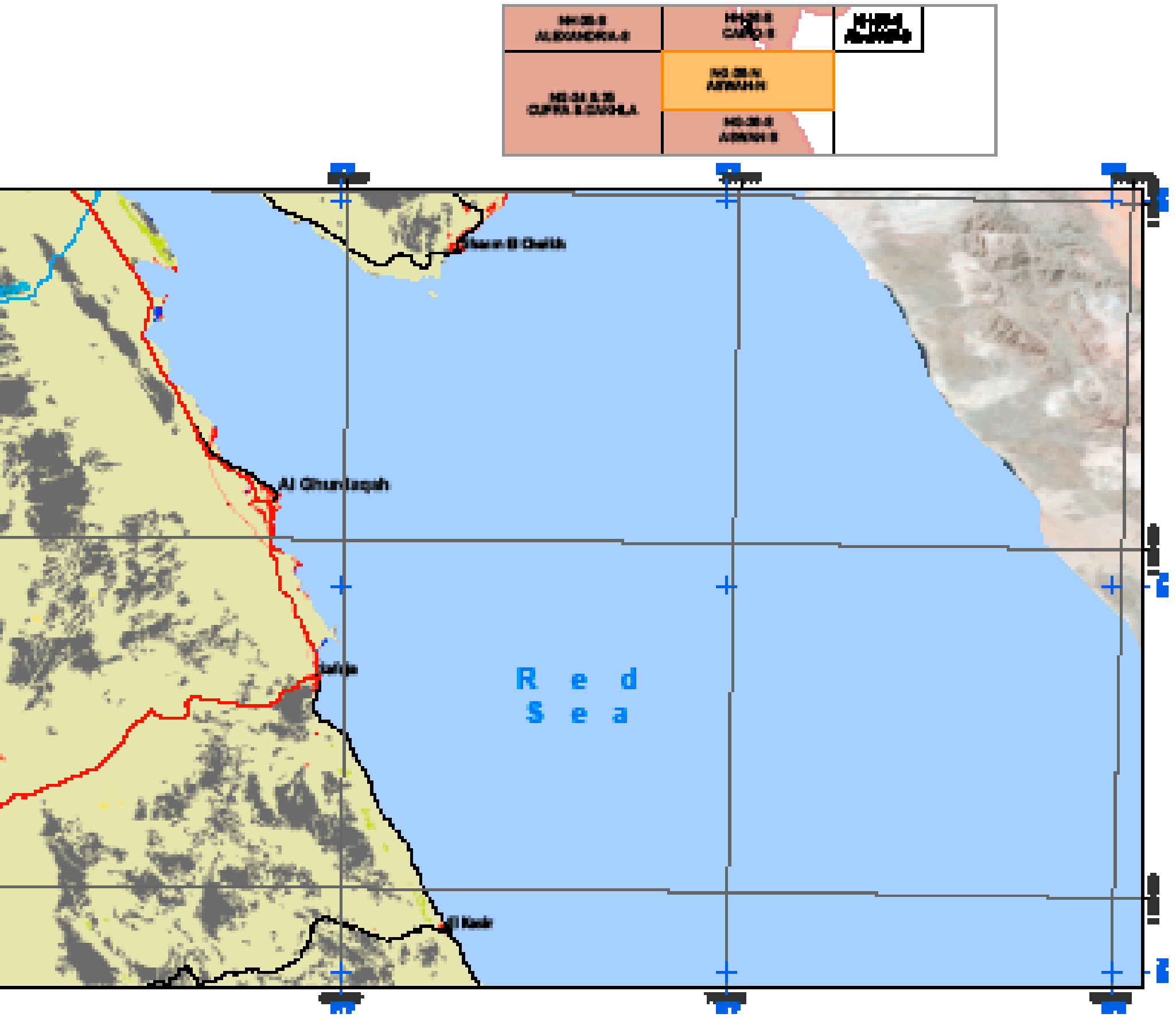
- Permanent water body
- Temporary water body
- Agriculture/Wetland

Built-up Land

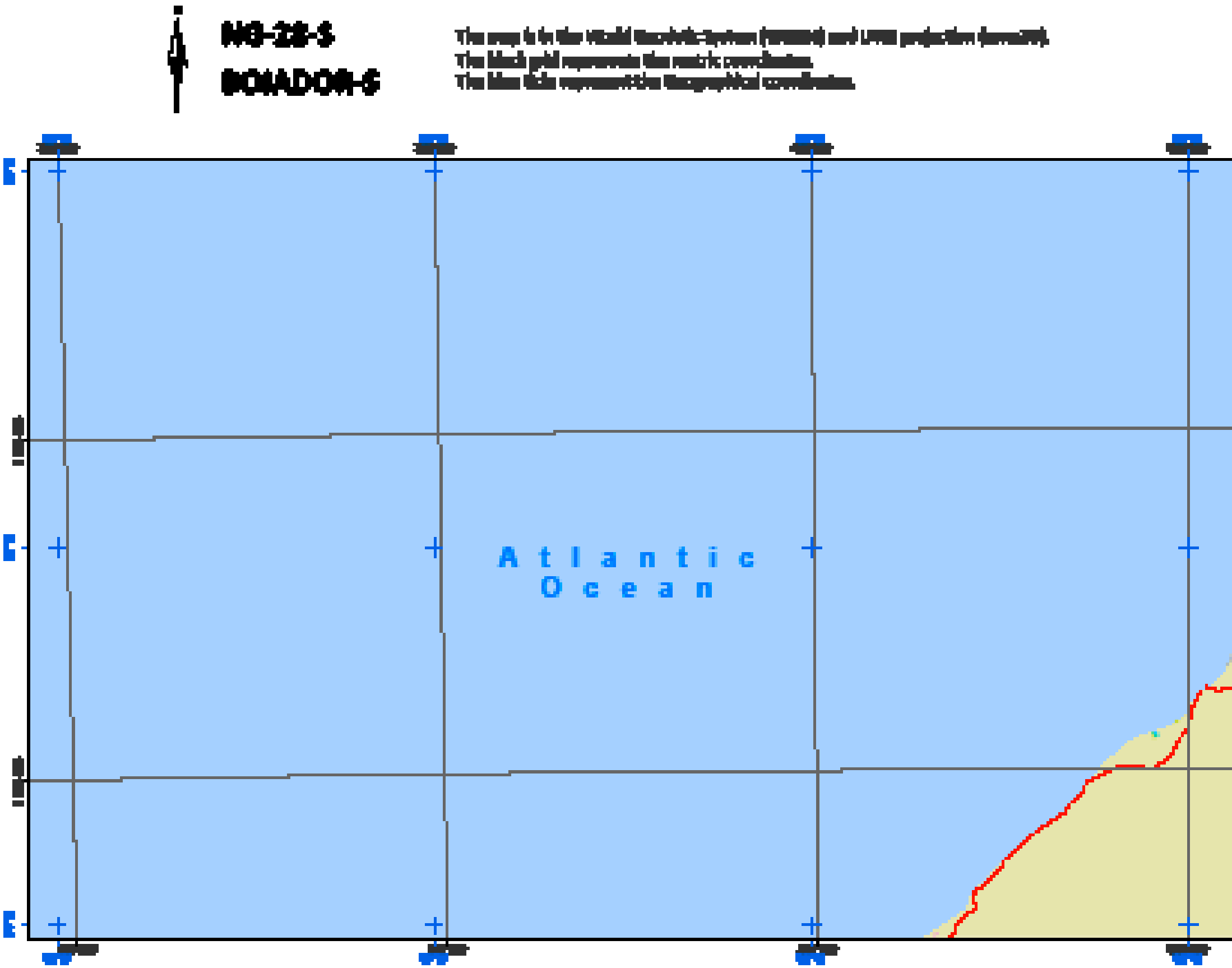
- Settlement

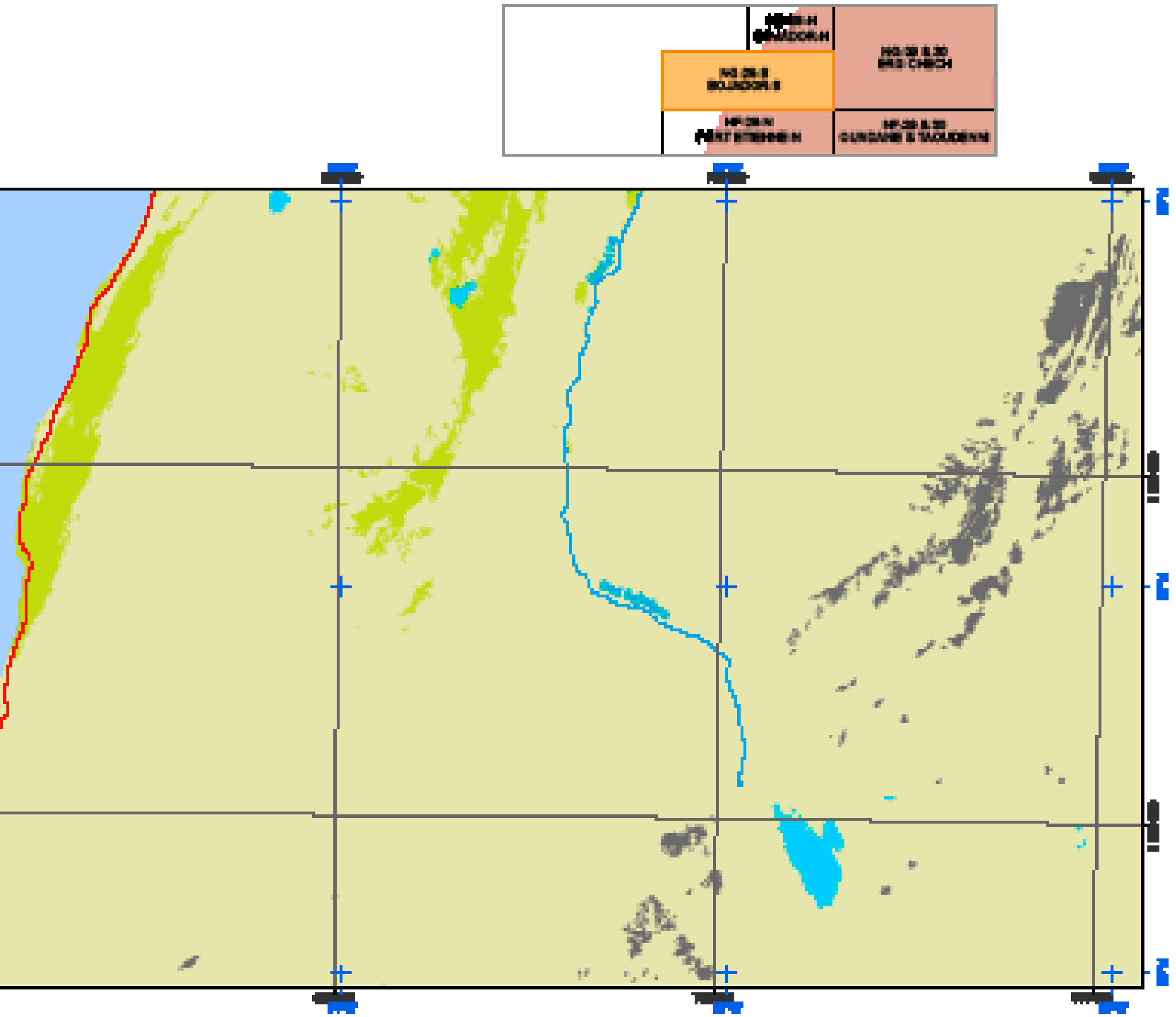
- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


Natural Vegetation
Forest
Shrubland
Rangeland
Bare Land
Sand dunes
Rock outcrop



page 103


Atlantic
Ocean



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Orchards

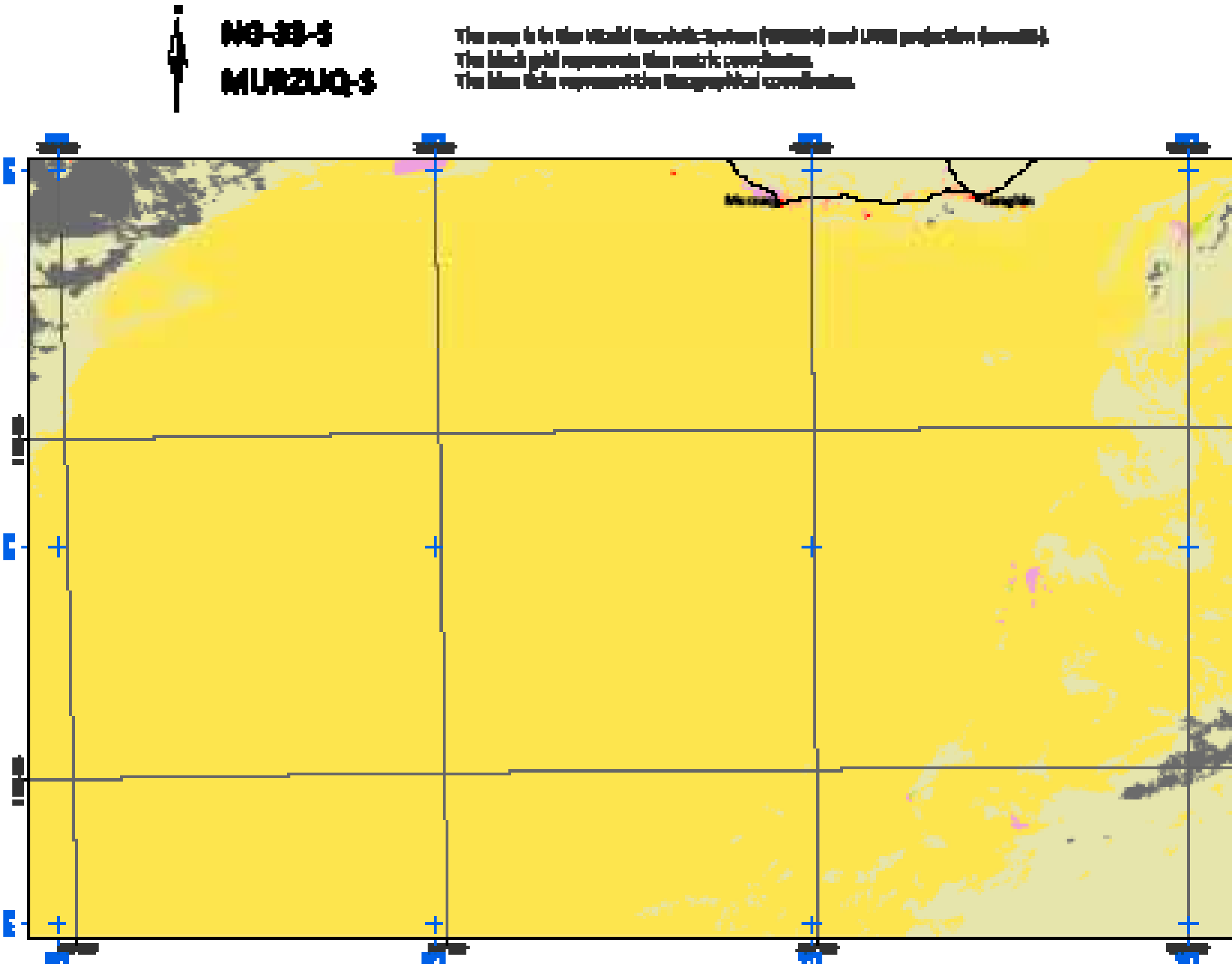
Wetland

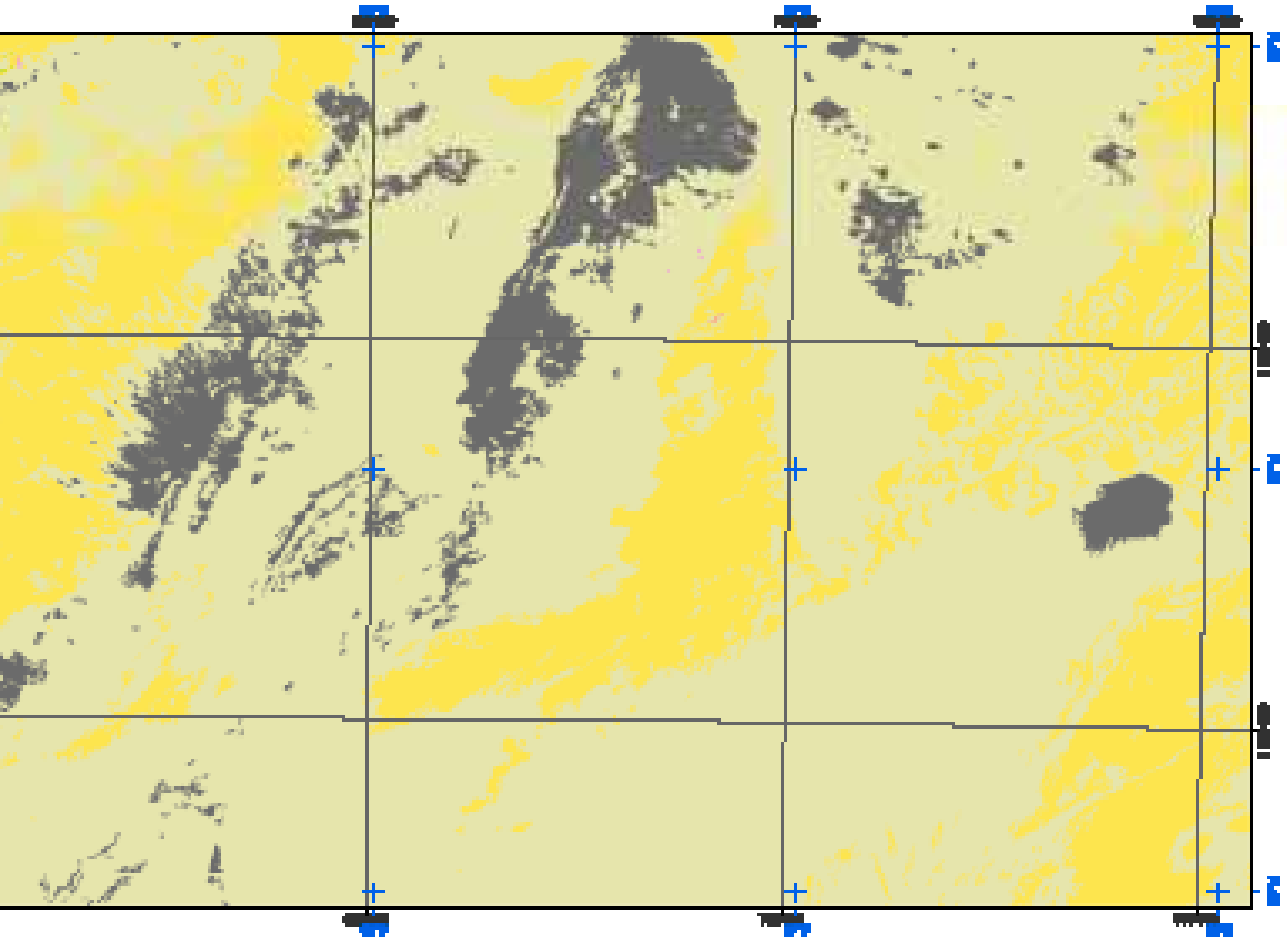
- Permanent water body
- Temporary water body
- Agriculture/fallow

