EUROPEAN COMMISSION
DIRECTORATE-GENERAL
HUMANITARIAN AID AND CIVIL PROTECTION - ECHO
ECHO A - Strategy, Policy and International Co-operation
Unit A.5 - Civil Protection Policy
Brussels, ECHO.A.5 (2016) 3129102

UD-RASP- Urban Disaster Resilience Through Risk Assessment and Sustainable Planning

Ref. No. ECHO/SUB/2016/740186/PREV19

D5.1-Implementation GIS

(31. October 2018)

Coordinated by

IABG mbH Geodaten Factory
Einsteinstraße 20
D-85521 Ottobrunn
GERMANY

In cooperation with:

United Nations University
Institute for Environment and Human Security
(UNU-EHS)
Platz der Vereinten Nationen 1,
53113 Bonn, Germany

Municipality of Monastir
Avenue Habib Bourguiba,
5019 Monastir, Tunisia

Task	T5 – Baseline documentation	
Action	A1.2-1.3, 2.3, 5.1	
Dissemination level	✓ Public ○ Restricted to other programme partners (including DG ECHO) ○ Restricted to a group specified by the consortium (including DG ECHO) ○ Confidential, only for members of the consortium (including DG ECHO)	
Publishing date	October 2018	
Task/activity leader	Task: IABG	Activity: IABG
Contact person	Felicitas Bellert	
Contributors	UNU-EHS, Municipality of Monastir	
Short summary	Implementation of a GIS expert system for mapping and data management – Initial installation and operation of the GIS based system – Implementation of a comprehensible GIS data structure and GIS based map production – Provision of all related files and documentation to run the system – Integration of all project related geodata for further application or publication – Documentation of the implemented GIS system	
Keywords	Geodata, GIS, mapping, data management, quality assurance, urban atlas, extraction guide, data modelling, satellite images, World View 3, technical specifications, quality standards, mapping guideline, mapping, quality assurance, data processing, plan d'aménagement (PAU), ArcGIS, ESRI, Data Reviewer, geodatabase, datasets, feature class, attribute	

The research leading to these results has received funding from the European Commission Directorate General Humanitarian Aid And Civil Protection (ECHO) under grant agreement No.ECHO/SUB/2016/740186/PREV19.
This publication reflects the views only of the author, and the European Union cannot be held responsible for any use which may be made of the information contained therein.

Table of Contents

List of figures

List of Tables

Abbreviations

CAD	Computer Aided Design
DG Echo	Directorate General Humanitarian Aid and Civil Protection
GIS	Geographic Information System
GML	Geography Markup Language
PAU	Plan d'aménagement
TIN	Triangulated Irregular Networks
RBJ	Reviewer Batch Job
UDRASP	Urban Disaster Resilience Through Risk Assessment and Sustainable Planning
ToC	Table of Content

1 Introduction

In the course of the project, a GIS expert system is implemented in Monastir. The creation of a GIS system provides a platform for an efficient data management of spatial information in the municipality. The system has the ability to support the municipality in different municipal tasks and meet a variety of thematic requirements.

The GIS system enables a centralized management of all the spatial data that are relevant for the municipality. Existing databases can be integrated into the system and combined with spatial information from other sources. By organizing the information in one location, data can easily be updated or edited in a standardized manner. By gathering data in a logical and consistent way, data integrity is ensured and redundancies can be decreased. The GIS system combines visualization with analytical functions. Spatial data can be searched and displayed, but also analyzed and transformed according to the specific municipal requirements. The system enables the mapping of past and current developments and offers a basis for simulations of processes like urban development or changing risks towards natural hazards in Monastir. The GIS system provides a powerful set of tools for increased efficiency and fast decision making for the municipality. It supports the planning, executing and tracking of spatial development processes within the municipality.

In the course of this project, a GIS database is created in line with the existing Tunisian standard defined by the *Plan d'aménagement (PAU)* as well as the European and global Urban Atlas and the *Food and Agriculture Organization of the United Nations (FAO)* standards. By generating a standardized database, comparability with data from other regions and organizations is ensured.

As an initial dataset, the PAU is integrated into the GIS system. In addition to the PAU, baseline mapping of the city is conducted and base products are created. Furthermore, geospatial data such as baseline information, critical infrastructure as well as socioeconomic and environmental data are included into the GIS system.

All of the included spatial data will be managed in the final GIS database, following international OGC standards. The workstation for the GIS database will be located in the Municipality of Monastir to ensure the integration into the planning and monitoring processes of the municipality. The results will furthermore be provided in the web-based information system (see D5.2 Report "UDRASP Web based information system").

2 Purpose and scope

This document provides a short overview of the relevant GIS files to run in the UDRASP-GIS environment. It is intended for all administrators and operators who apply and maintain the UDRASP-GIS and consists of the following parts:

- Components of the UDRASP-GIS
- Guidelines
- Workflow
- Application of the UDRASP-GIS environment
- Documentation and Guidance
- Overview Delivery

3 Components of the UDRASP-GIS

The UDRASP-GIS is one main output of the project UDRASP, and the environment for all vector data related production and updating tasks to maintain the provided baseline. The GIS system provides data files, tools, a data model, and documents of the GIS training for data extraction, quality control, data processing and management to update all contained information in a consistent manner.

The UDRASP-GIS environment is based on the following components:

Table 1: Overview GIS Components

Component	Description
Desktop Client MXD	Desktop Client for mapping and modification of features and attributes in the GIS geodatabase, including an ArcMap[1] document file, customized for the UDRASP-GIS. The base product ArcMap contains all functions for the efficient capturing and modification of data. This document is the user interface and allows the presentation and the direct editing of geodata. All components listed below are stored in the so-called ArcMap document file. This file is stored in the file system using the extension '.mxd'.
Map Templates	Map templates ensure a standardized editing and geo processing environment (data view) or standardized layouts on a series of maps (layout view). Two types of view are available within a '.mxd document: Data view: direct editing or maintenance of geodata Layout view: provision of map layouts for reporting or publication purposes
Symbology	The symbology of a feature layer contains the visualization of the data. It is possible to illustrate all features of a layer with the same symbol, or use different symbols for different groups of features. Features are distinguished with the help of feature attributes. Features containing the same attribute value are displayed with the same symbol. A symbology is presented in so-called layer files and stored in the file system using the extension '.lyr'.
Quality Control	Quality assurance consists of visual or technical quality control. Several tools and files are available within the ESRI ArcGIS software to review the updated vector data, and to apply quality checks.
Geodatabase	A geodatabase contains geographical and spatial data. Geodatabases are an alternate way to store GIS information in one large file, which can contain vector layers (as multiple point, polygon, and/or polyline layers) or raster layers. Geodatabases are stored as single files with the ".gdb" extension or ".mdb" extension.
Guidelines	Extraction criteria and specifications: – UDRASP Data Model – Extraction rules

[1] ArcMap – one main component of ArcGIS Desktop; document file with extension *.mxd

The overall objective of the UDRASP-GIS is the maintenance of the provided vector data products and the administration of the GIS framework and related system files. For that reason, a Client Desktop (ArcGIS[2]) is provided and equipped with all necessary system files to operate with the vector data products. The related geodatabase is configured as file geodatabase. Maintenance and backup strategies should be organized after the implementation.

The following figures schematically illustrates that each component is directly related to the Client Desktop (operator) and is mandatory for running the system.

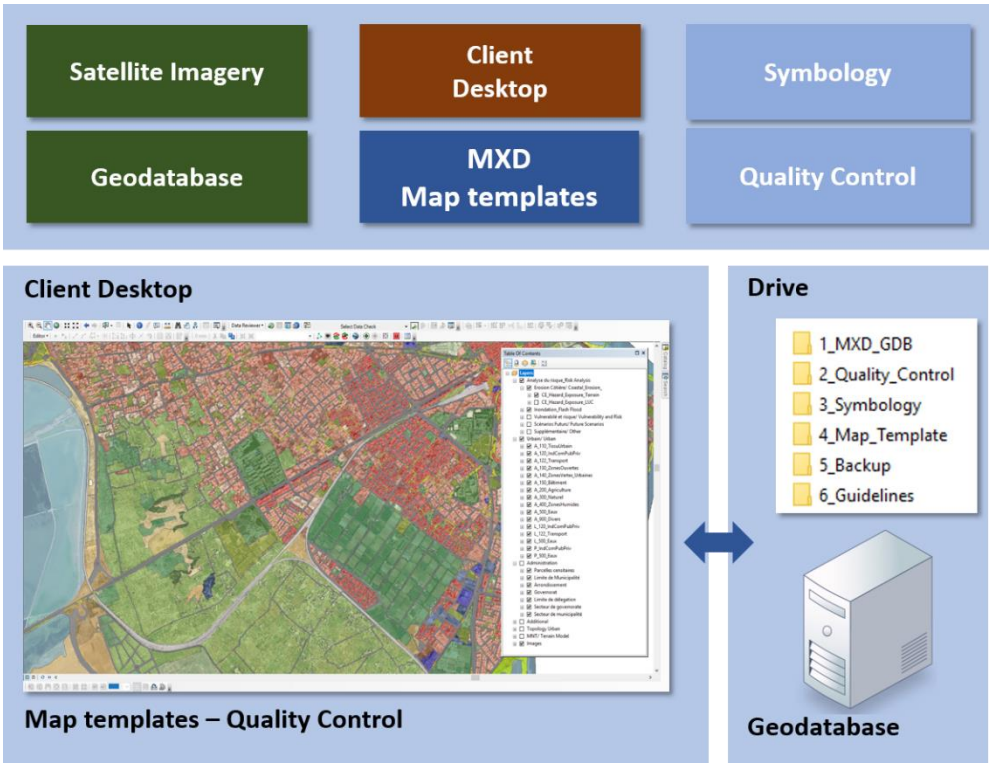


Figure 1: Relevant GIS Components

3.1 MXD –description and application

Each ArcMap document file consists of three main components:

Data Frame with Data View contains and presents a collection of layers. These layers are displayed in a particular order for a given map extent and map projection

Table of Contents (ToC) manages the data structure of the ArcMap document file. It contains feature, raster, and matrix layers, including thematic grouping and drawing order, and helps to manage the display properties of the Data View and the symbol assignment. A layer represents the data of one physical data source (e.g., layer 'A_122_Transport represents the feature class A_122_Transport of the UDRASP geodatabase). It assists in the management of GIS data inside the ArcMap document file. All

[2] *ArcGIS – ESRI Software V 10.4.1*

included data are loaded into the Data Frame as a layer and listed in the ToC. Thus, a layer is a 'data container', which contains the data visualization settings. Three types of layers are differentiated:

- group layer (e.g., URBAN, Additional, Administration)
- feature layerA_110_UrbanFabric, : A_122_Transport, L_500_Water, etc.
- raster layer: contains raster files like imagery, DTM etc. / World View 3 imagery data is used as the underlying raster data source for mapping purpose in the project.

Toolbars and additional tools: The functions and commands in ArcMap are organized as tools. The tools are grouped into toolbars, according to their functionality. Each of these toolbars can be switched on and off. In addition to the toolbars, further tools are summarized for different tasks in extensions, which can be integrated into the map document (e.g., Data Reviewer for quality assurance purpose). Recommended toolbars are:

- Editor and Advanced Editing: contain several tools for data capturing and editing.
- Data Reviewer: integrates tools for checking the quality of the data.
- Labeling: allows features and their attributes to be visualized using labeling expressions.
- Feature Cache: contains functions to manage the cache of feature data, in order to improve the performance of the data visualization in the Data View and the ArcMap document file.
- Topology: groups functions for feature modification and for quality control.