Built-up Land

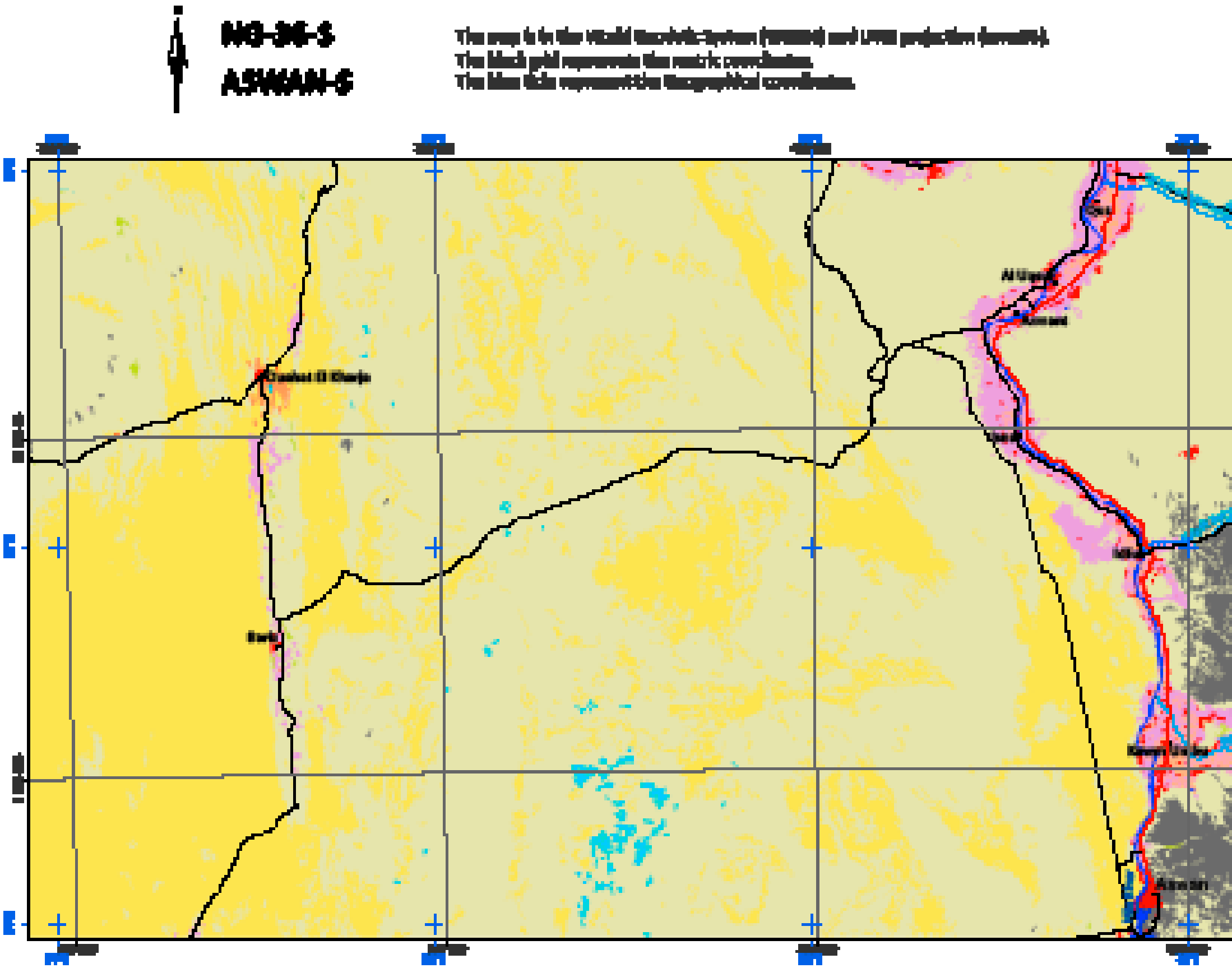
- Settlement

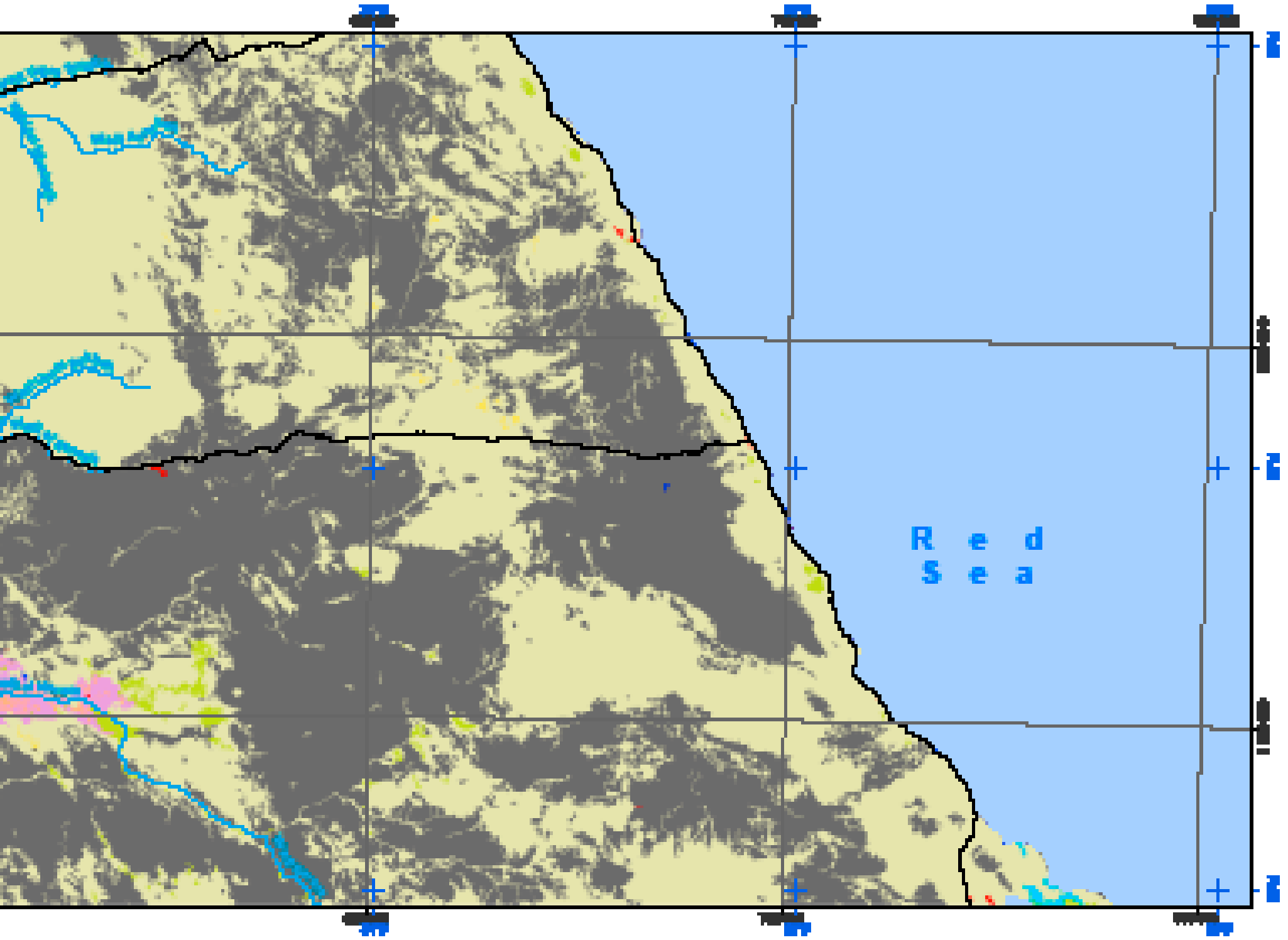
- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


Natural Vegetation
Forest
Shrubland
Rangeland
Barren Land
Barren and Sparsely Vegetated
Hard Clinker
Rock Outcrop




Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Natural
Permanent water body
Temporary water body
Aquaculture/Saline
Built-up Land
Settlement
Perennial stream
Intermittent stream
Canal
Primary road
Secondary road
Tertiary road


Natural Vegetation
Forest
Shrubland
Rangeland
Bare Land
Sand dunes
Rock outcrop



Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Waterbody
- Permanent water body
- Temporary water body
- Aquaculture/Saltpan

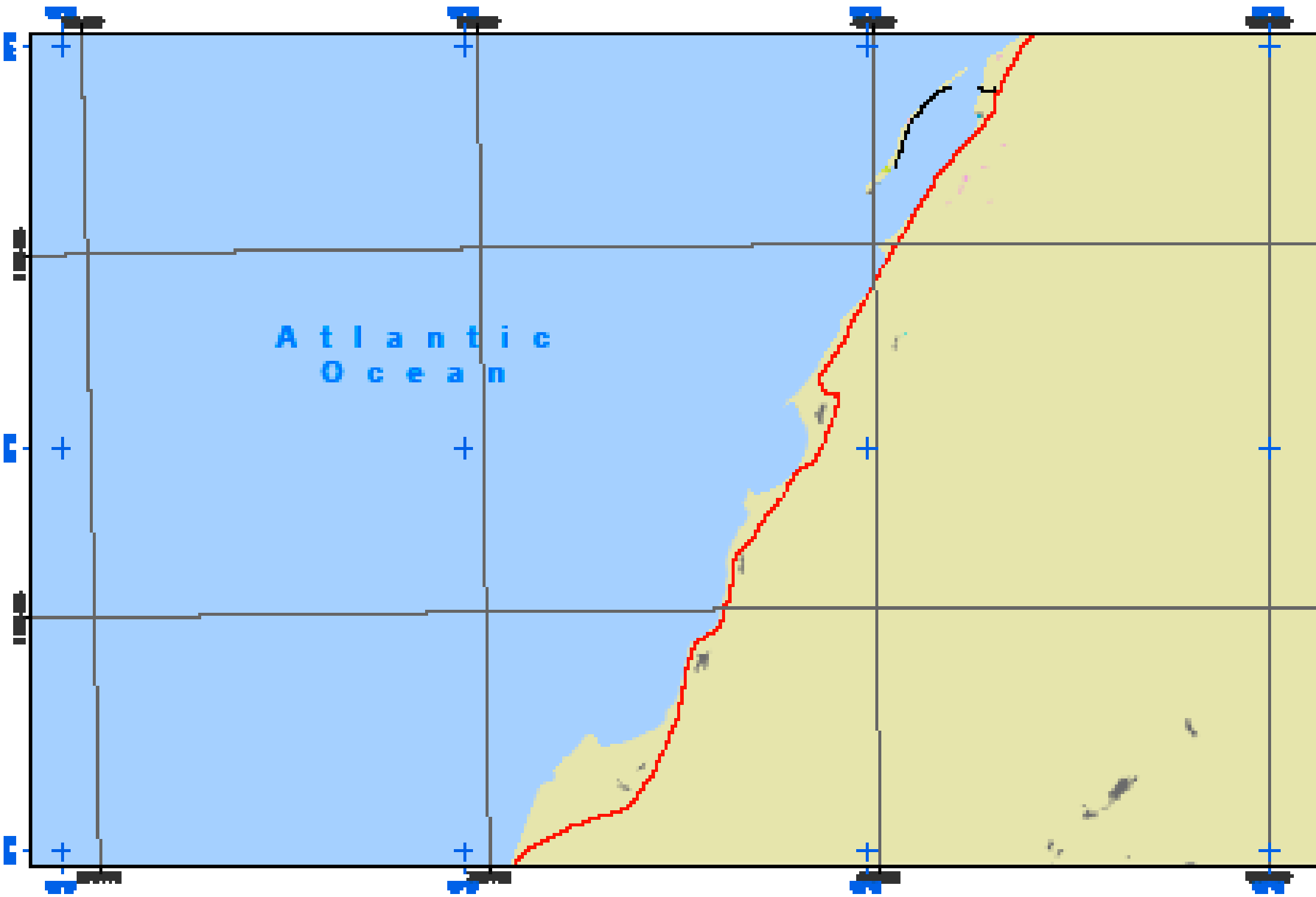
Built-up Land
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

MF-232-N

PORT ETIENNE-N

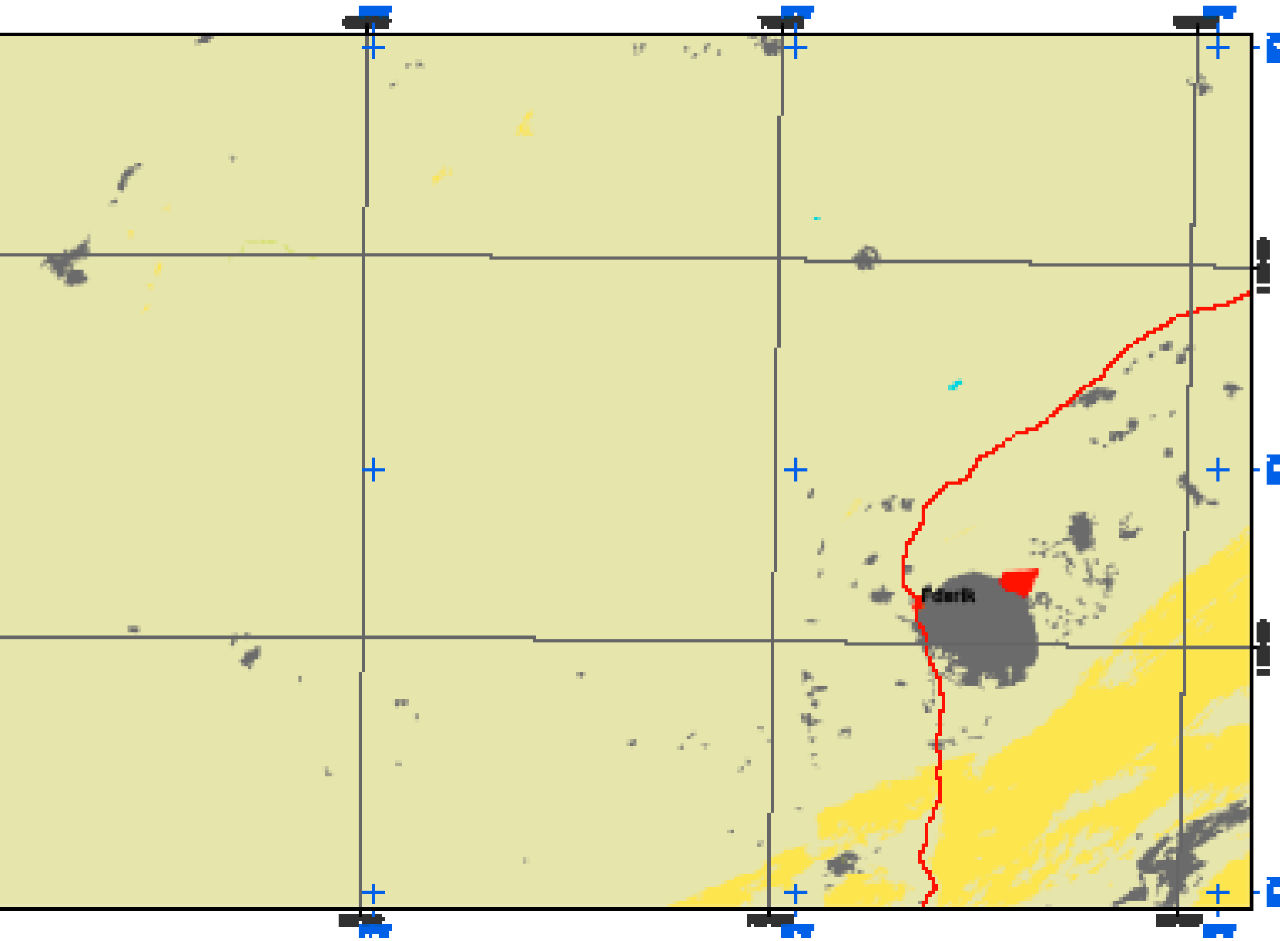
The map is in the World Geodetic System (WGS84) and UTM projection (km-grid).
The black grid represents the metric coordinates.
The blue ticks represent the Geographical coordinates.