The mentioned ArcMap components have been configured for the project to obtain a well-structured and efficient mapping environment. In addition, data frame properties like the definition of a coordinate system, or the configuration of feature layer visualization, including symbology, labeling, and visibility of layers have been configured in a customized **UDRASP_Template_Finale.mxd** template.

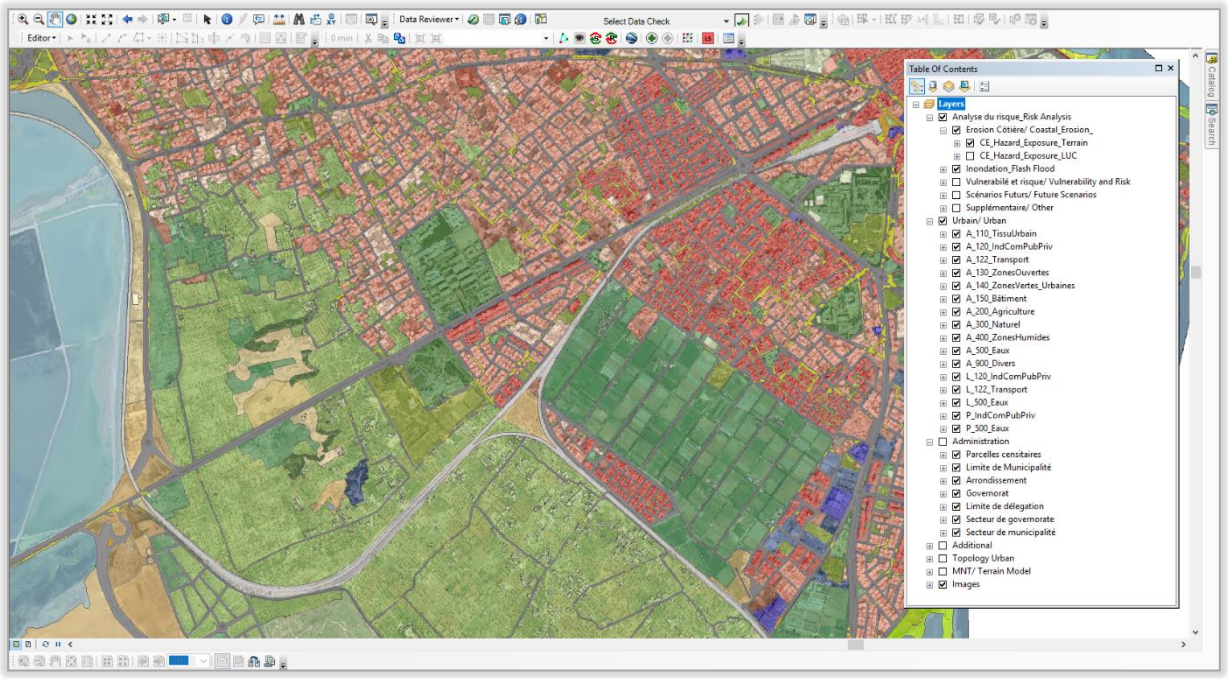


Figure 2: UDRASP-Template.mxd

3.2 Map Templates – description and application

A map template is a map document (*.mxd) from which new documents can be created. Templates may contain basemap layers as described before or be a variety of commonly used page layouts. Map templates ensure to generate standardized layout on a series of maps. A various selection of Map templates can be applied using a selection, which is already provided by the software provider. Otherwise, each user can easily design new templates.

For project purpose, a UDRASP Map template has been developed to create maps for reporting and publication purpose. This template is available within the project UDRASP delivery.

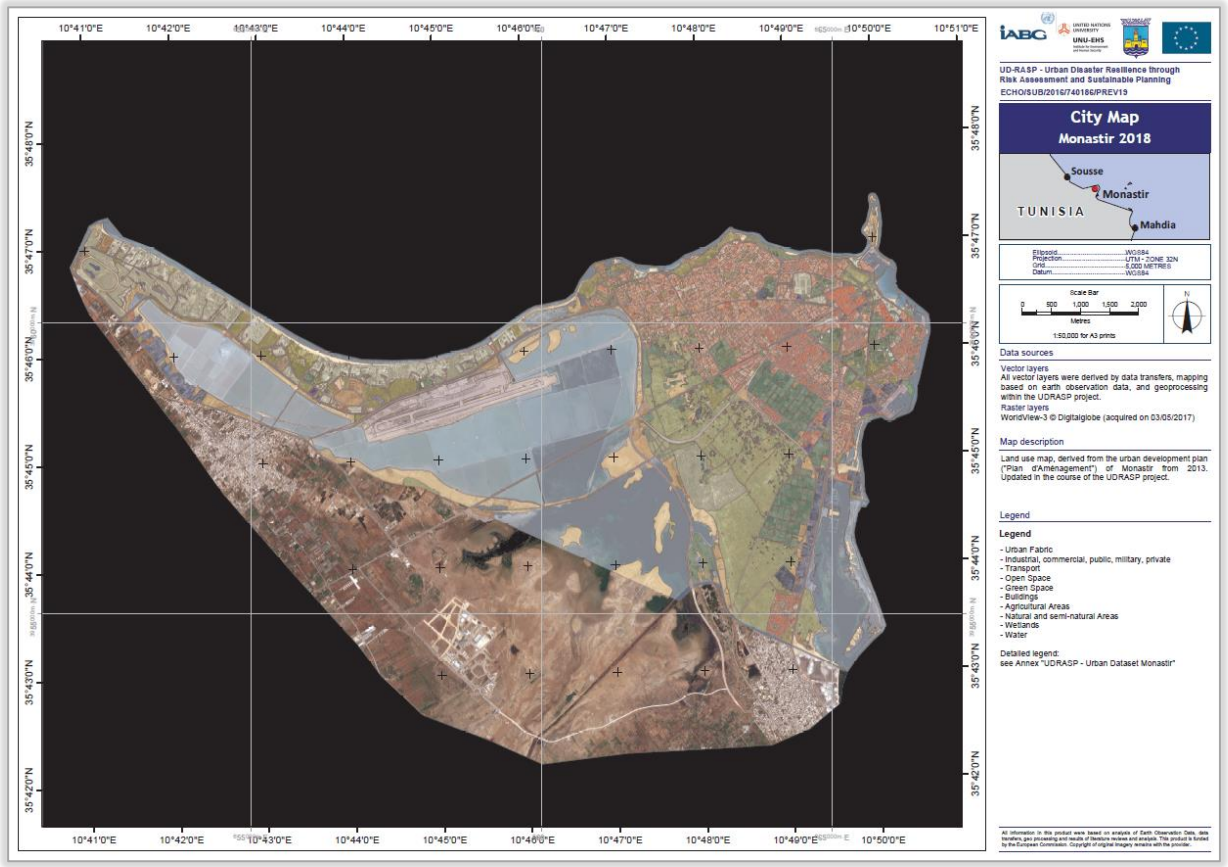


Figure 3: UDRASP Map Template for reporting and publication

3.3 Symbology – description and application

The symbology of a feature layer contains the visualization of the data. It is possible to illustrate all features of a layer with the same symbol, or use different symbols for different groups of features. Features are distinguished with the help of feature attributes. Features containing the same attribute value are displayed with the same symbol. The symbology of a feature layer can be stored. A so-called layer file stores information of a feature layer, especially the symbology. The file extension for a layer file is *.lyr. A 'lyr'- file is provided for each layer, and for each of the provided ArcMap document files applying to the UDRASP geodatabase.

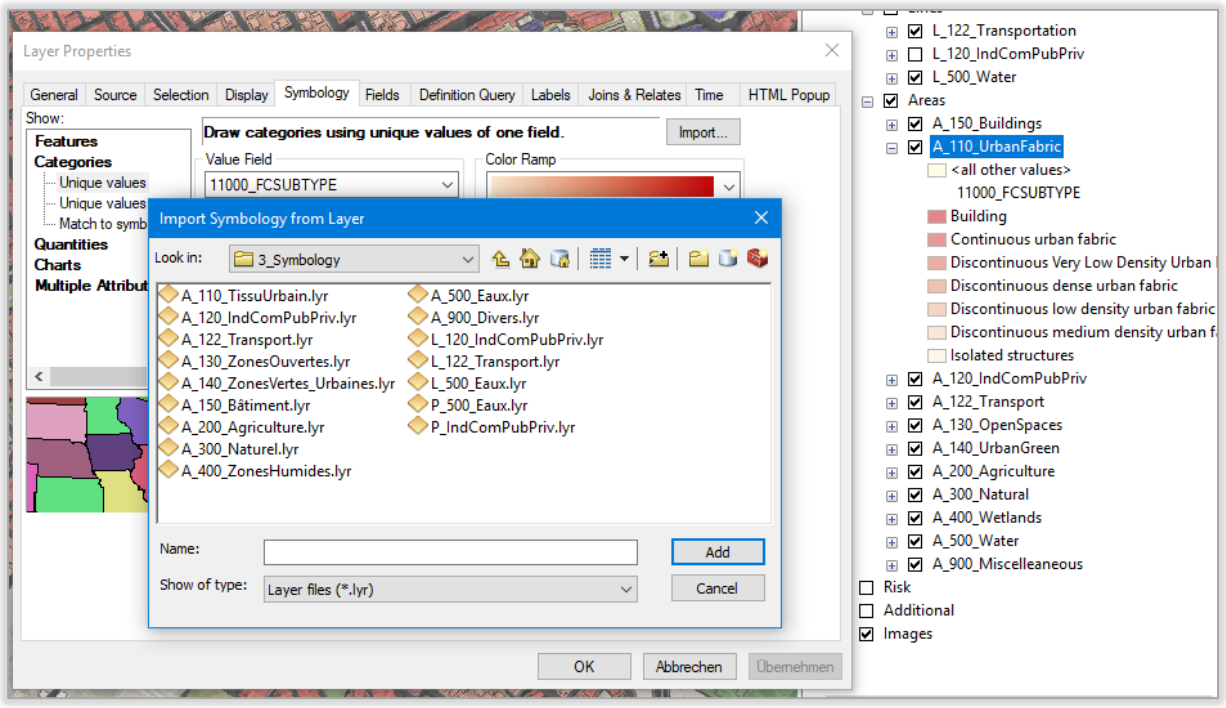


Figure 4: UDRASP – Selection or import of layer files to define the symbology of each layer

Customized layer files are provided within the project. They can be modified and stored at any time according to users needs.

Delivery: UDRASP Layer files [see 8.6]

3.4 Quality Control – description and application

The quality control process can be generally divided into two parts in order to achieve a high quality level:

- **Visual Quality Control**: is aimed at detecting errors, by screening data in its spatial, thematic, or geometrical context.

This visual approach supplements concepts and tools of technical quality checks in an efficient manner. If new features are captured, or changes are made to existing features, the modifications need to be reviewed by an independent user, mainly the GIS Operator, regarding the described data quality elements Completeness, Positional Accuracy, Thematic Accuracy, and Logical Consistency. The data reviewer toolbar can help to locate and communicate visually detected errors for validation and correction.

- **Technical Quality Control** is mostly designed to review the captured features by automated checks and routine

In order to validate all captured features regarding their Positional Accuracy, Thematic Accuracy, Logical Consistency, and Completeness, two core functionalities "**topology** " and "**data reviewer**" are provided and further described below.