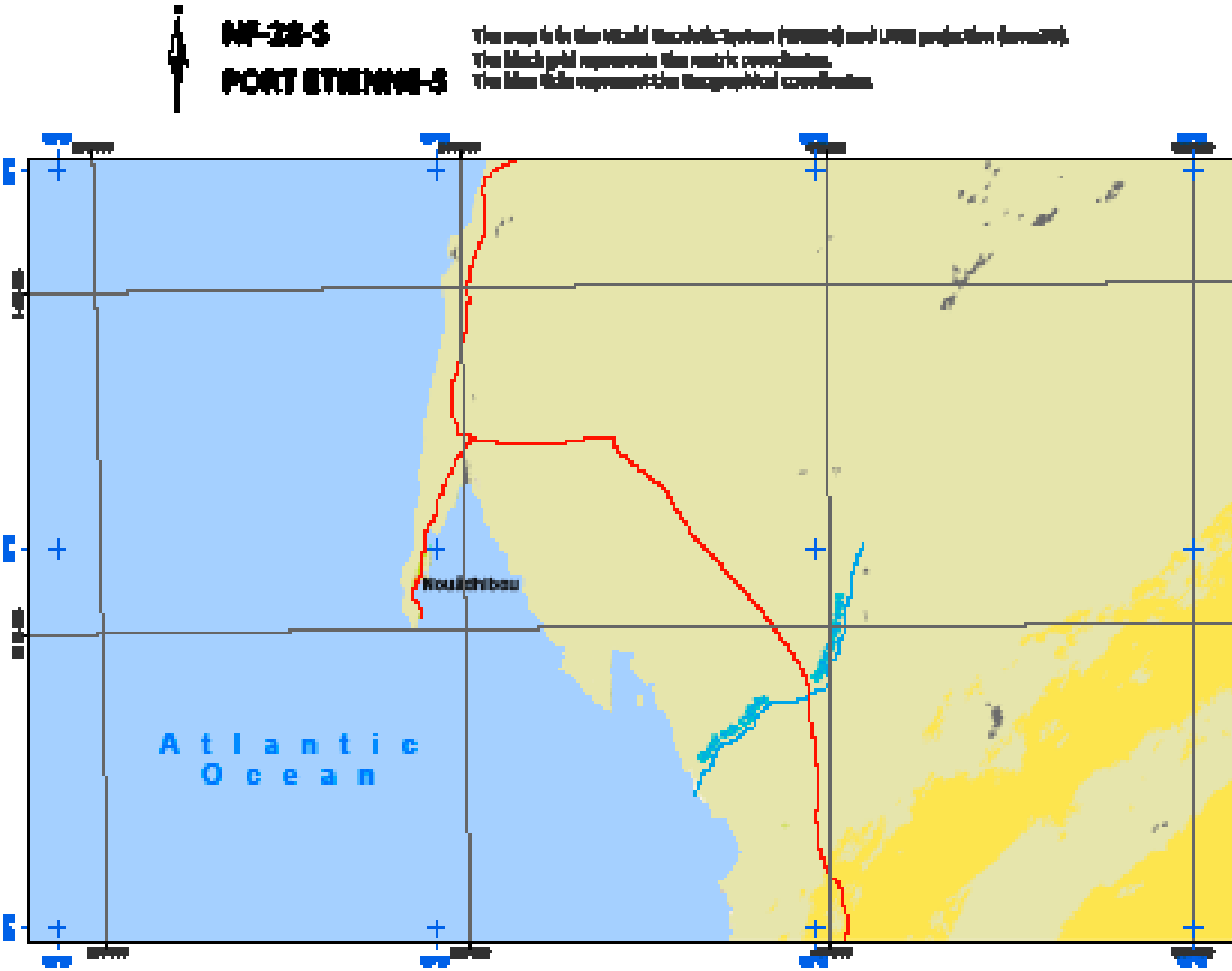


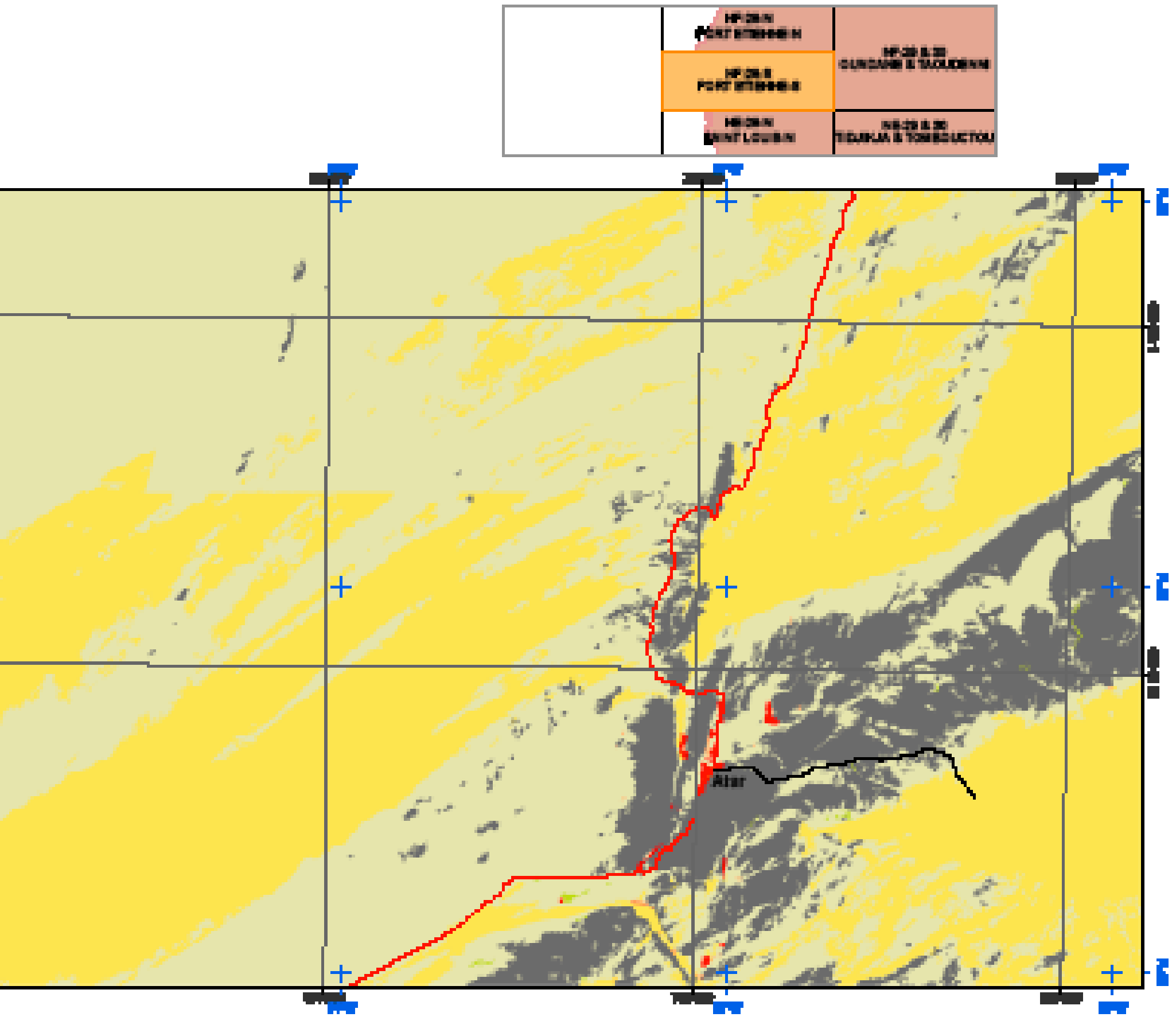
Scale 1:1 237 000

Natural Vegetation
- Forest
- Shrubland
- Steppe/Rangeland

Bare Land
- Barren with little or sparse vegetation
- Sand dunes
- Rock outcrop


Pakaria


Nouâdhibou
A t l a n t i c
O c e a n



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

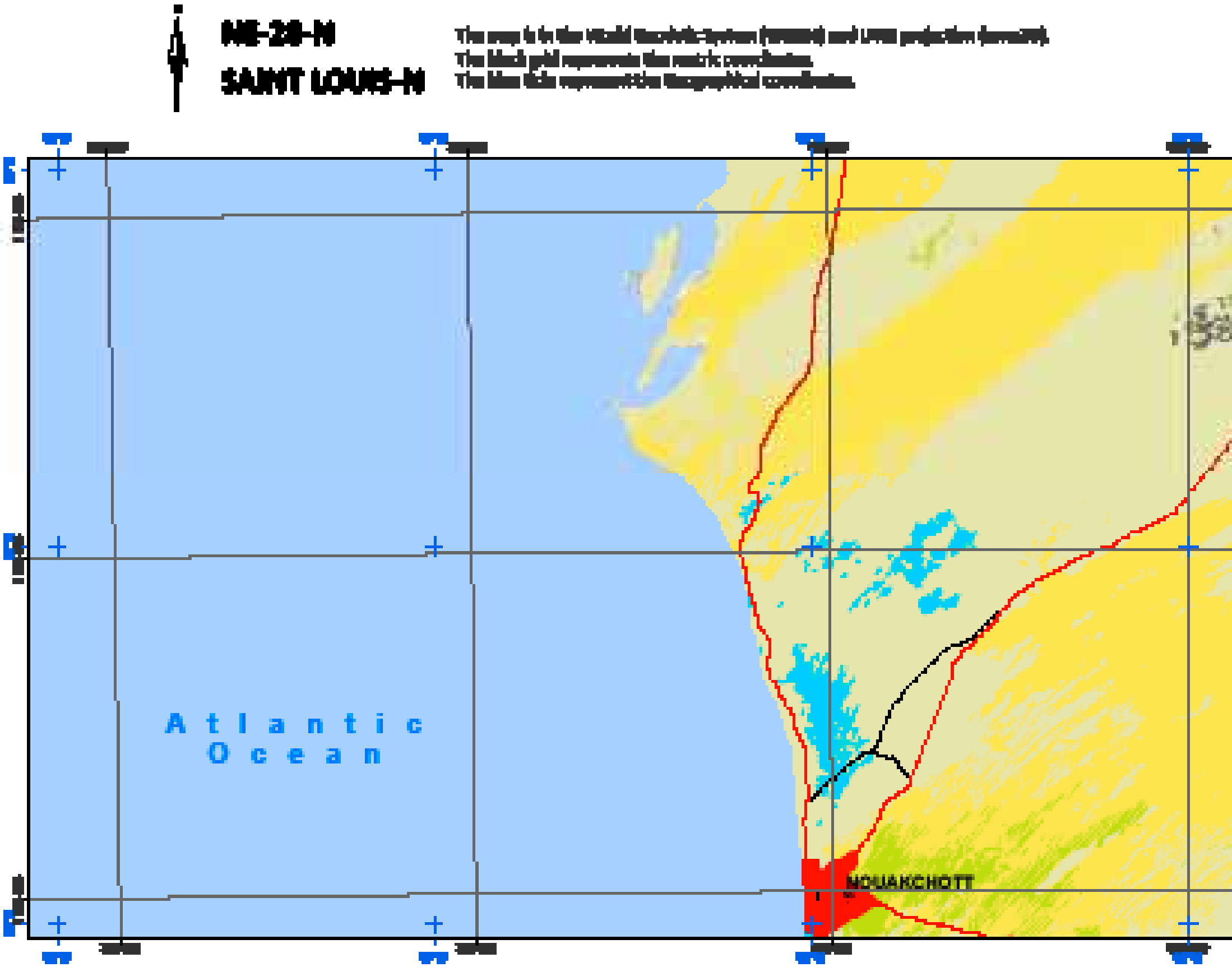
Wetland

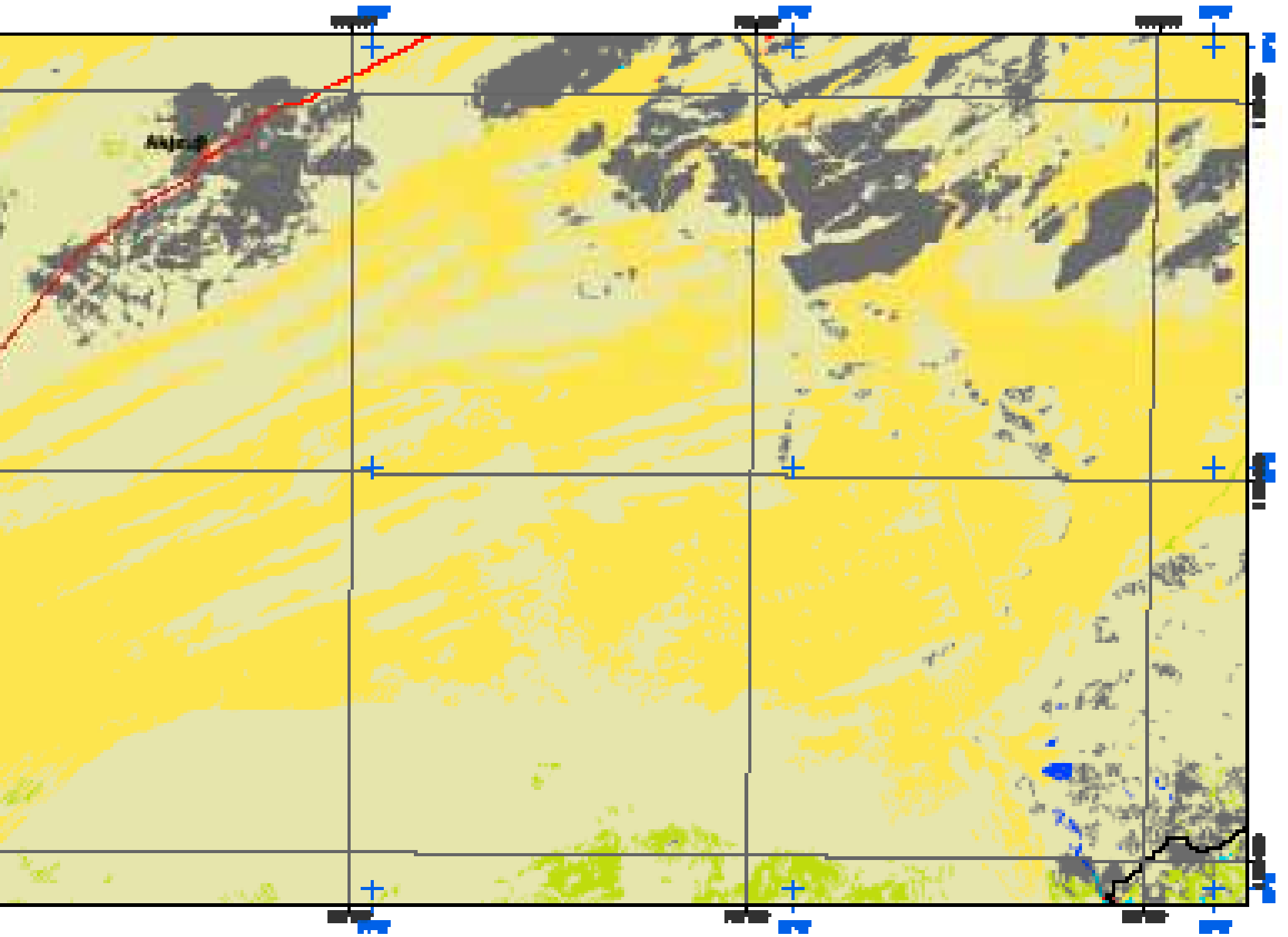
- Permanent water body
- Temporary waterbody
- Agricultural water

Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


Atlantic
Ocean
NOUAKCHOTT



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Fallow

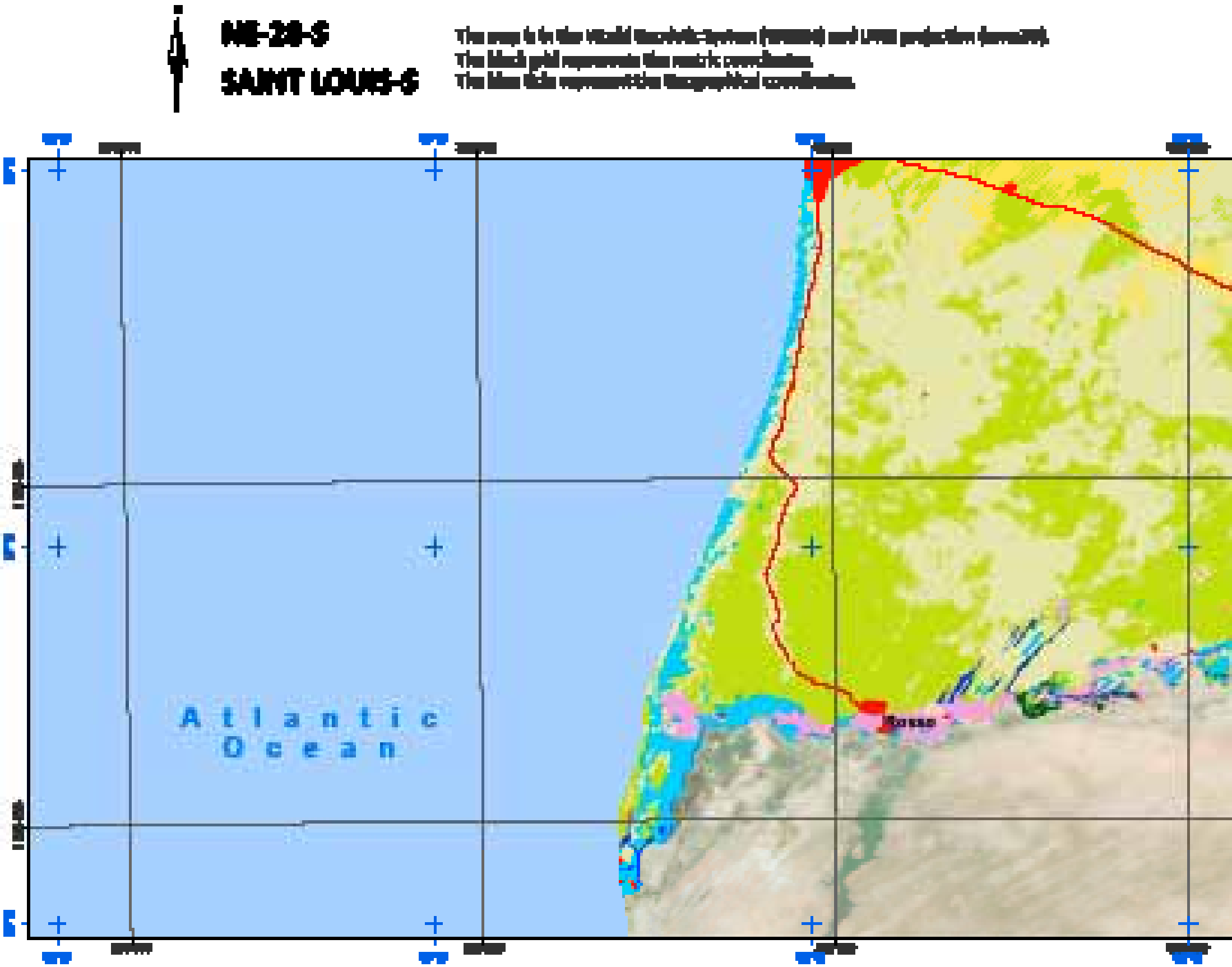
Wetland

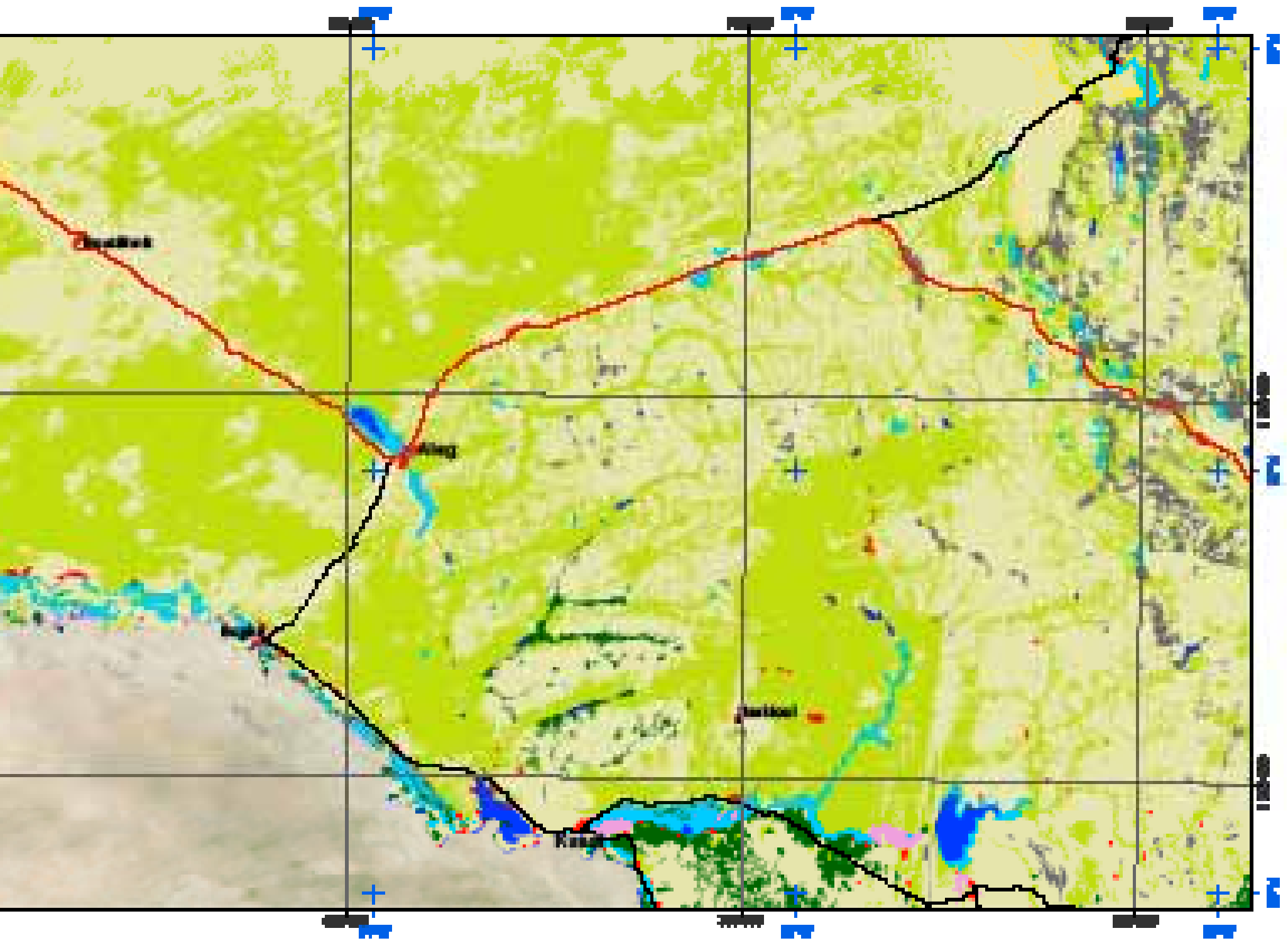
- Permanent water body
- Temporary water body
- Agricultural fields

Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


Atlantic
Ocean



Cultivated Land

Irrigated perennial crops

Rainfed perennial crops

Irrigated annual crops

Rainfed annual crops

Others

Wetland

Permanent water body

Temporary water body

Agriculture/fallow

Built-up Land

Settlement

Perennial stream

Intermittent stream

Canal

Primary road

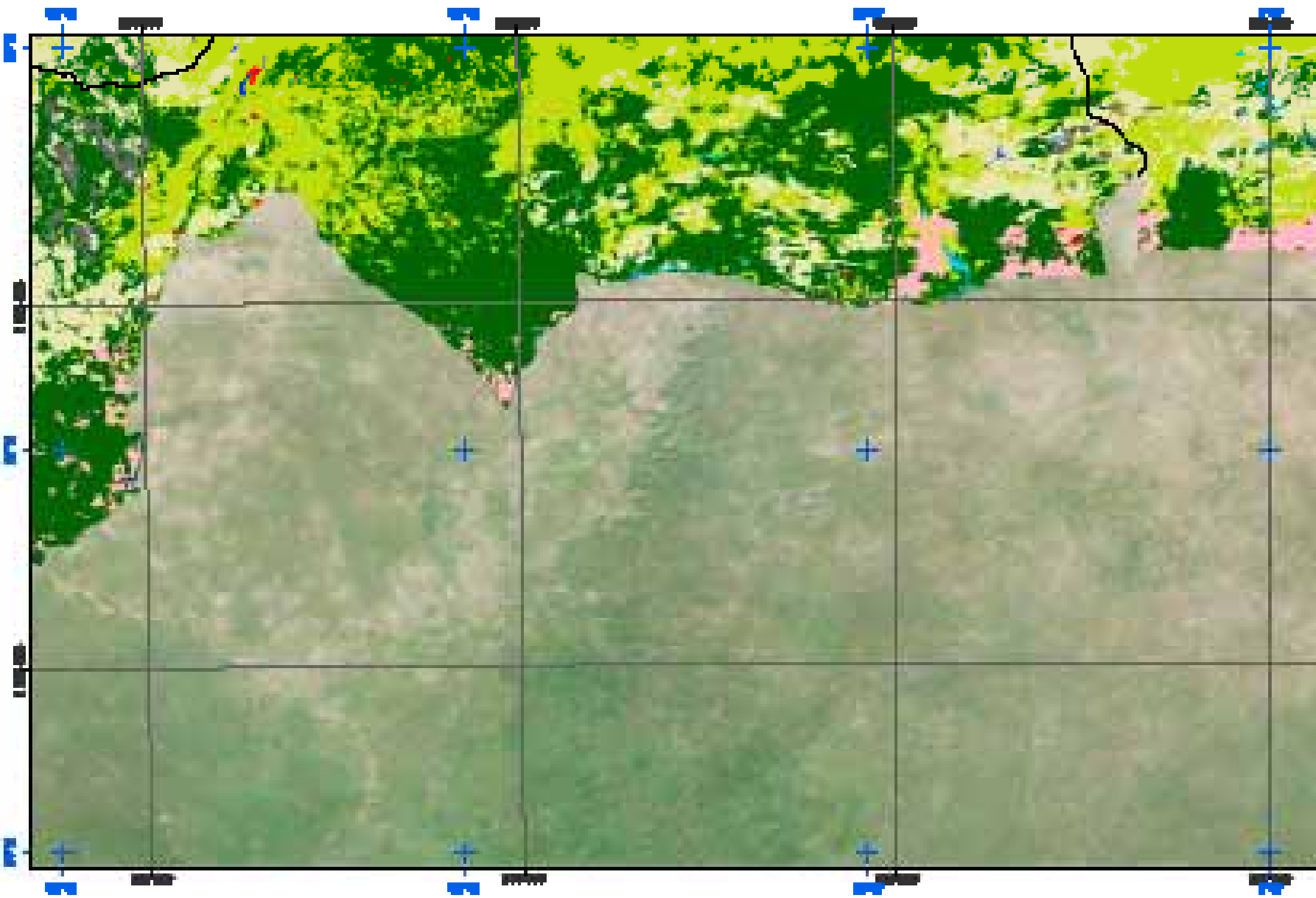
Secondary road

Tertiary road

ND-29-N

BAMAKO-N

The map is in the World Geodetic System (WGS84) and UTM projection (zone 29N).
The black grid represents the metric coordinates.
The blue dots represent the Geographical coordinates.