3.4.1 'Topology' toolbar

A topology is the arrangement that defines how area, line, and point features share coincident geometries. It determines the rules concerning the spatial relationships between the features within the area of interest. Topology usually constrains how features share geometry (adjacent boundary, sharing same nodes, etc.), and helps to manage and enhance data integrity using integrity rules (e.g. an Area Feature must not overlap, must not have gaps). A topology is stored in a geodatabase, as one or more relationships that define how the features in one or more feature classes share geometry.

Figure 5: Topology Toolbar

In the context of this project, a topology is only applicable to harmonize common edges and relations between adjacent boundaries. Quality specifications are based on the "Urban Atlas"- Standard[3] and customized for the project purpose.

The application of topology is described as **part of the GIS training documentation (D6.2 GIS training**).

3.4.2 'Data Reviewer' toolbar

The purpose of the technical validation is to verify features using automated checks and routines. The 'Data Reviewer' toolbar provides the functionality to create checks, which are routines to facilitate the validation of the captured features of the UDRASP geodatabase. These checks are a core functionality of the 'Data Reviewer', and ensure an enhancement of the quality of the captured features.

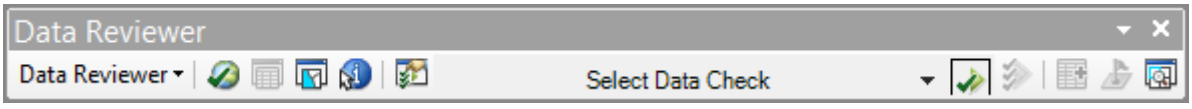


Figure 6: Data Reviewer Toolbar

For managing and executing an efficient and valuable quality control process, the checks can be stored in so-called '**Data Reviewer Batch Jobs'** (in short RBJ- files).

The Technical Quality Control of the UDRASP geodatabase is designed to execute RBJ- files, to verify errors of the captured features considering the data quality elements Completeness, Positional Accuracy, Thematic Accuracy, and Logical Consistency.

[3] Mapping Guide for an European Urban Atlas (v4.7 / 2012): Mapping Guide and class description for the product "Urban Atlas " of the Copernicus Project

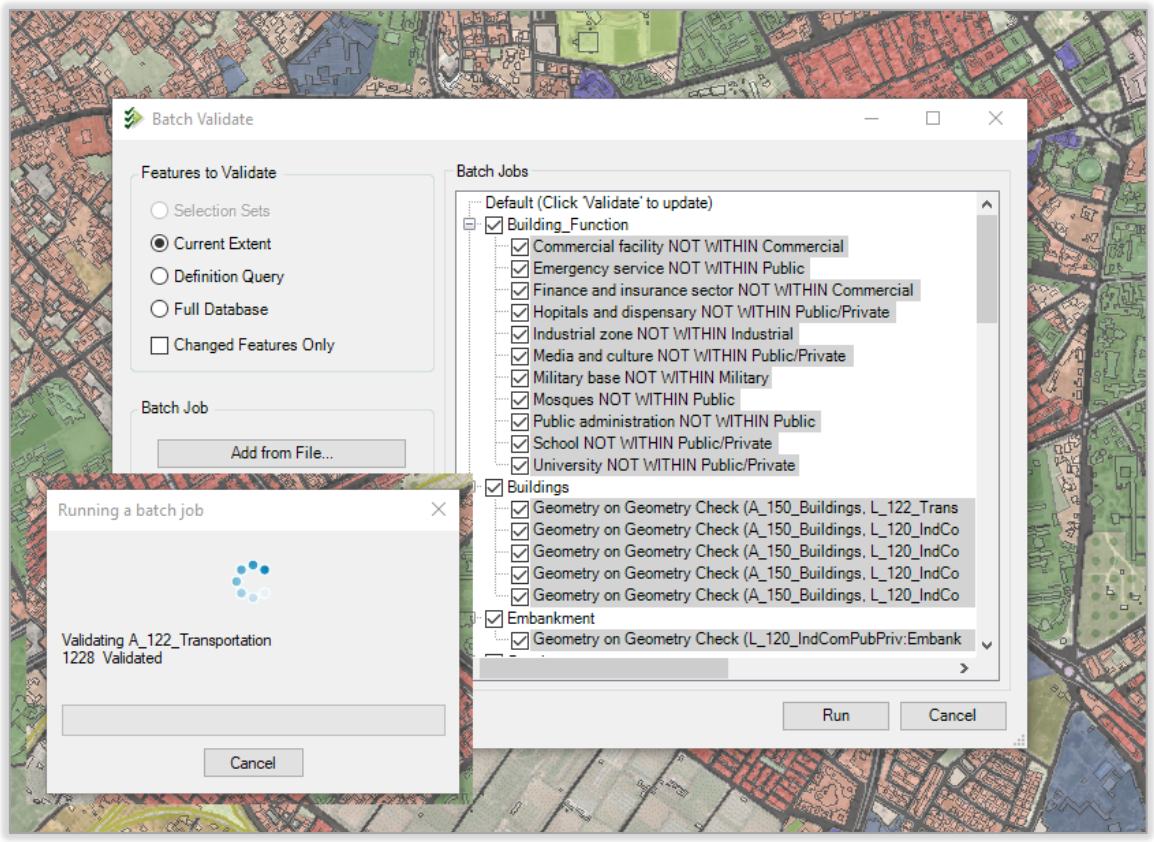
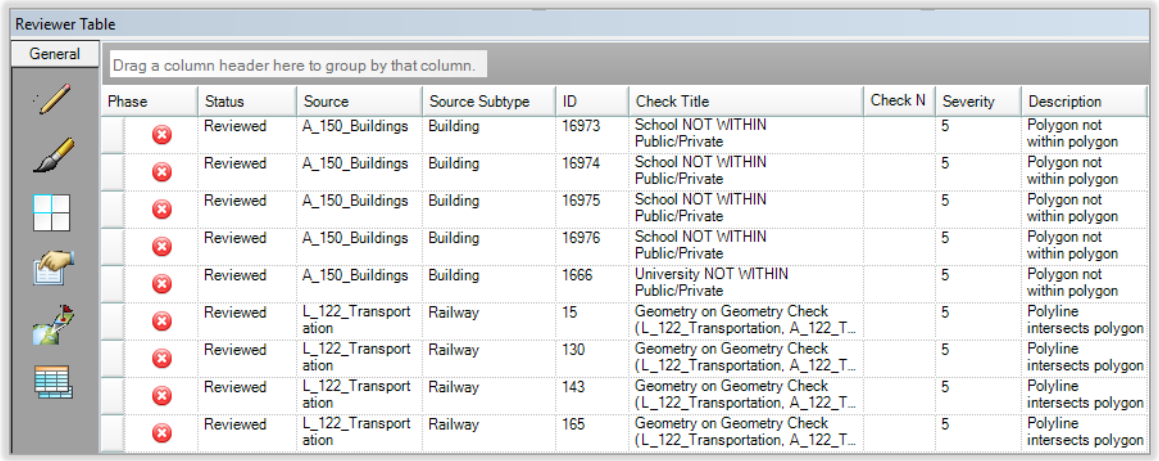