Natural Vegetation

Forest

Shrubland

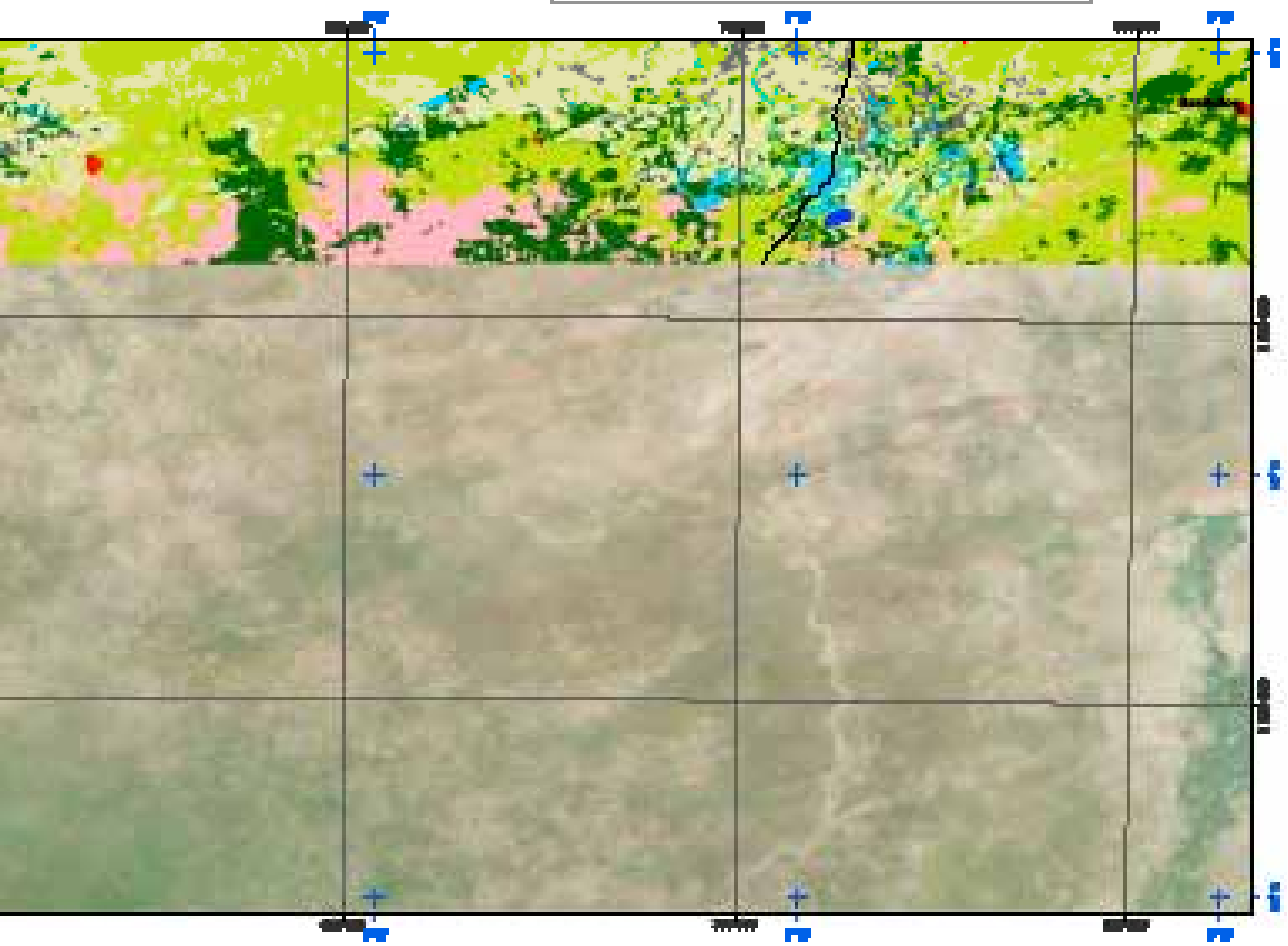
Grassland/cropland

Bare Land

Barren or sparsely vegetated

Sand dunes

Rock outcrop



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Chaks

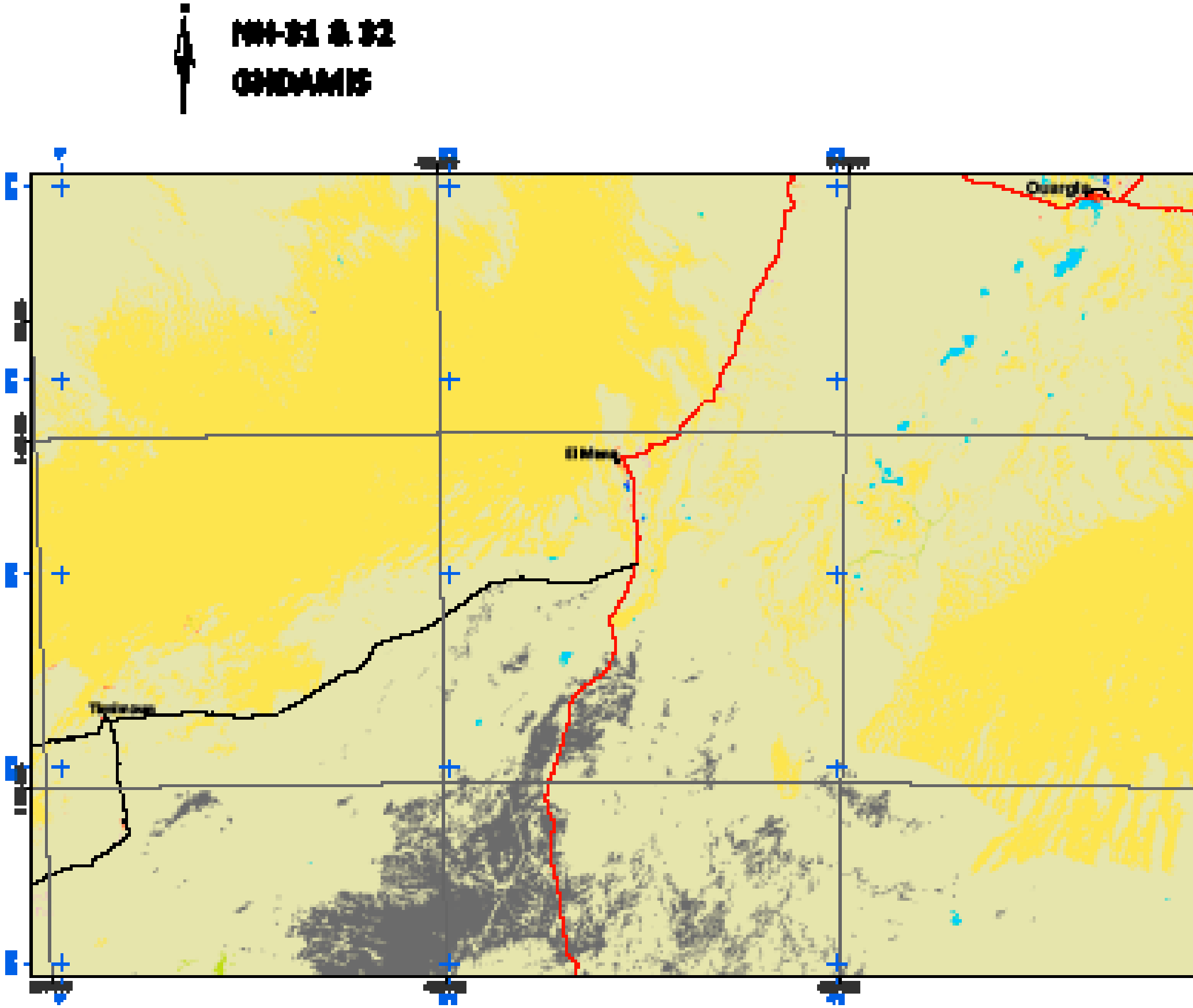
Wetland

- Permanent water body
- Temporary waterbody
- Aquaculture/fishery

Built-up Land

- Settlement

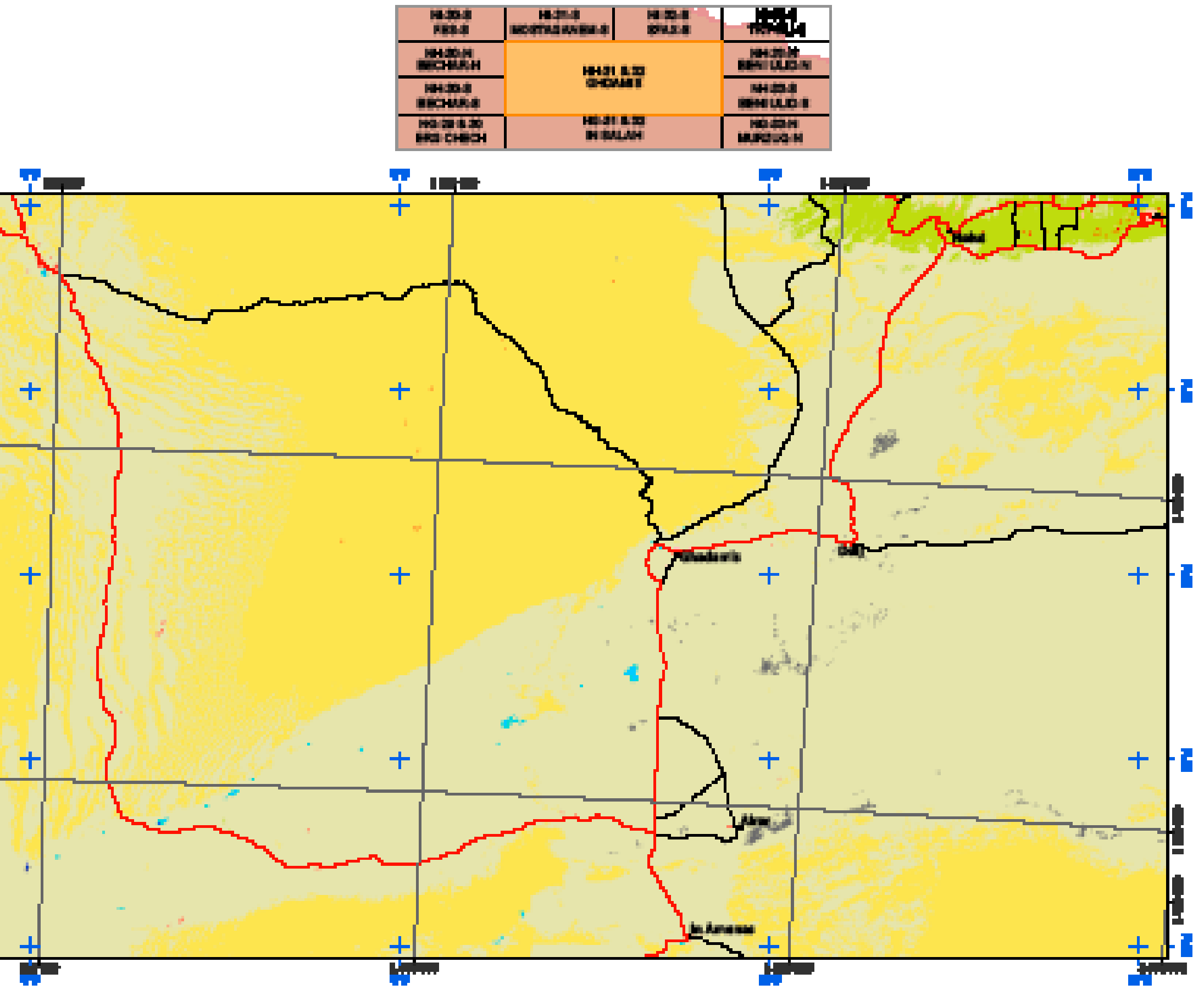
- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road



Natural Vegetation
Forest
Shrubland
Steppe/Rangeland

Bare Land
Bare rock/clay/gravel/sand
Sand dunes
Rock outcrop

The map is in the World Geodetic System (WGS84) and UTM projection (zone31).
The black grid represents the metric coordinates.
The blue ticks represent the Geographic coordinates.



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

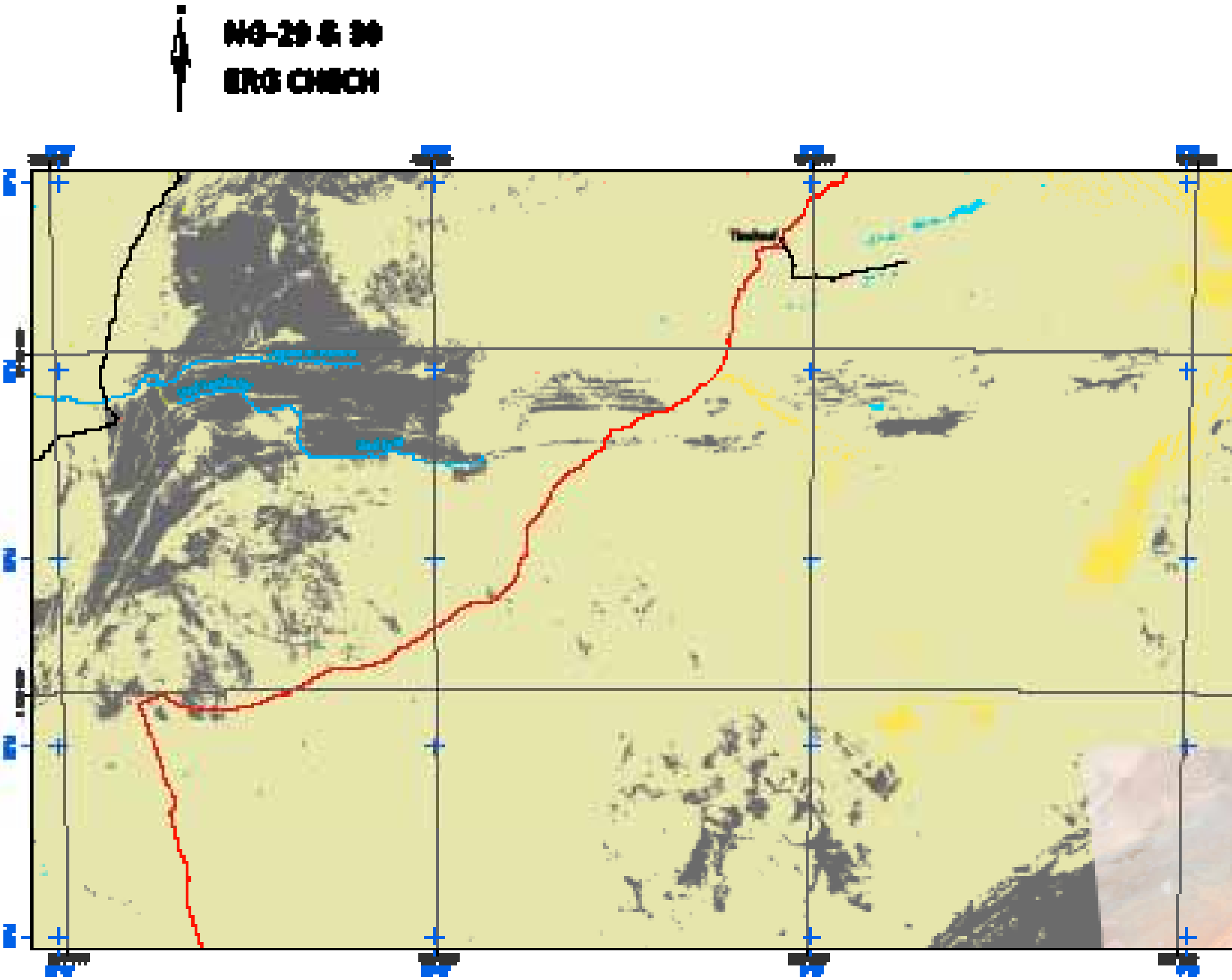
Wetland

- Permanent waterbody
- Temporary water body
- Agriculture/olive

Built-up Land

- Settlement

- Powerline
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

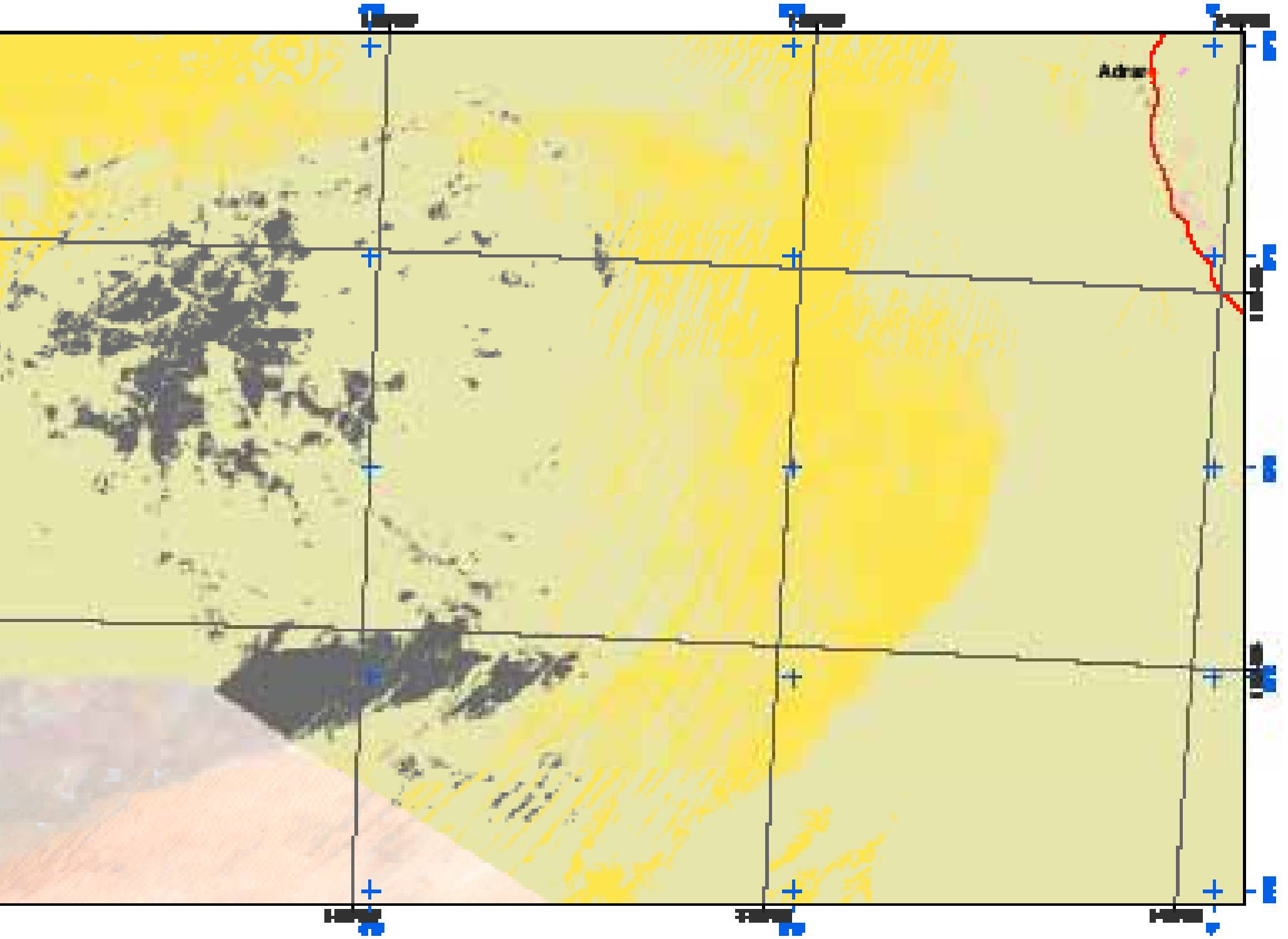


Scale 1:2 000 000

This map is for the World Geodetic System [WGS84] and UTM projection [zone 47].
The blue grid represents the cartesian coordinates.
The black grid represent the Geographical coordinates.

Natural Vegetation
Forest
Grassland
Cropland/Rangeland

Biome Level
Barren or sparsely vegetated
Sand dunes
Rock outcrop



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Orchards

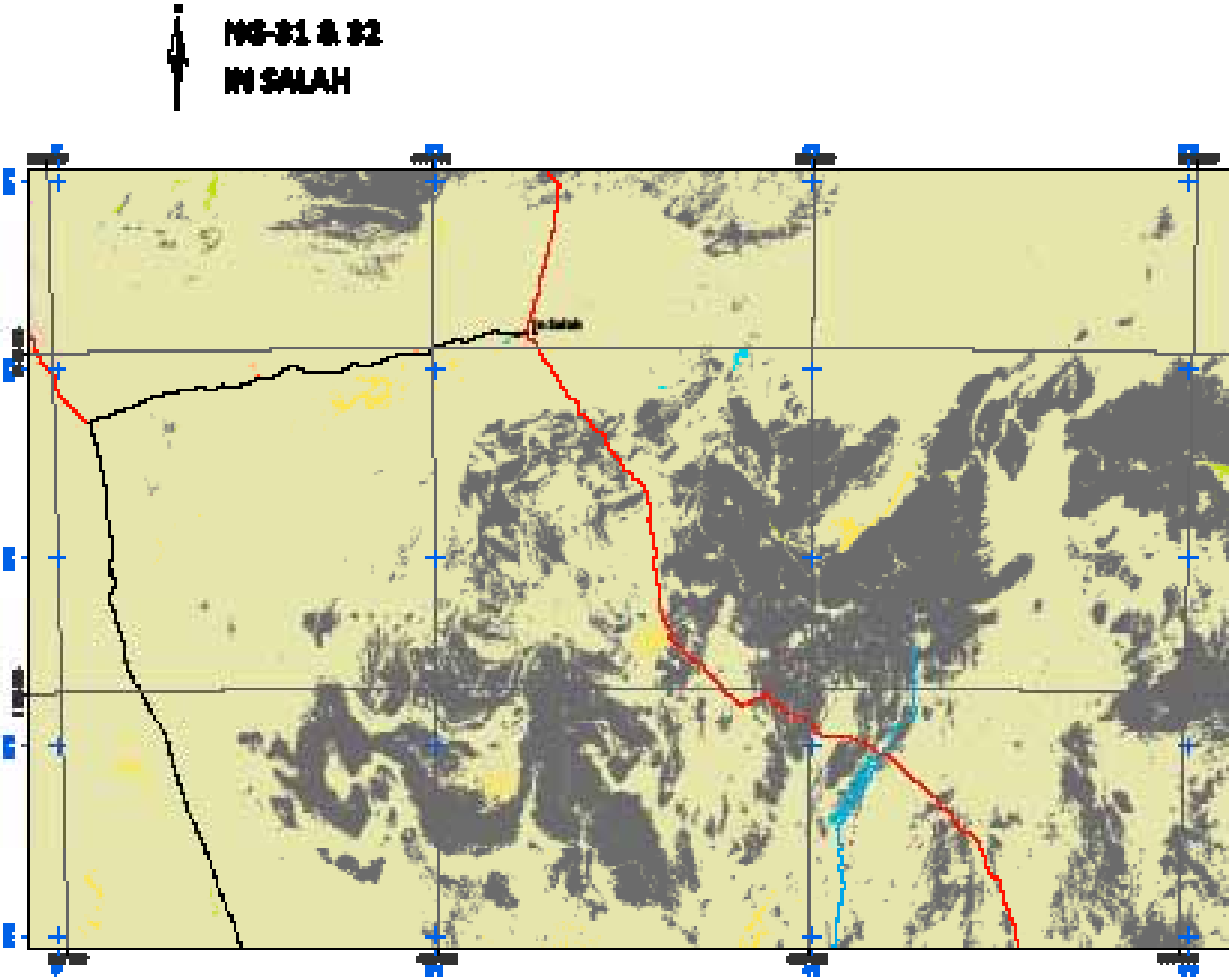
Wetland

- Permanent water body
- Temporary waterbody
- Aquaculture/Saline

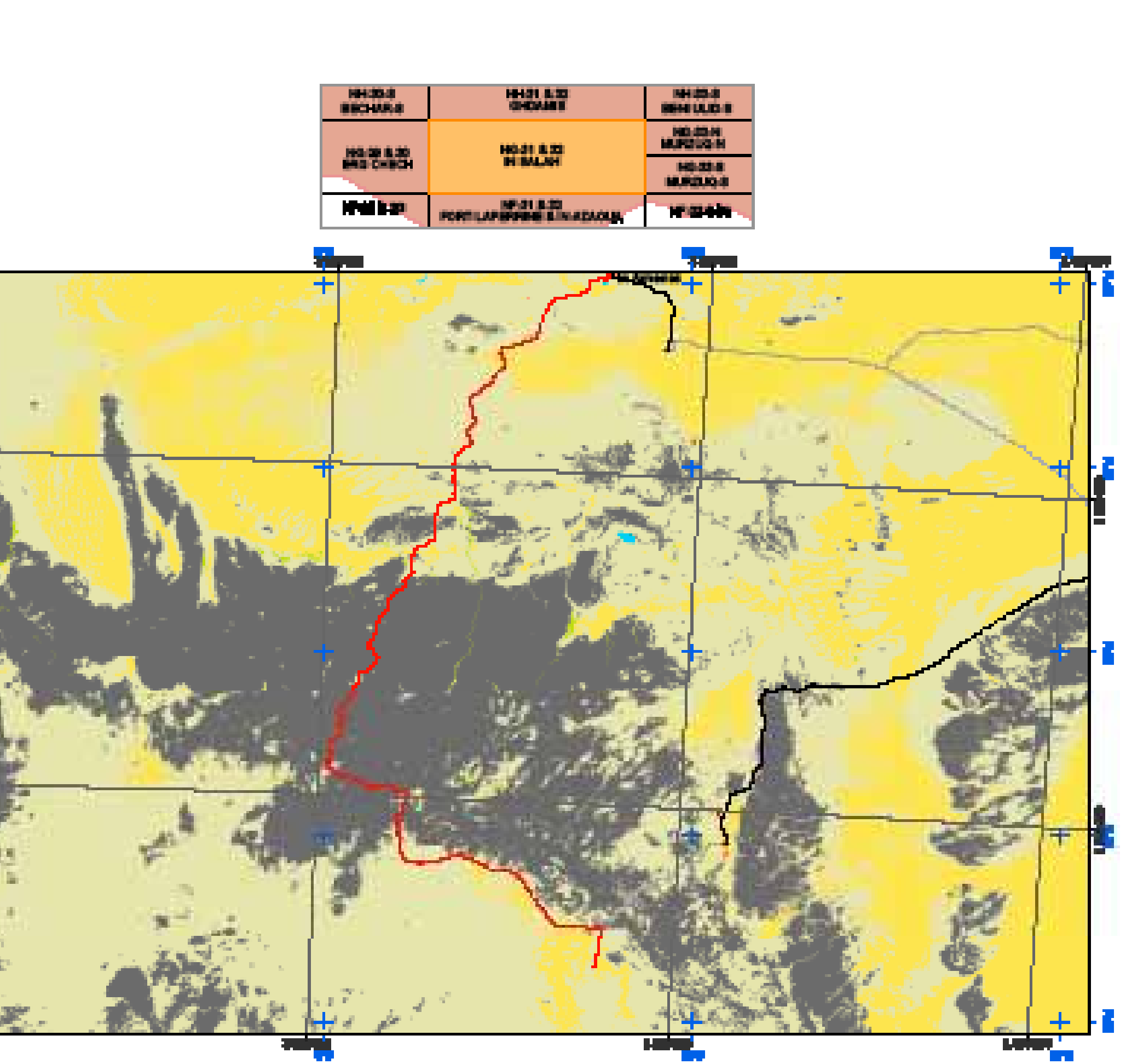
Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road



The map is in the World Geodetic System (WGS84) and UTM projection (zone 48).
The black grid represents the metric coordinates.
The blue ticks represent the Geographical coordinates.



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

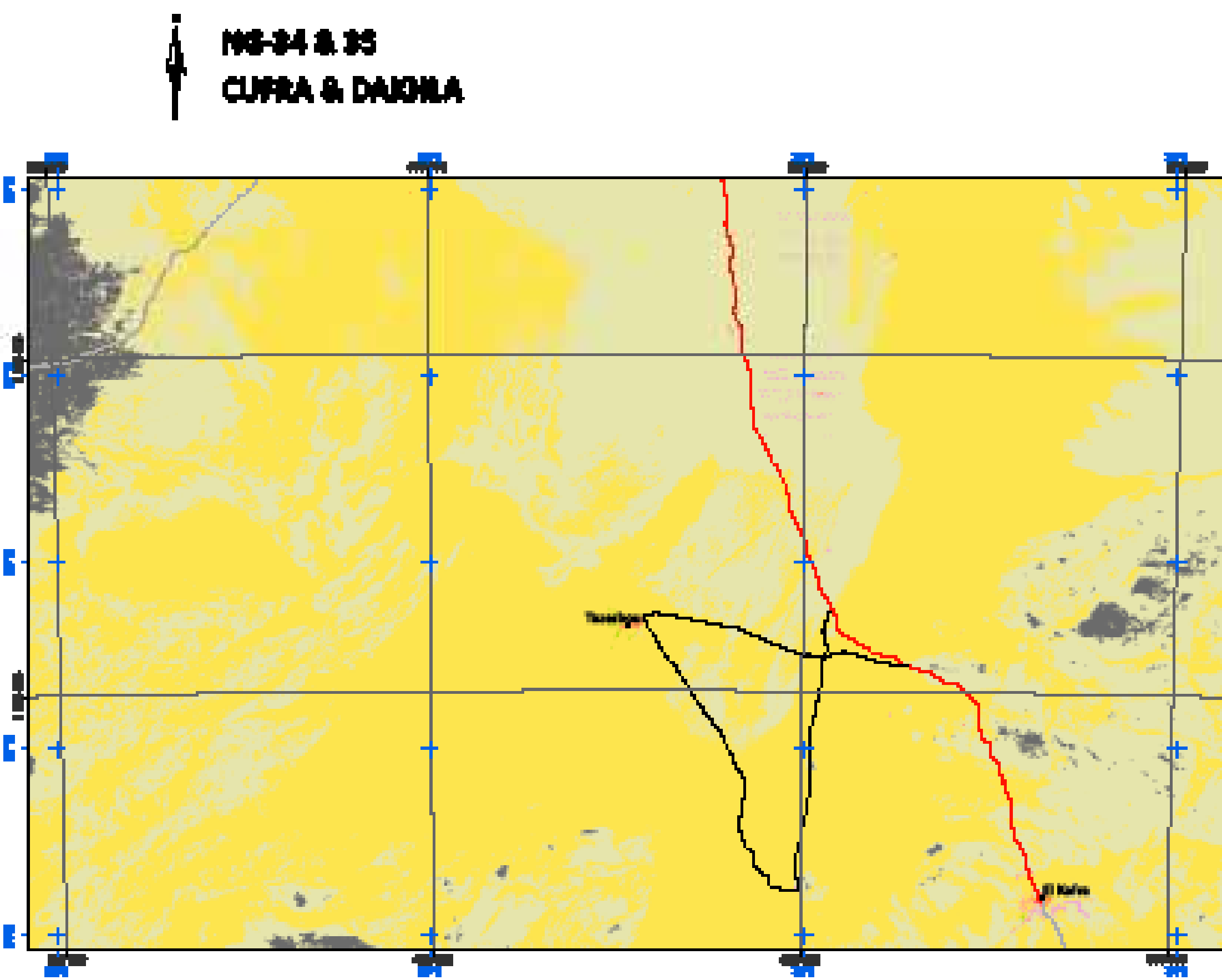
Wetland

- Permanent waterbody
- Temporary water body
- Agriculture/Water

Building Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Motorway
- Boundary road
- Tertiary road

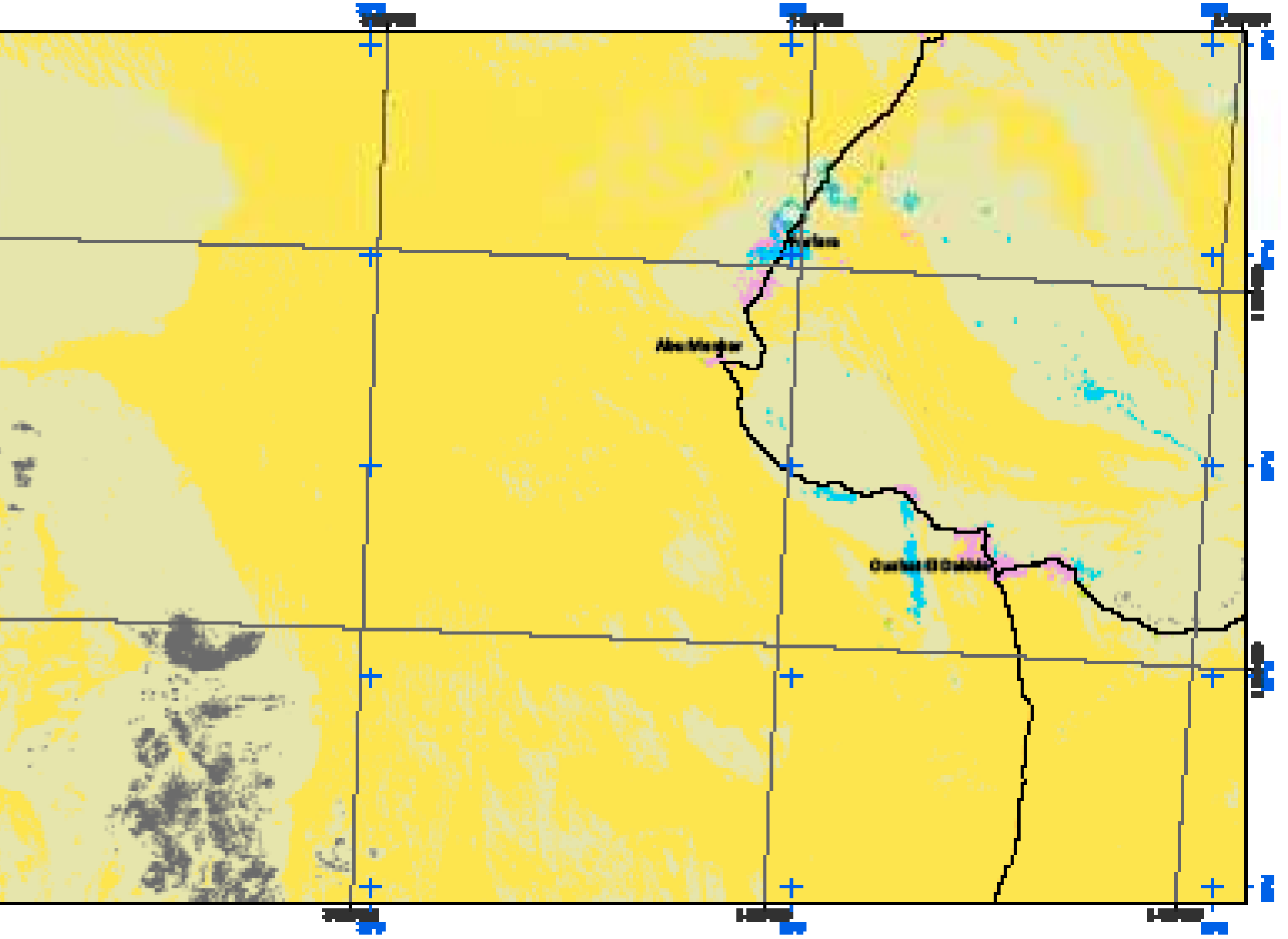


Scale 1:2 [illegible]

The map is in the World Geodetic System [illegible] and UTM projection [illegible].
The black grid represents the metric coordinates.
The blue lines represent the Geographic coordinates.

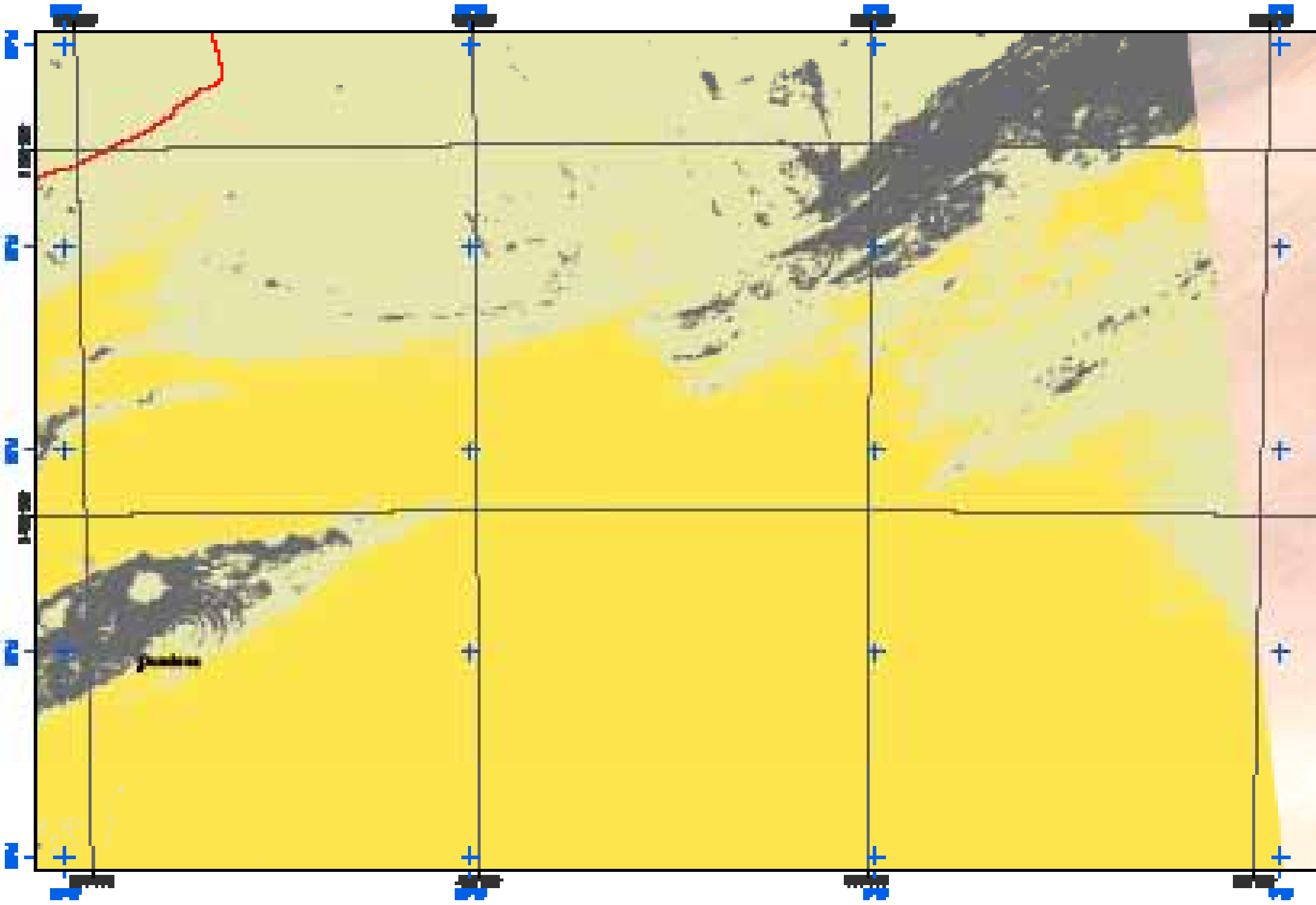
Natural Vegetations
Forest
Shrubland
Steppe/Rangeland

Bare Land
Bare rock/dry/sparse vegetation
Sand dunes
Rock outcrop



NF-28 & 30

OUADANE & TAOUDENNI



Natural Vegetation

Forest

Shrubland

Cropland/Rangeland

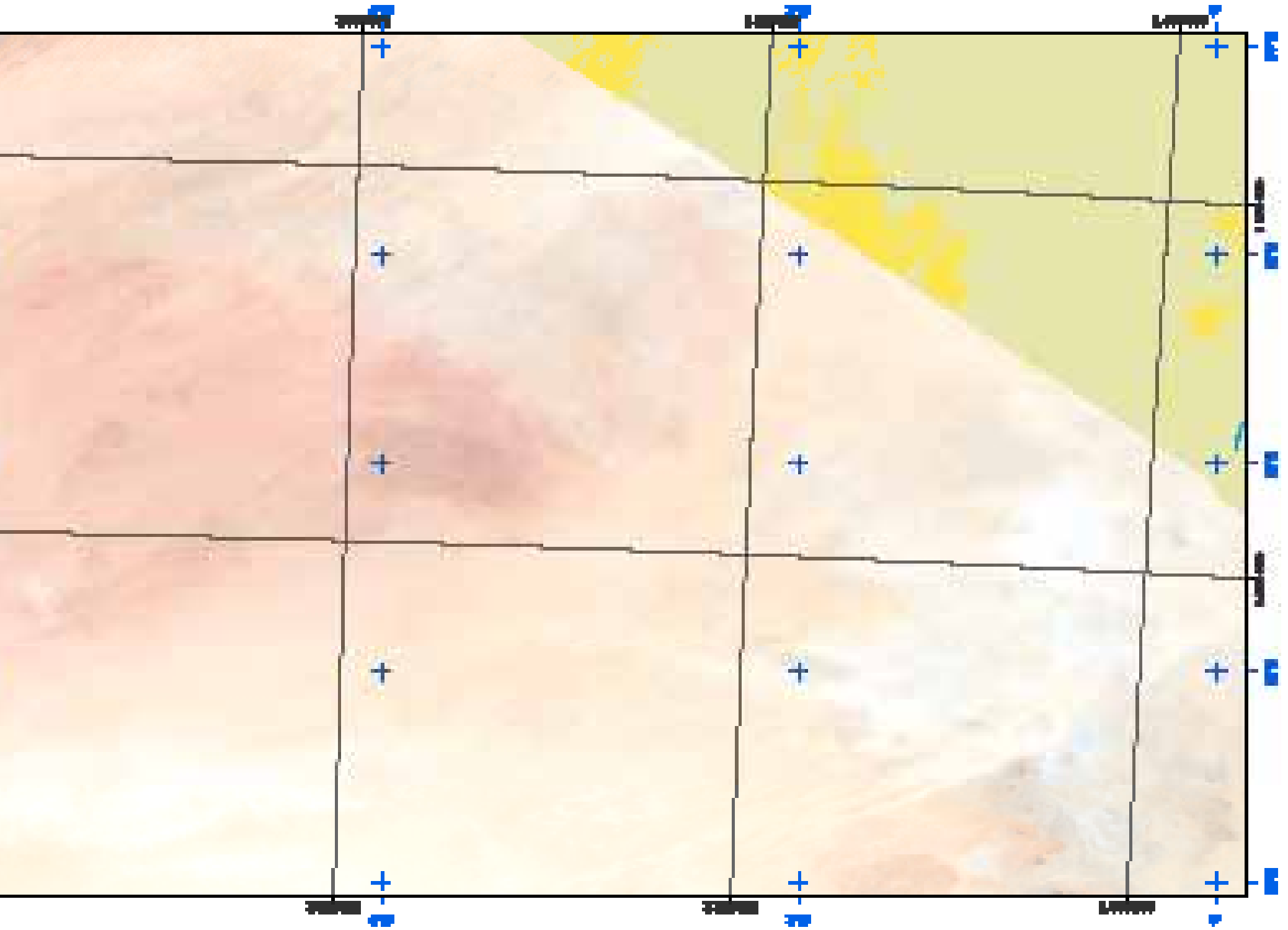
Base Land

Barren or Sparsely vegetated

Sand dunes

Rocky outcrop

[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]		
[illegible]	[illegible]	[illegible]