Figure 7: UDRASP - Validation by batch jobs

The geodatabase **UDRASP_QualityControl_ReviewerTemplate.gdb** stores any configuration parameters for the visual validation, and is additionally provided in the project.



Phase	Status	Source	Source Subtype	ID	Check Title	Check N	Severity	Description
	Reviewed	A_150_Buildings	Building	16973	School NOT WITHIN Public/Private		5	Polygon not within polygon
	Reviewed	A_150_Buildings	Building	16974	School NOT WITHIN Public/Private		5	Polygon not within polygon
	Reviewed	A_150_Buildings	Building	16975	School NOT WITHIN Public/Private		5	Polygon not within polygon
	Reviewed	A_150_Buildings	Building	16976	School NOT WITHIN Public/Private		5	Polygon not within polygon
	Reviewed	A_150_Buildings	Building	1666	University NOT WITHIN Public/Private		5	Polygon not within polygon
	Reviewed	L_122_Transportation	Railway	15	Geometry on Geometry Check (L_122_Transportation, A_122_T...		5	Polyline intersects polygon
	Reviewed	L_122_Transportation	Railway	130	Geometry on Geometry Check (L_122_Transportation, A_122_T...		5	Polyline intersects polygon
	Reviewed	L_122_Transportation	Railway	143	Geometry on Geometry Check (L_122_Transportation, A_122_T...		5	Polyline intersects polygon
	Reviewed	L_122_Transportation	Railway	165	Geometry on Geometry Check (L_122_Transportation, A_122_T...		5	Polyline intersects polygon

Figure 8: UDRASP - Results of validation stored in a reviewer database

The delivery of following **Reviewer Batch Jobs** and **Reviewer Template Geodatabase** is part of the GIS Implementation task:

- UDRASP_QualityControl_ReviewerTemplate.gdb
- UDRASP_Attribute_Checks.rbj
- UDRASP_General_Checks.rbj
- UDRASP_Geometry_Checks.rbj
- BuildingFunction_NotWithin_AreaSubtype.txt

Content and objectives of each check is described in the following tables.

Table 2: General quality control checks as DataReviewer RBJ-file DG-Echo_General_Checks.rbj

Check Name	Description
Cutback	• Line and Area Feature Classes • Minimum Angle size: 10°
Dangles	• Line Feature Classes • Dangle Tolerance: >10 m
Domain	• Point, Line and Area Feature Classes
Duplicate geometries	• Point and Line Feature Classes
Duplicate vertex	• Line and Area Feature Classes • Tolerance: 0.5 m
Invalid geometries	• Point, Line and Area Feature Classes
Multipart geometries	• Line and Area Feature Classes
Non-linear segments	• Line and Area Feature Classes
Self-closing lines	• Line Feature Classes
Polygon Sliver	• Area Feature Classes • Thinness Ratio: 0.5 Maximum Polygon Area: 25m² A_150_Building, 100 m² all other
Subtype check	• Point, Line and Area Feature Classes

Table 3: Geometric quality control checks as DataReviewer RBJ-file DG-Echo_Geometry_Checks.rbj

Check Name	Description
Buildings	A_150_Buildings should not overlap: • L_122_Transportion • A_122_Transportation • L_120_IndComPubPriv with FCSubtype: Wall, Fence, Seawall, Embankment
Embankments	• L_120_IndComPubPriv and A_120_IndComPubPriv, both with FCSubtype Embankment • Embankment Line Features are not allowed to cross Embankment Area Features
Polygon Overlaps	• Area Feature Classes • Exception: Bridge/Tunnel

Check Name	Description
Transport	• L_122_Transportion are not allowed to intersect A_122_Transportion with FCSubtype = Railways and associated land FCSubtype = Associated road objects FCSubtype = Fast transit roads and associated land FCSubtype = Other road and associated land • L_122_Transportion are not allowed to intersect L_120_IndComPubPriv with FCSubtype = Wall FCSubtype = Fence FCSubtype = Sea wall FCSubtype = Embankment
Unnecessary boundaries	• Area Feature Classes • Exception: A_150_Buildings • Exception: L_120_IndComPubPriv with FCSubtype = Supply networks
Unnecessary nodes	• Line Feature Classes • Exception: L_120_IndComPubPriv with FCSubtype = Supply networks
Gaps	• Area Feature Classes of Urban Dataset
Line Overlaps	• Overlapping of Wall/Fence/ embankment/ Seawall
Attribute Area vs. Building (e.g. Commercial Area + Building)	• A_120_IndComPubPriv and A_150_Buildings

Table 4: Attribute quality control checks as DataReviewer RBJ-file DG-Echo_Attribute_Checks.rbj

Check Name	Parameter	Description
UA Code	According to Urban Atlas Standard	Point, Line and Area Feature Classes
Attribute Checks	According to data model	Mandatory fields shall filled in completely.
Area sizes	According to UDRASP rules	See Table 6

The application of the data reviewer toolbar is described as **part of the GIS training documentation (D6.2 GIS training**).

3.5 Geodatabase – description and application

"A geodatabase is a collection of geographic datasets of various types held in a common file system folder, or a multiuser relational DBMS (such as Oracle, Microsoft SQL Server, PostgreSQL, Informix, or IBM DB2). Geodatabases come in many sizes, have varying numbers of users and can scale from small, single-user databases built on files up to larger workgroup, department, and enterprise geodatabases accessed by many users."[4] A geodatabase:

- is the native data structure and is the primary data format used for editing and data management.
- is the physical store of geographic information, primarily using a database management system (DBMS) or file system.
- is a comprehensive information model for representing and managing geographic information, implemented as a series of tables holding feature classes, raster datasets, and attributes.
- software logic provides the common application logic used throughout ArcGIS for accessing and working with all geographic data in a variety of files and formats (e.g. shape files, computer-aided drafting (CAD) files, triangulated irregular networks (TINs), grids, CAD data, imagery, Geography Markup Language (GML) files, and numerous other GIS data sources). [5]

Geodatabases are structured in different datasets and organized as features classes[6], attribute tables[7] and imagery or raster datasets[8].

For project purpose, several parameters have been defined to organize project related geospatial data.

- Organization in datasets
- Resolution and tolerance
- Spatial reference

3.5.1 Datasets within the UDRASP geodatabase

The following **datasets** are available:

Table 5: Datasets of the UDRASP geodatabase

Data Sets	Description
Urban:	Urban fabric, industrial, commercial, public and private zones, transportation, open spaces, urban green, agriculture, natural zones, wetlands, water, buildings

[4] http://desktop.arcgis.com/en/arcmap/latest/manage-data/geodatabases/what-is-a-geodatabase.htm
[5] http://desktop.arcgis.com/en/arcmap/latest/manage-data/geodatabases/what-is-a-geodatabase.htm
[6] Table with a shape field containing point, line or polygon geometries for geographic features, Each row is a feature (ESRI)
[7] Collection of rows, each containing the same fields. Feature classes are tables with shapes fields. (ESRI)
[8] Contains raster which represent continuous geographic phenomena (ESRI)

Data Sets	Description
Administration	Census parcels, city limit and sectors of the municipality, district, governorate and sectors, limit of delegation
Additional	Climate, deep groundwater, geology, irrigation zones, land cover, shallow groundwater, urban development (period over 30 years), urban zones, watersheds, faults of Tunisia Geographical extension: Governorate Monastir / or Municipality of Monastir (urban zones and urban development)
Coastal Erosion	Hazard prone areas (coastal erosion), exposure (coastal erosion)
Flash Flood	Hazard prone areas (flash flood), exposure (flash flood), watercourse lines, critical infrastructure, vulnerability files and risk layer (flash flood)
Risk_Current_2018	Risk Zones in 15 units, flash flood risk zones combining exposure and social vulnerability.
Risk Future Scenario	Future Risk Zones in 15 units, developed for 4 scenarios (A-D)
Risk other	critical infrastructure, coast line, units (considered for risk assessment), hazard watercourse lines (flash flood), "zone bleue" (source: Civil Protection: flash flood)
Raster Layer	Mosaic of "World View 3 (WV3)" Imagery for Monastir, – Acquisition date: 05 March 2017 (provided by EUSI) – Ground Resolution: 0.3 m – Based on: Digital Terrain Model (DTM, derived from WV3 imagery) Flash Flood – Results: FF* raster layer (source: flood modelling) Urban Growth – Results: Urban Growth layer raster layer (source: urban growth modelling)

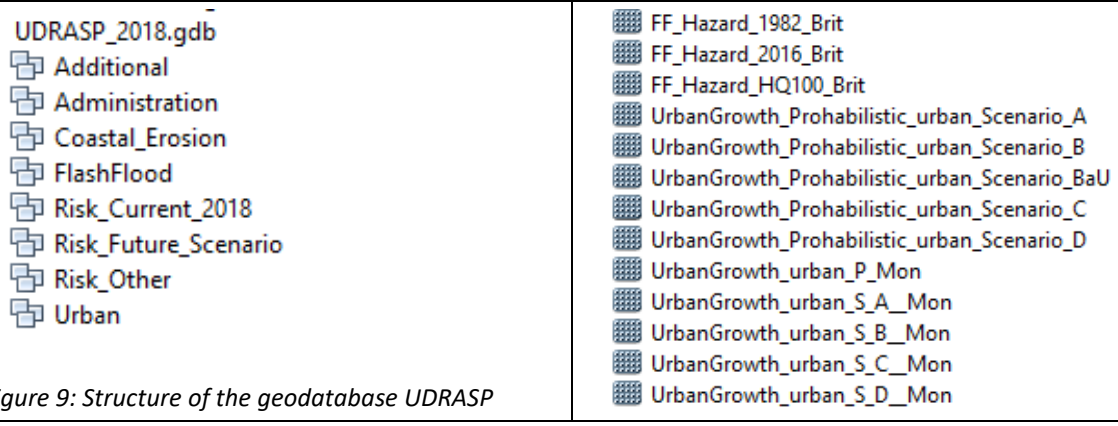


Figure 9: Structure of the geodatabase UDRASP

The datasets represents different topics to structure the project content in a comprehensive manner. The geodata was collected and integrated by different sources (see chapter 5 Workflow):

- Data collection and integration in the database (e.g. datasets "additional", "administration")
- Data transfer and mapping based on earth observation data (e.g. dataset "urban")
- Data management and geo processing (e.g. dataset "risk assessment")

The geodatabase within this project is developed according the UDRASP data model, which ensures a harmonized, and standardized data structure and fulfils the requirements of ISO guidelines and OGC standards. Details of the data model are described in [D1.1 Technical Documentation] and attached within this delivery.