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Fallow

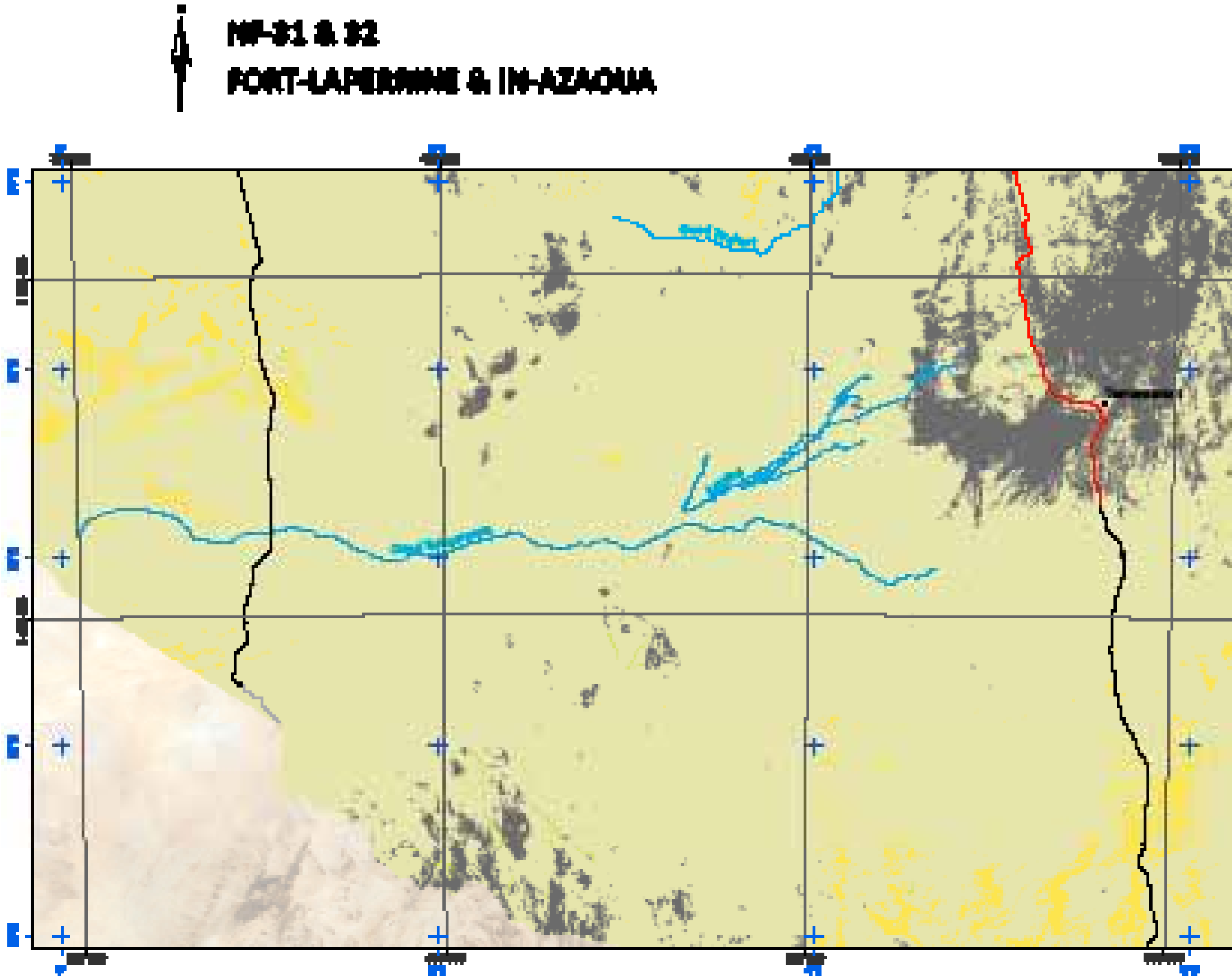
Wetland

- Perennial water body
- Temporary water body
- Aquaculture/fishpond

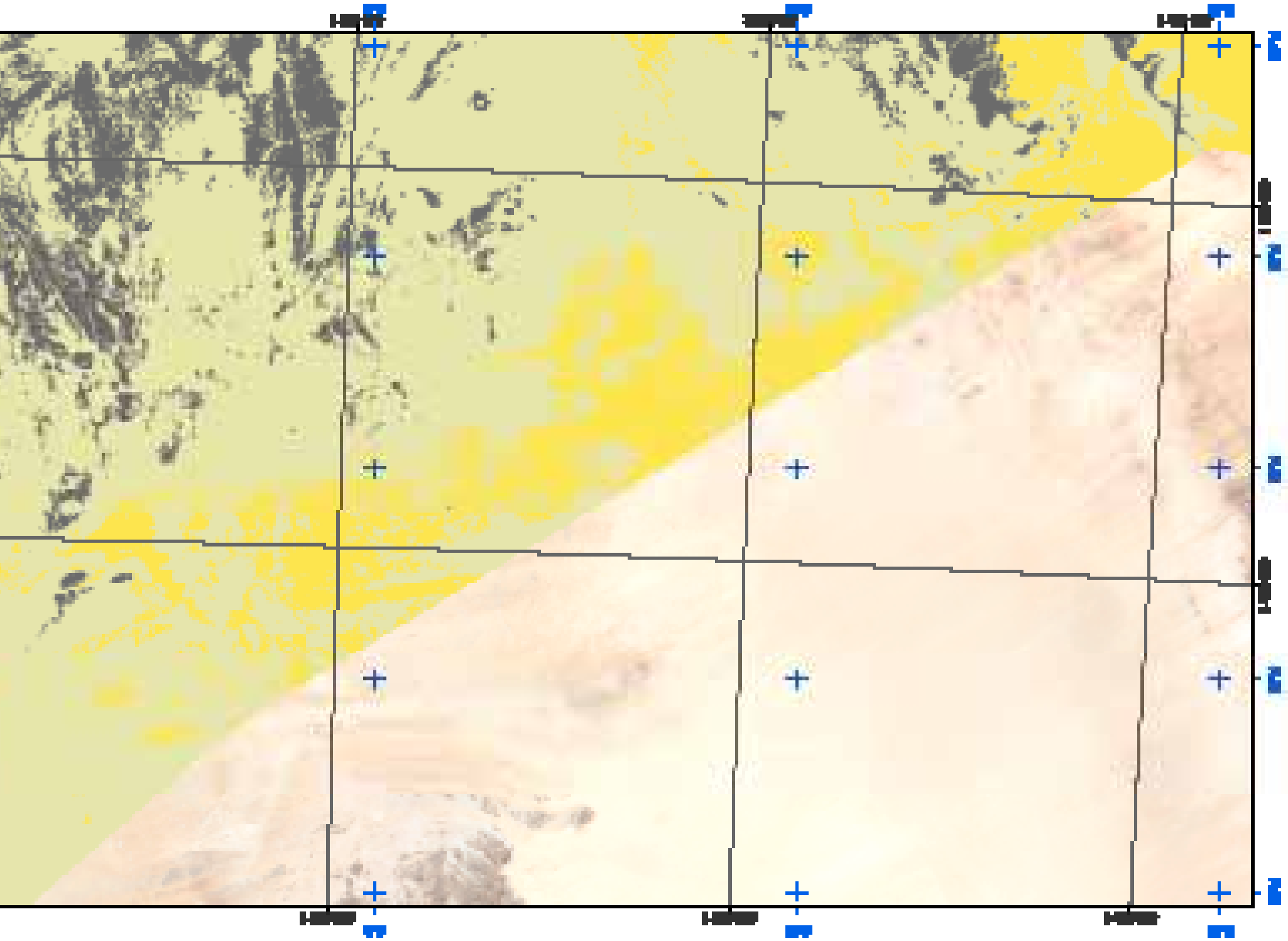
Built-up Land

- Settlement

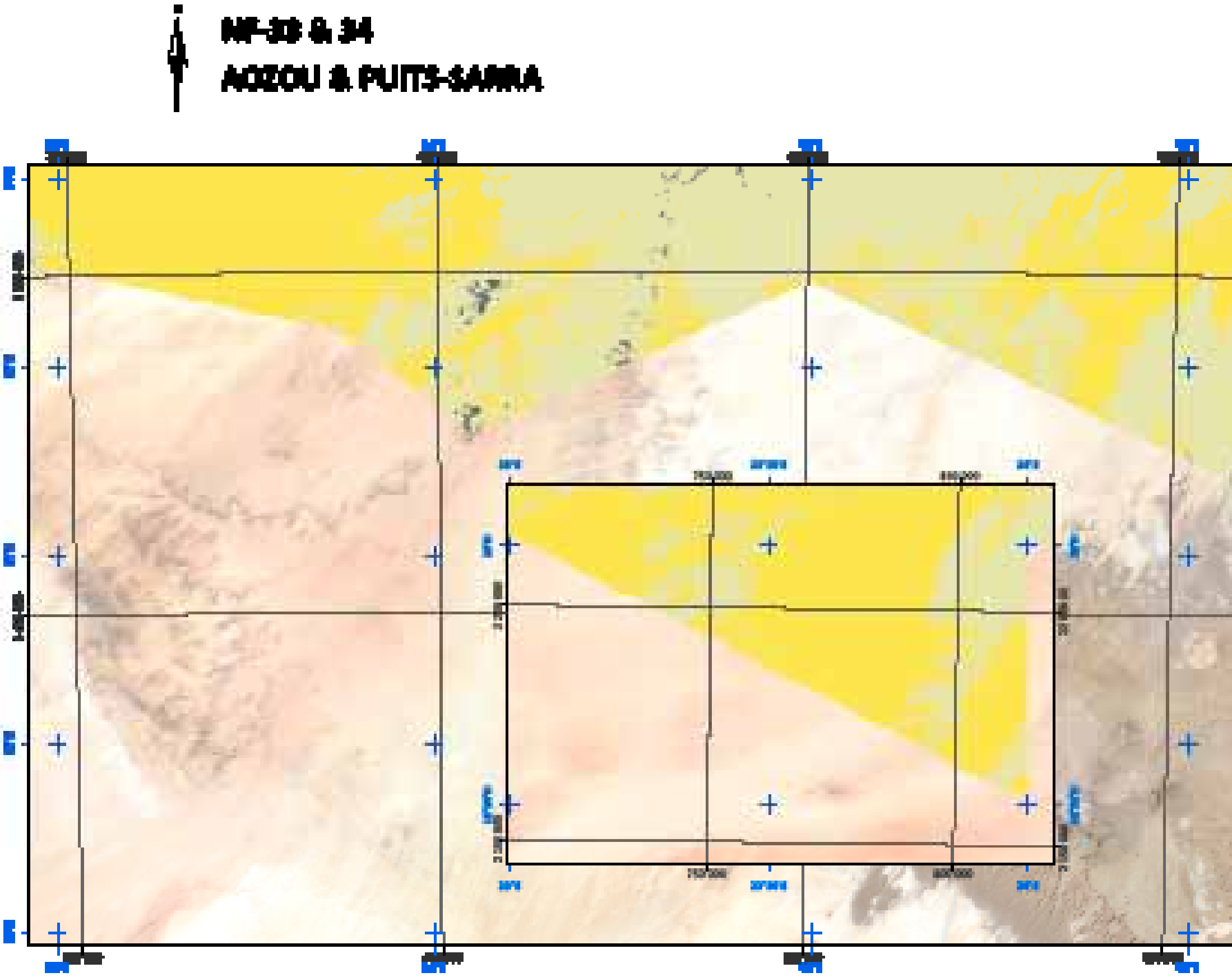
- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


Natural Vegetation
Forest
Shrubland
Wetland/Rangeland
Bare Land
Sand dunes
Rock outcrop

page 130




Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Wetland
Permanent waterbody
Temporary water body
Agricultural holding
Built-up Land
Settlement
Perennial rivers
Intermittent rivers
Canal
Primary road
Secondary road
Tertiary road

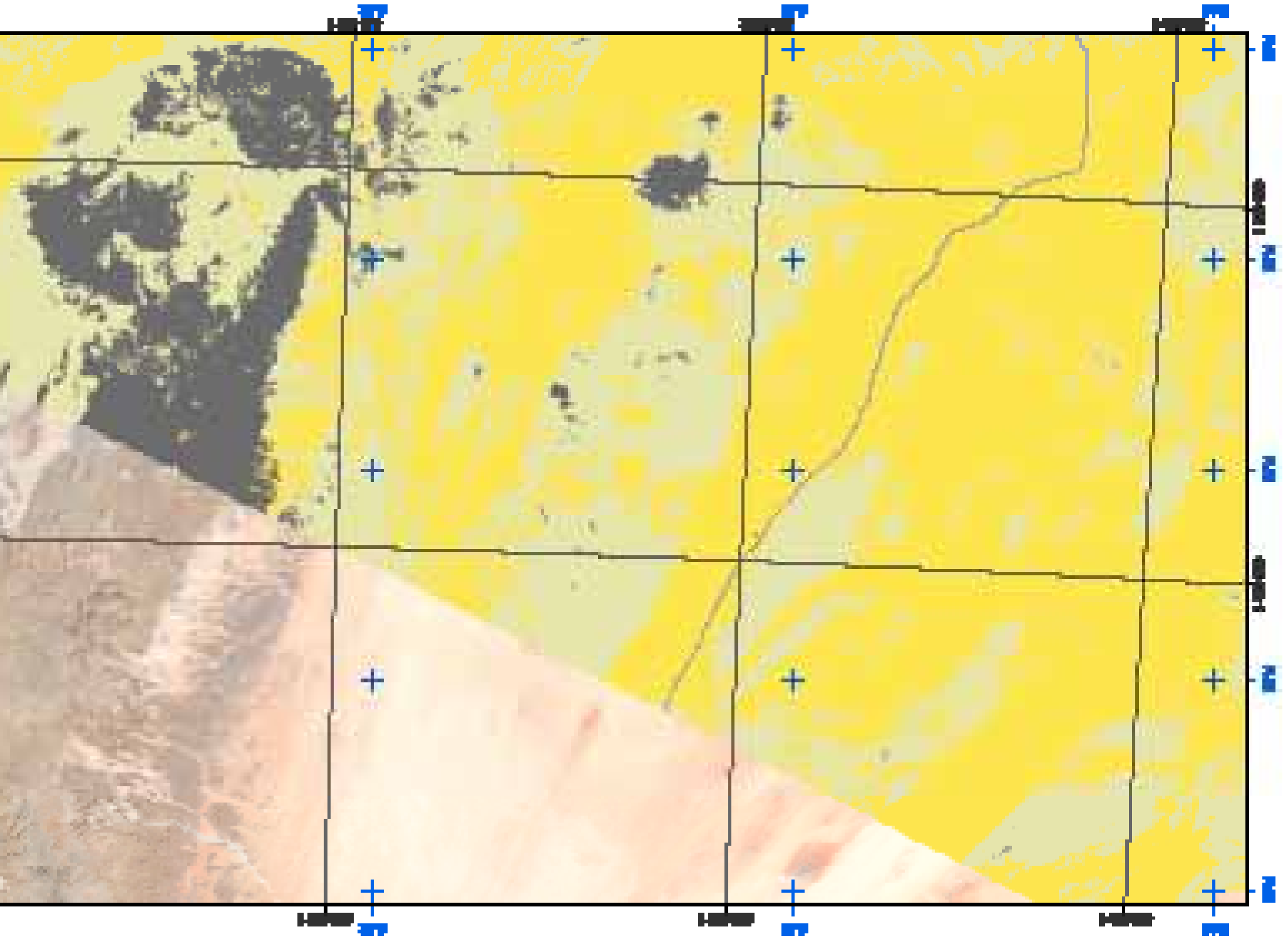


Scale 1:3 000 000

The map is in the World Geodetic System (present) and UTM projection (zone 30).
The black grid represents the metric coordinates.
The blue ticks represent the Geographical coordinates.

Natural Vegetation
- Forest
- Shrubland
- Steppe/Rangeland

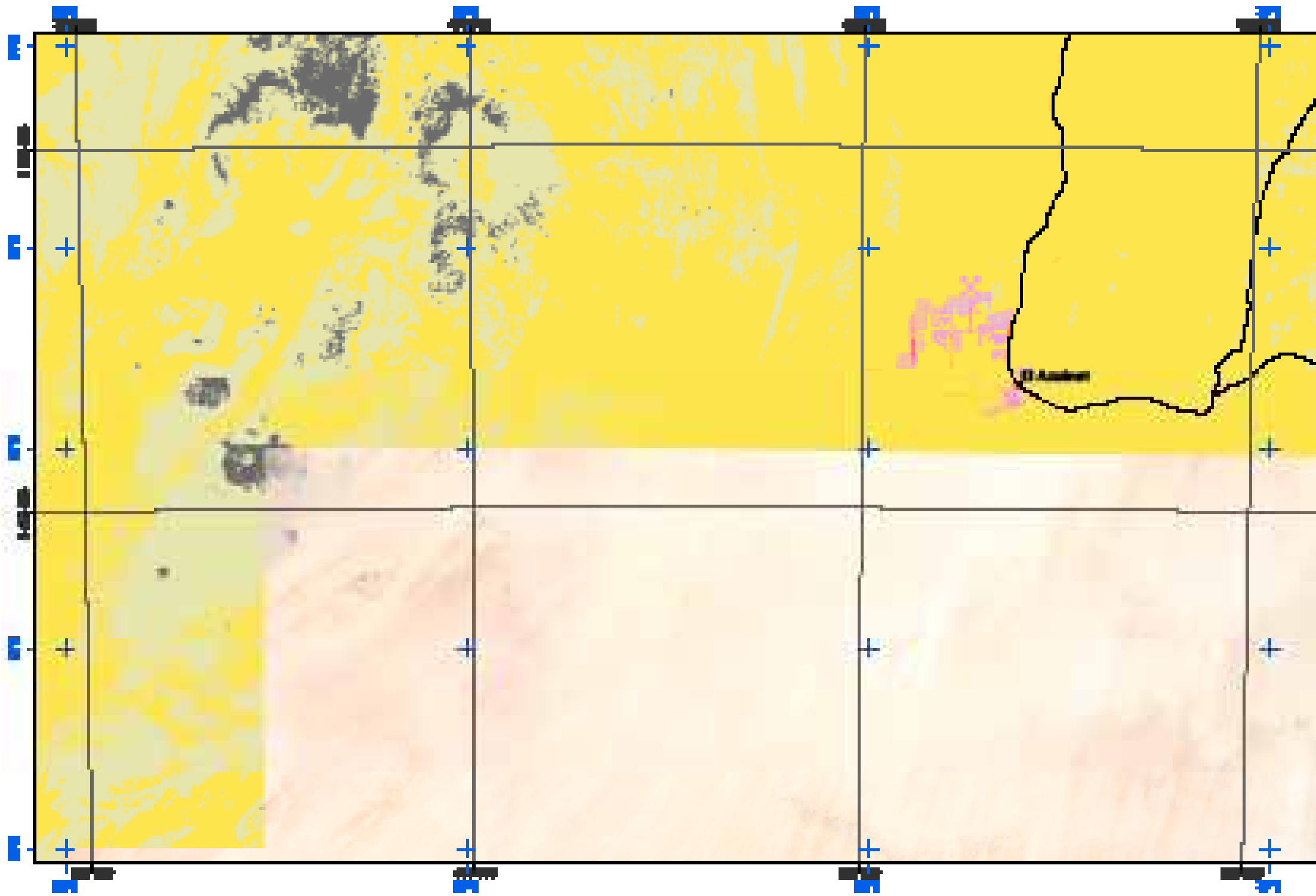
Bare Land
- Desert/sandy sparse vegetation
- Sand dunes
- Rock outcrop




Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Clouds
Wetland
Permanent water body
Temporary water body
Agriculture fallow
Built-up Land
Settlement
Perennial stream
Intermittent stream
Canal
Primary road
Secondary road
Tertiary road

MAP-NO 8.34

AYN-AL-GHAZAL & WADI-HALFA



Scale 1:3 000 000

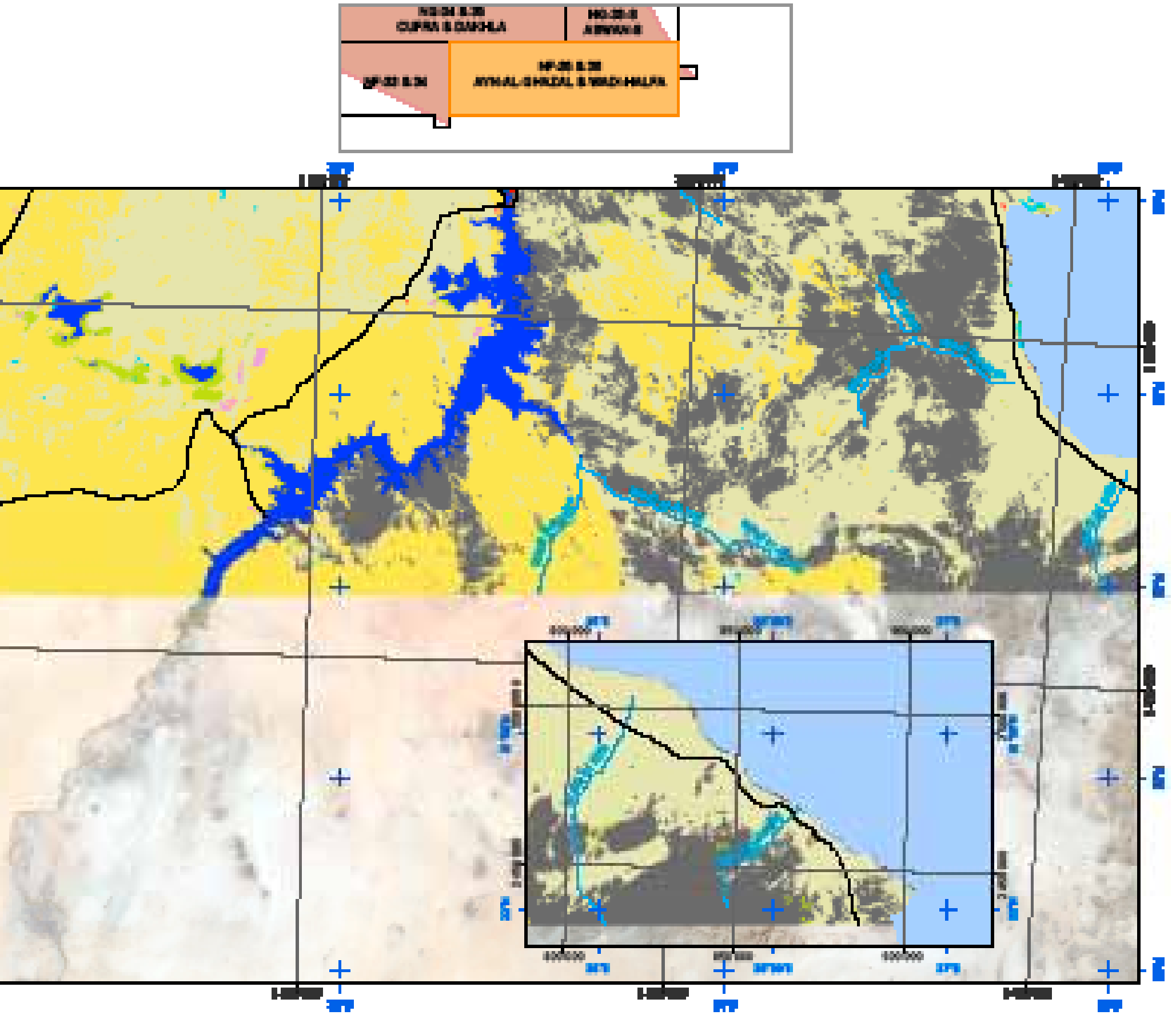
The map is in the World Geodetic System (WGS84) and UTM projection (zone36).
The black grid represents the metric coordinates.
The blue ticks represent the Geographical coordinates.

Natural Vegetations

- Forest
- Shrubland
- Steppe/Rangeland

Bare Land

- Barren with dry sparse vegetation
- Sand dunes
- Rock outcrop

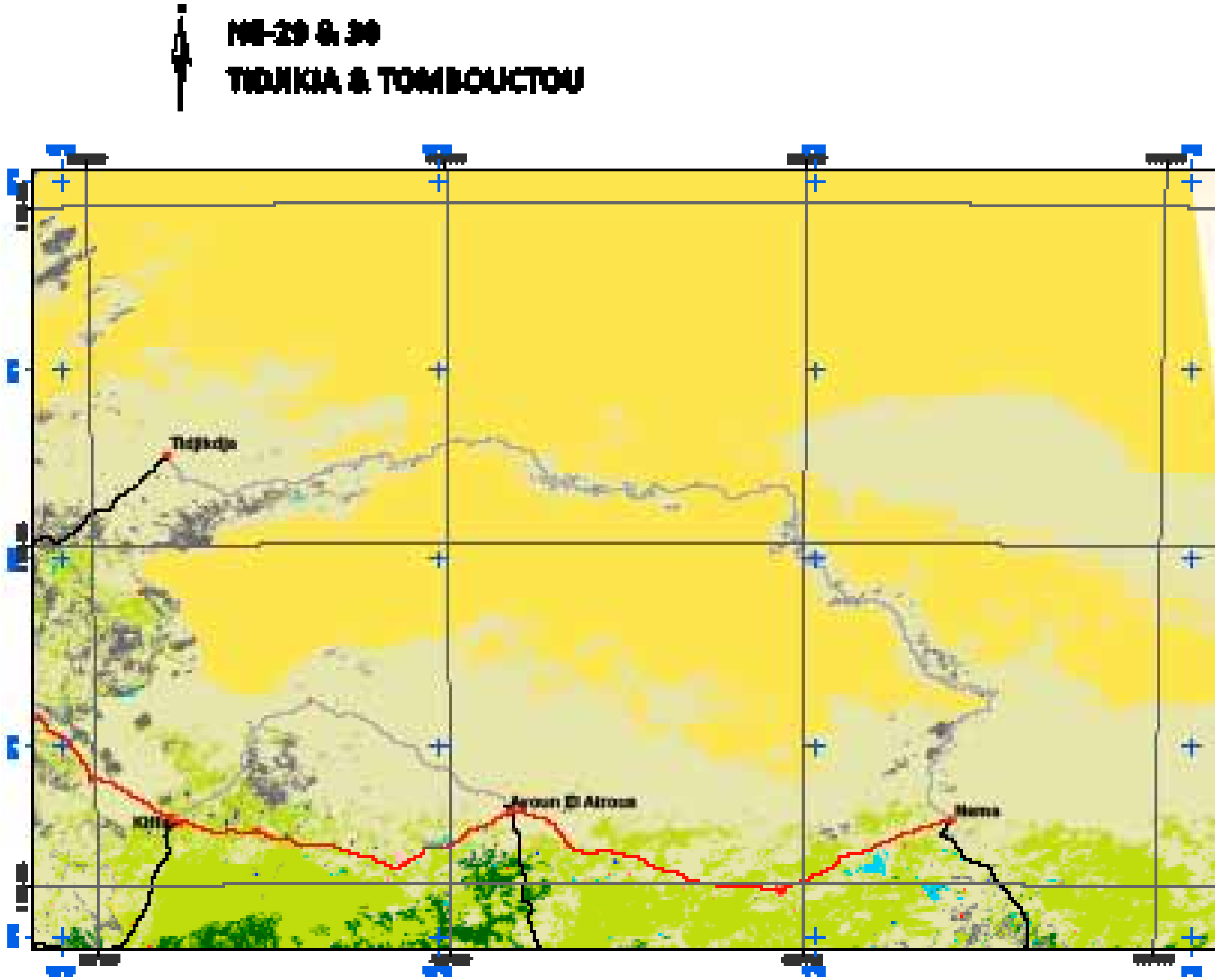


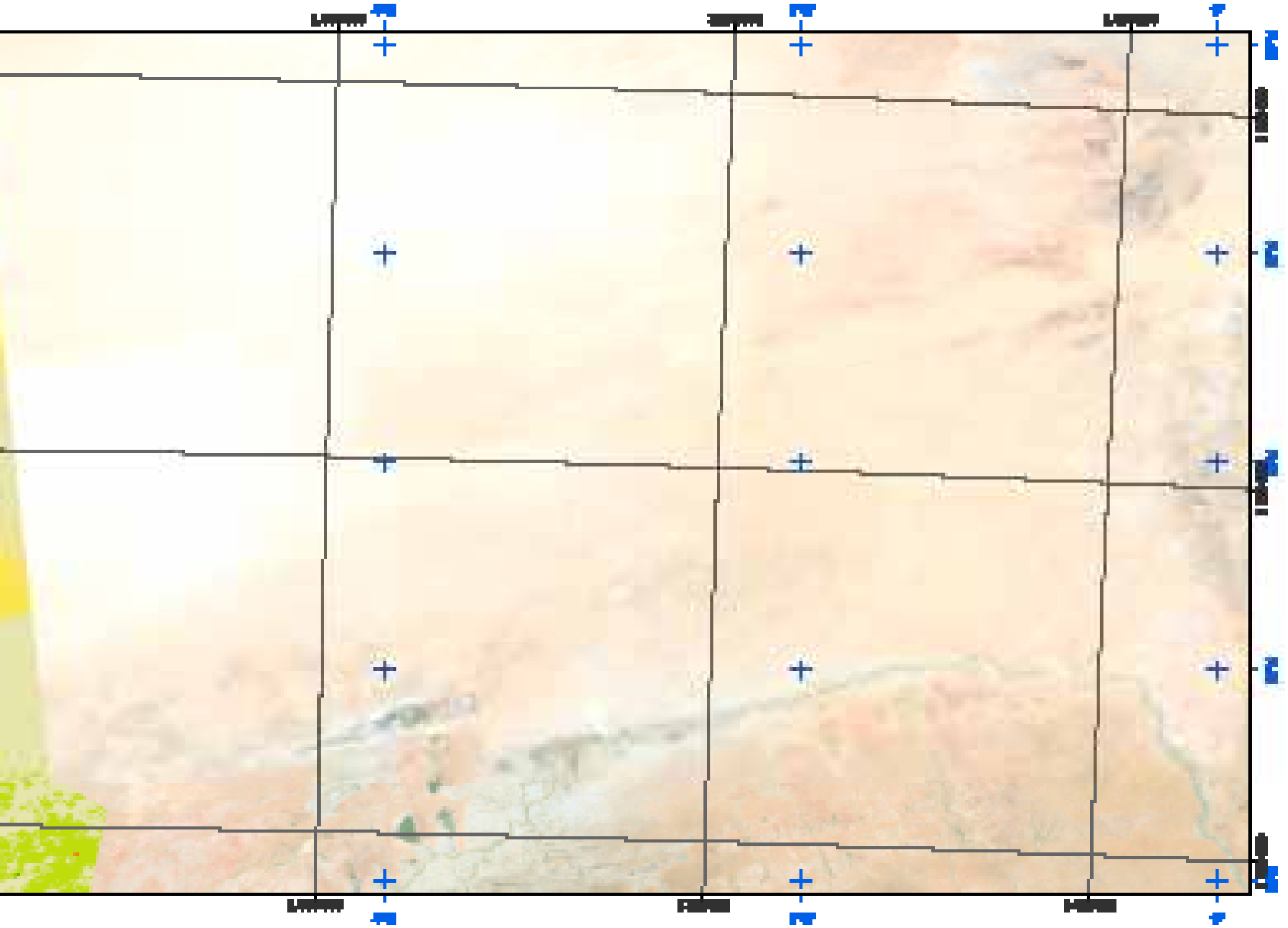
Cultivated Land
- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

Wetland
- Permanent waterbody
- Temporary water body
- Agriculture lakes

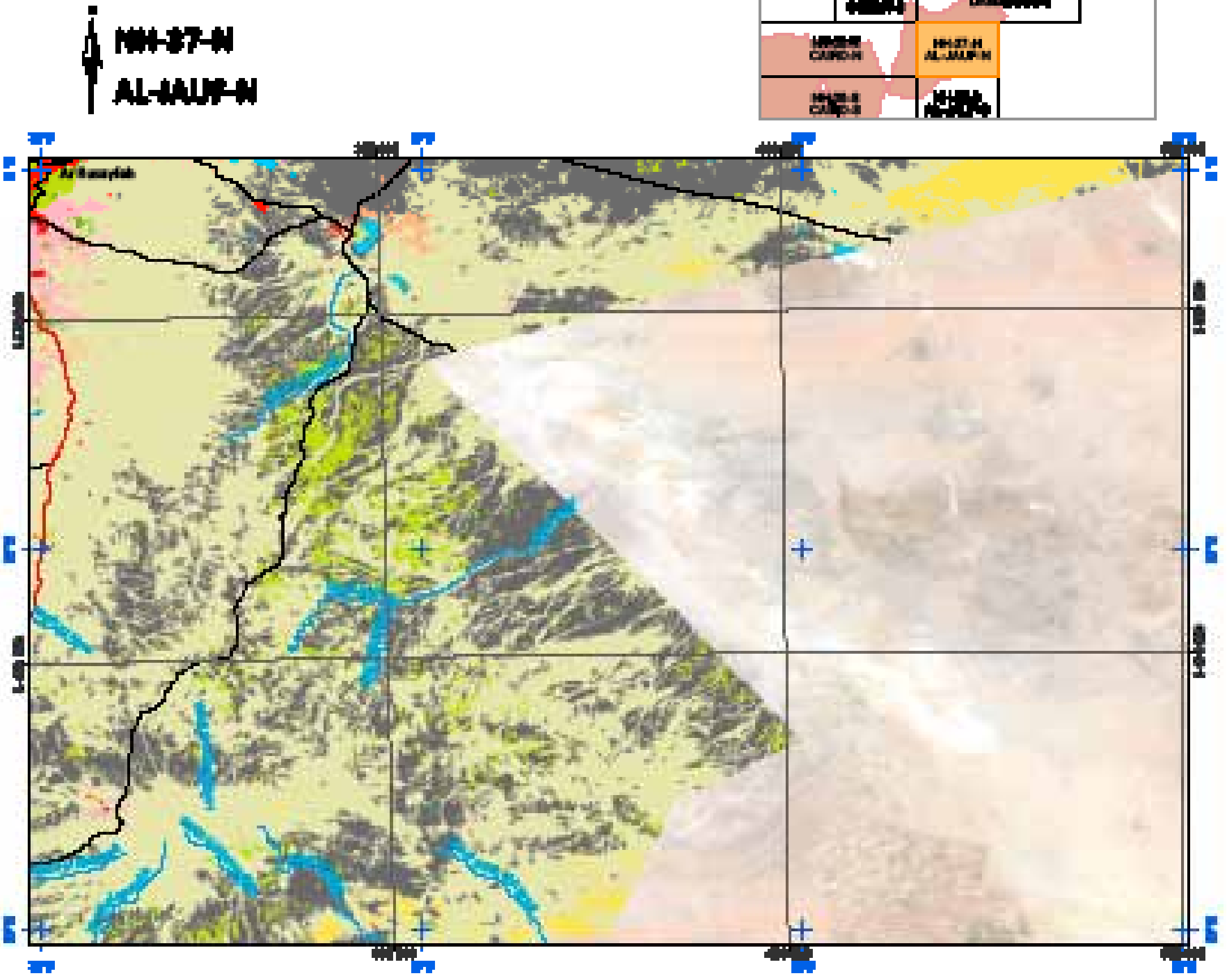
Built-up Land
- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road


Tidjikdja
Ayoun El Atrous
Nema




Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Wetland
Permanent waterbody
Temporary water body
Agricultural lakes
Built-up Land
Settlement
Perennial rivers
Intermittent rivers
Canal
Motorway
Main road
Track road

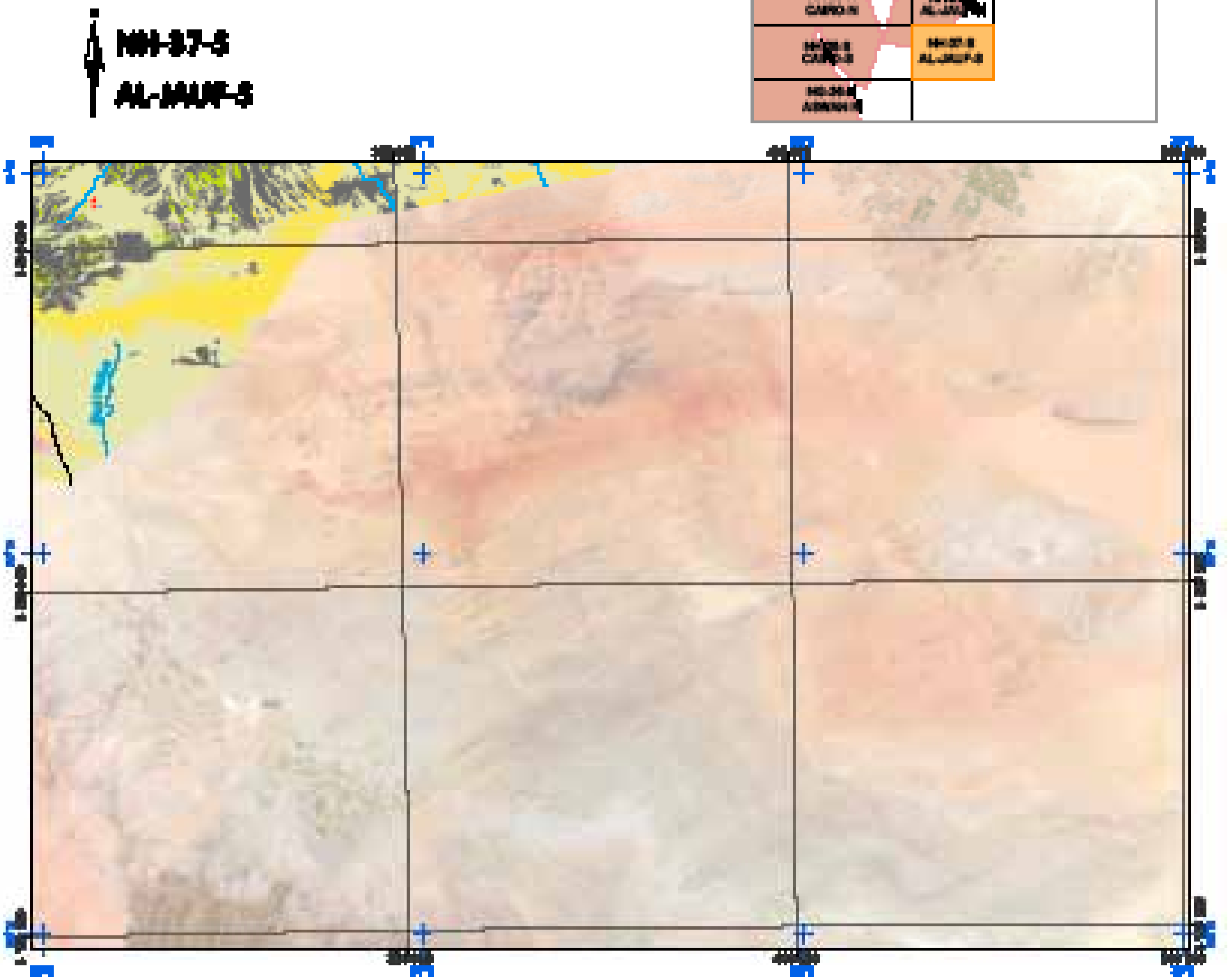


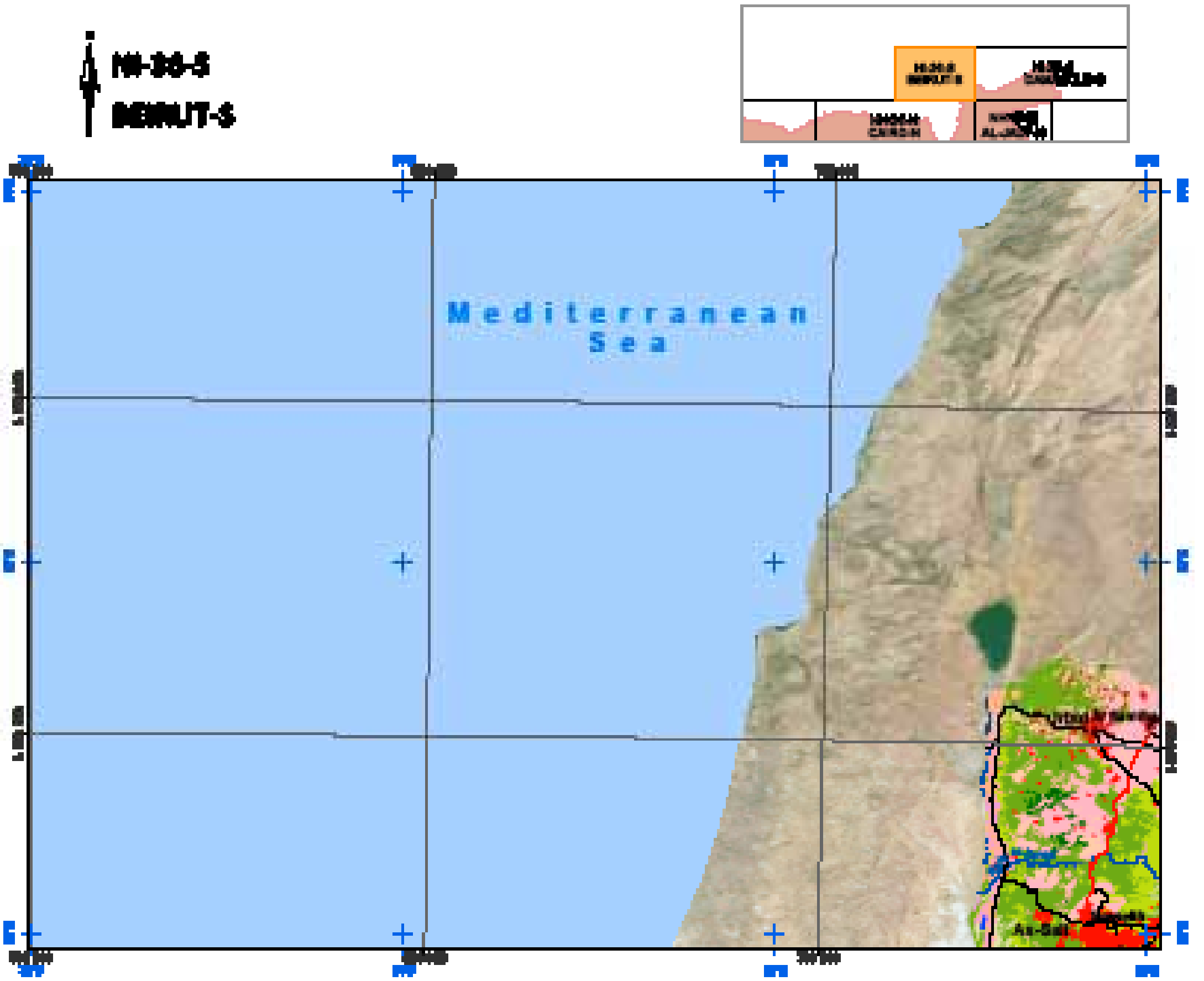
Scale 1:1 250 000

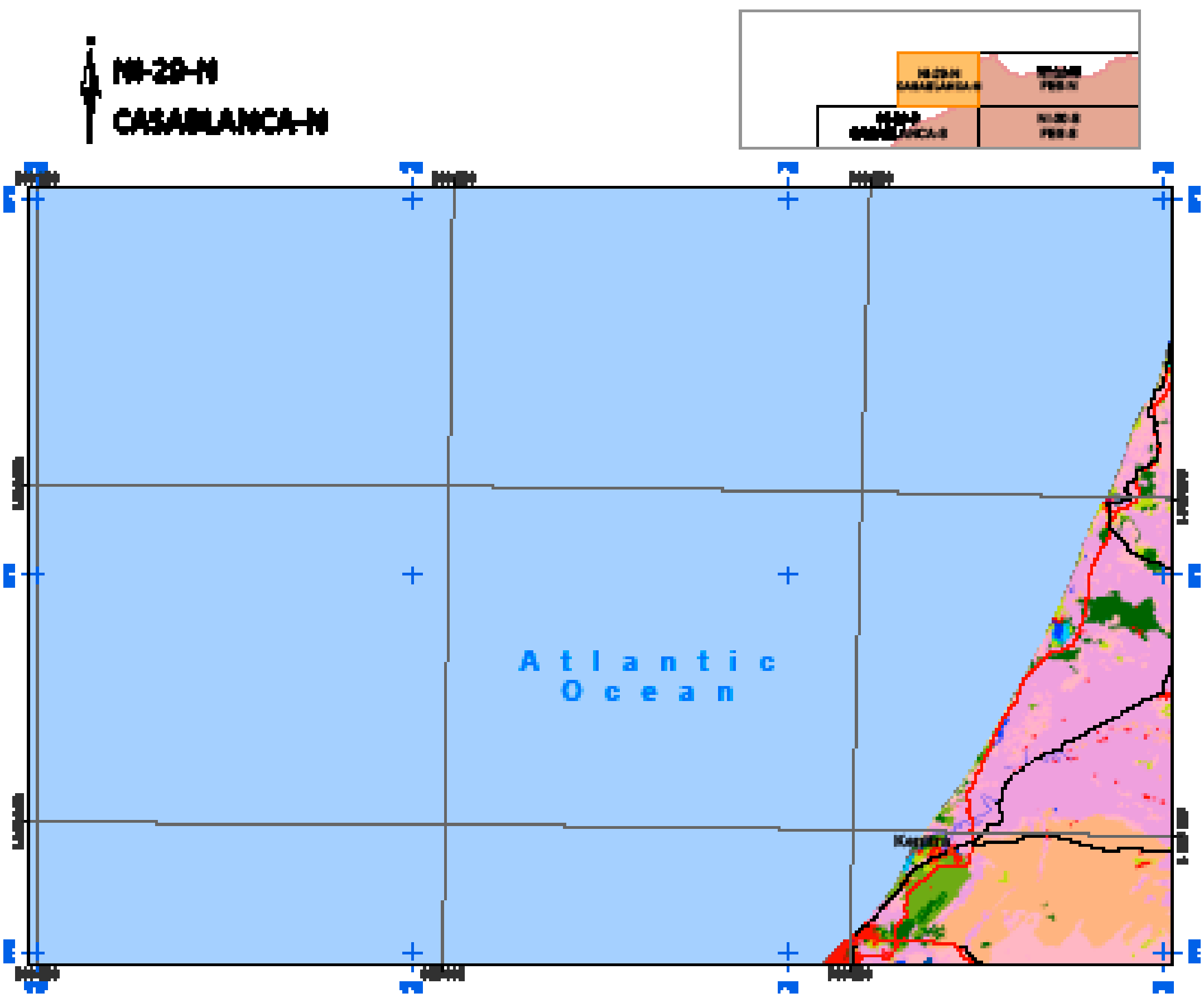
The map is in the World Geodetic System (WGS84) and UTM projection (zone 37).
The black grid represents the metric coordinates.
The blue ticks represent the Geographical coordinates.

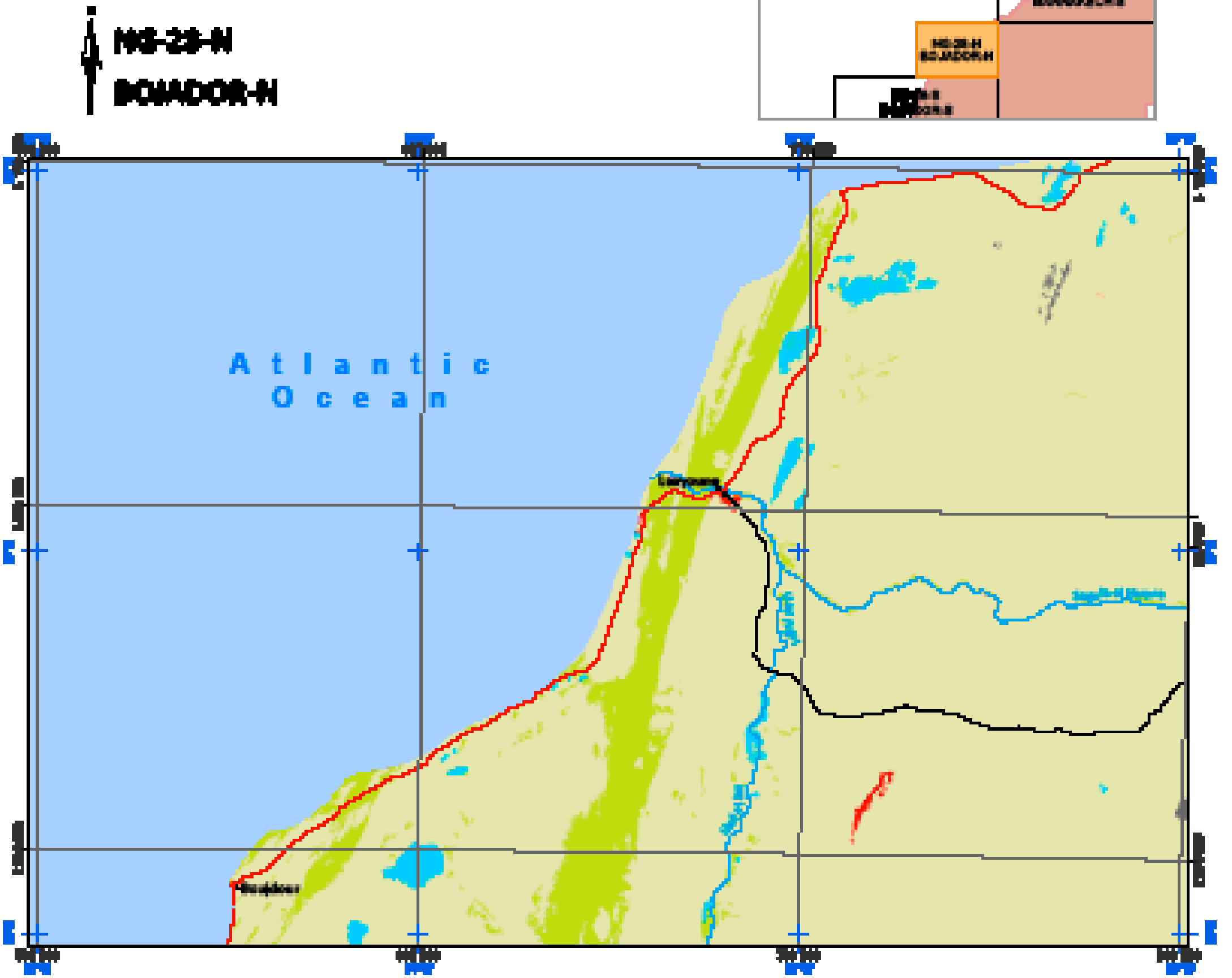
Natural Vegetation
Forest
Shrubland
Agro-pastoral land

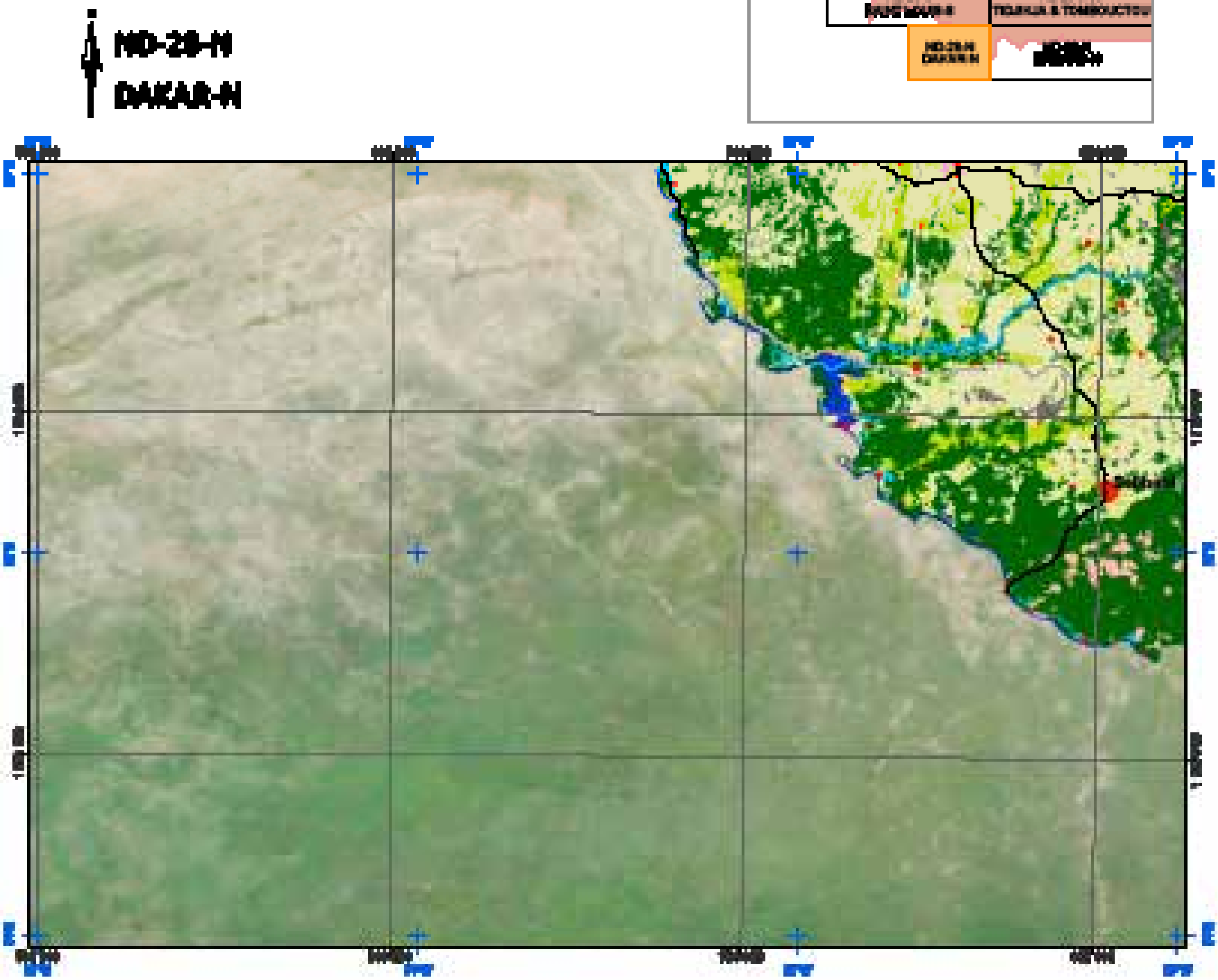
Human Land
Human settlement, agro-pastoral
Sand dunes
Rock outcrop


N
Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Water bodies
Permanent water body
Temporary water body
Aquaculture/fishing
Built-up Land
Settlement
Perennial stream
Intermittent stream
Canal
Primary road
Secondary road
Tertiary road


Mediterranean
Sea


M6-20-N
CASABLANCA-N
Atlantic
Ocean


Atlantic
Ocean



Cultivated Land

- Irrigated perennial crops
- Rainfed perennial crops
- Irrigated annual crops
- Rainfed annual crops
- Oasis

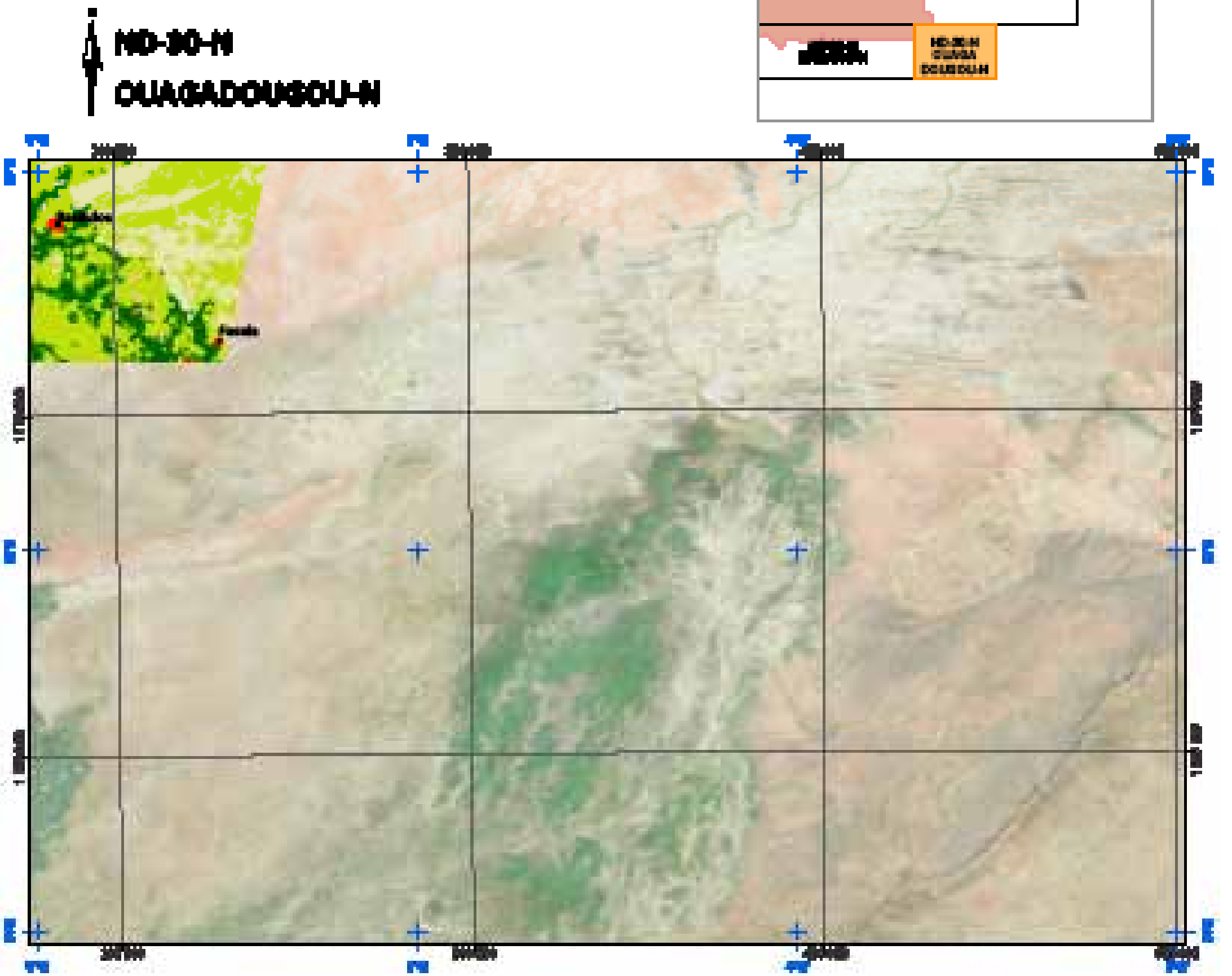
Other Land

- Permanent water body
- Temporary water body
- Aquaculture/Saline

Built-up Land

- Settlement

- Perennial stream
- Intermittent stream
- Canal
- Primary road
- Secondary road
- Tertiary road

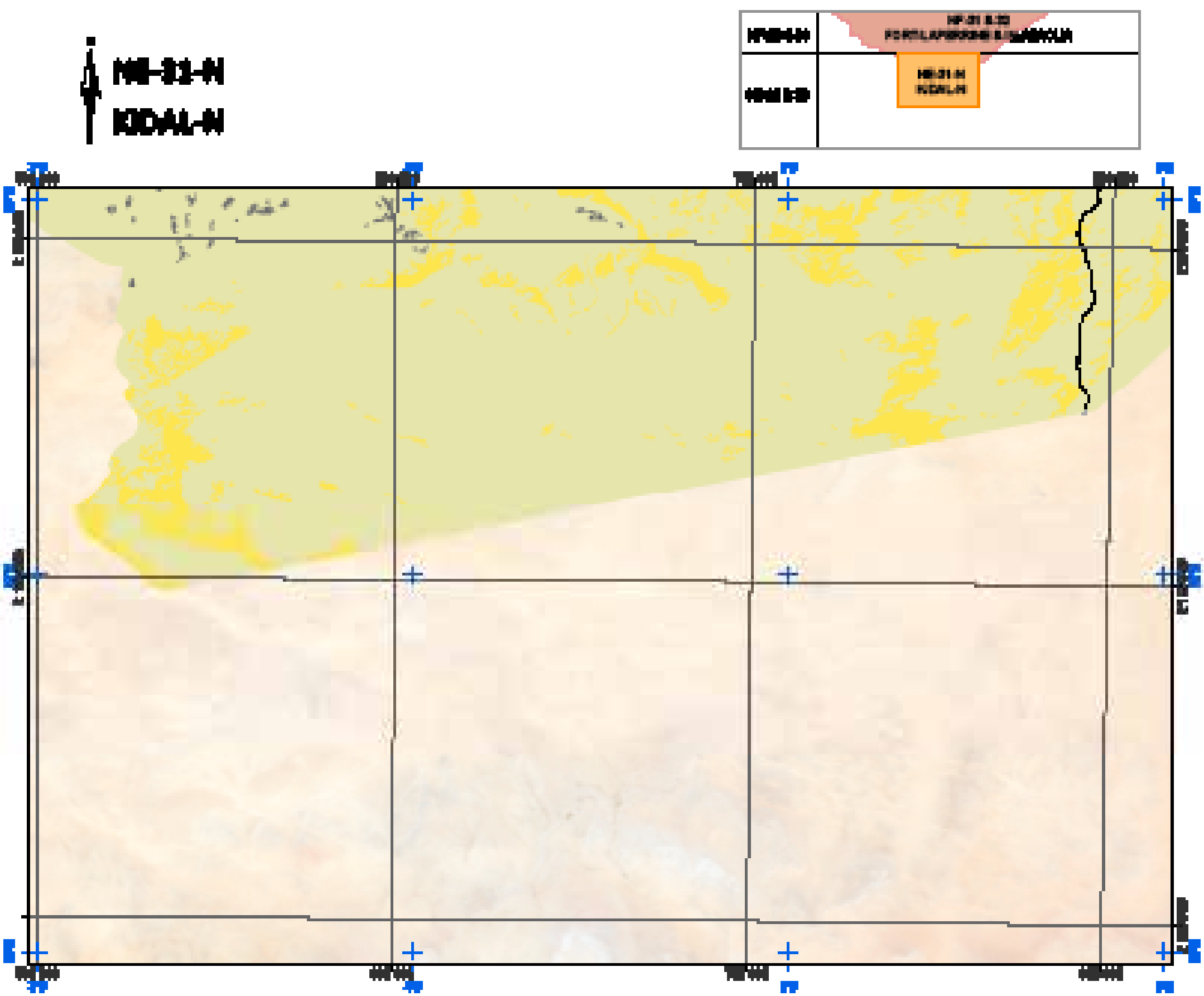


Scale 1:1 250 000

The map is in the World Geodetic System (WGS84) and UTM projection (zone 30).
The black grid represents the metric coordinates.
The blue dots represent the Geographical coordinates.

Natural Vegetations
- Forest
- Shrubland
- Grass/Cropland

Bare Land
- Bare soil/dry sparse vegetation
- Sand dune
- Rock outcrop



Cultivated Land
Irrigated perennial crops
Rainfed perennial crops
Irrigated annual crops
Rainfed annual crops
Oasis
Water bodies
Permanent water body
Temporary water body
Aquaculture/ponds
Built-up Land
Settlement
Permanent stream
Intermittent stream
Canal
Primary road
Secondary road
Tertiary road

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ABBREVIATIONS AND ACRONYMS

ACSAD	Arab Center for the Study Arid Zones and Dry Lands
AMPs	Aromatic and medicinal plants
CAS	Chinese Academy of Sciences
CC	Climate Change
DLR	German Aerospace Center / *Deutche Zentrum fur Luft- und Raumfahrt*
eq CO2	Equivalent CO2, IPCC unit to compare the global warming impacts of different greenhouse gases
ESA	European Space Agency
FAO	Food and Agriculture Organization
gC	grams carbon, scientific measuring unit for GHG
GDA	*Groupements de Développement Agricole* / agricultural development group
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas Emissions
GIZ	German Agency for International Cooperation / *Deutsche Gesellschaft für Internationale Zusammenarbeit*
GMP	Green Morocco Plan / *Plan Maroc Vert*
GUF	Global Urban Footprint
GW	Gigawatts (= 1000 watts)
ha	Hectare, land measurement unit,(= 10,000 square meters)
IC	Intercalary Continental
ICARDA	International Center for Agricultural Research in the Dry Areas
INDCs	Intended Nationally Determined Contributions
IPCC	Intergovernmental Panel on Climate Change
km	Kilometre, length of 1000 metres
km²	Square kilometres, land area measuring unit
kWh/m2/j	Kilowatt hour/square metres/day, Unit to measure daily solar resources
LANDSAT	Land Satellite (Earth Spatial Observation Programme)
LCCS	Land Cover Classification System
LDN	Land Degradation Neutrality
m	Meter, unit of length, international reference
m/s or m·s−1	Meters per second, unit of speed
MCU	Minimum Cartographic Unit
MENA	Middle East and North Africa
MENA-DELP	MENA - Desert Ecosystems and Livelihoods Knowledge Sharing and Coordination Project
mm	Millimetre, unit to measure height or precipitations (rainfall)
Mteq CO2	Millions of ton equivalents CO2
MW	Megawatts, measure of electricity or thermal power of a million watts
NPP	Net primary production
NRP	National Reforestation Plan
OLI	Operational Land Imager

OSS	Sahara and Sahel Observatory / *Observatoire du Sahara et du Sahel*
PAMPA	Programme d'Actions Multi Pays en Agro-écologie / Multi-country support programme for agro-ecology
PRODESUD	*Programme pour le développement et la promotion des Initiatives locales dans le Sud-Est de la Tunisie* / programme to promote local initiatives in southeast Tunisia
RADI	Institute of Remote Sensing and Digital Earth
REEWP	Regional Economic Empowerment of Women Project, run by OXFAM-Quebec
SASS	*Système Aquifère du Sahara Septentrional* /Northwest Sahara Aquifer System
SAU	*Surface Agricole Utile* / Useful Agricultural Surface
SDGs	Sustainable Development Goals
TC	Terminal Complex
UMA	*Union du Maghreb Arabe* / Arab Maghreb Union
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Program (Tunisia)
UNFCCC	United Nations Framework Convention on Climate Change
UTM	Universal Transverse of Mercator
WB	World Bank
WGS-84	World Geodetic System, 1984 version

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ATLAS OVERVIEW

This Atlas includes land cover maps of Algeria, Egypt, Jordan, Morocco, and Tunisia. It is intended to decision-makers, development partners and the general public.

Through some fifty maps and a brief multi-thematic explanation, this Atlas aspires to highlight the linkages between ecosystem services and populations livelihoods in desert areas and their potentialities.

The reader will also find illustrations about the major ecosystems of the project area and their role in transboundary cooperation and socio-economic development to address global changes.

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