Urban_Administration_Additonal Datasets

Urban
- A_110_UrbanFabric
- A_120_IndComPubPriv
- A_122_Transportation
- A_130_OpenSpaces
- A_140_UrbanGreen
- A_150_Buildings
- A_200_Agriculture
- A_300_Natural
- A_400_Wetlands
- A_500_Water
- A_900_Miscelleaneous
- AOI_Topo
- L_120_IndComPubPriv
- L_122_Transportation
- L_500_Water
- LAF
- P_120_IndComPubPriv
- P_500_Water
- Urban_Topology

Administration
- A_CensusParcel
- A_CityLimit
- A_District
- A_Governorate
- A_LimitDelegation
- A_SectorGovernorate
- A_SectorMunicipality

Additional
- A_Climate
- A_DeepGroundwater
- A_Geology
- A_IrrigationZones
- A_Landcover
- A_ShallowGroundwater
- A_UrbanDevelopment
- A_UrbanZones
- A_Watersheds
- AOI
- L_FaultsTunisia

Coastal Erosion_FlashFlood_Risk_Current 2018 and Future Scenario Datasets,

Coastal_Erosion
- CE_Hazard_Exposure

Flash_Flood
- FF_Exposure_Transport
- FF_Exposure_UrbanFabric
- FF_Exposure_UrbanFabric_Distribution
- HQ100_Hazard_vector

Risk_Current_2018
- BuildingBlocks_Vulnerability_Risk_2018_15units
- BuildingBlocks_Vulnerability_Risk_2018_ALLblocks
- SubUnits_socioeconomic_profile_2018_ALLunits
- SubUnits_Vulnerability_Risk_2018_15units

Risk_Future_Scenario
- Units_FutureRisk_15

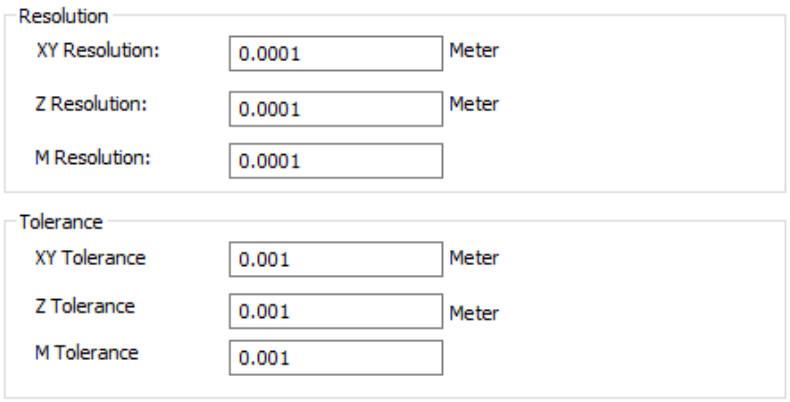
Risk_Other
- A_CriticalInfrastructure
- A_FlashFlood_ZoneBleue_CivilProtection
- A_Units_Pop
- L_Coastal_Line
- L_Hazard_Watercourse

Raster-Layer Flash Flood/ Urban Growth
- FF_Hazard_1982_Brit
- FF_Hazard_2016_Brit
- FF_Hazard_HQ100_Brit
- UrbanGrowth_Prohabilistic_urban_Scenario_A
- UrbanGrowth_Prohabilistic_urban_Scenario_B
- UrbanGrowth_Prohabilistic_urban_Scenario_BaU
- UrbanGrowth_Prohabilistic_urban_Scenario_C
- UrbanGrowth_Prohabilistic_urban_Scenario_D
- UrbanGrowth_urban_P_Mon
- UrbanGrowth_urban_S_A__Mon
- UrbanGrowth_urban_S_B__Mon
- UrbanGrowth_urban_S_C__Mon
- UrbanGrowth_urban_S_D__Mon

3.5.2 Technical parameters of the geodatabase

Some general database parameters are listed below:

Resolution and tolerance of the database is defined as follows:



S**patial reference** for the UDRASP database is:

WGS_1984_UTM_Zone_32N
WKID: 32632 Authority: EPSG

Projection: Transverse_Mercator
False_Easting: 500000.0
False_Northing: 0.0
Central_Meridian: 9.0
Scale_Factor: 0.9996
Latitude_Of_Origin: 0.0
Linear Unit: Meter (1.0)

Delivery:	UDRASP Geodatabase “UDRASP_2018.gdb”
Version:	10.4.1 / ESRI ArcGIS

4 Guidelines

An extendable set of geospatial features was defined, representing an adequate selection corresponding to the UDRASP concerns. All specified UDRASP features are implemented in the UDRASP data model and geodatabase. In order to consistently control and manage all mapping or data maintenance activities, some general rules and guidelines have been additionally determined.

General rules and guidelines

- based on Urban Atlas Standard[9]
- modified for the UDRASP project

[9] Mapping Guide for an European Urban Atlas (v4.7 / 2012): Mapping Guide and class description for the product "Urban Atlas " of the Copernicus Project

Table 6: Comparison of guidelines of Urban Atlas vs. UDRASP

Rules and guidelines	Urban Atlas	UD-RASP
Scale	1 : 10.000	1 : 5000
Satellite imagery	Spatial Resolution < 5m	Spatial Resolution = 0.3m
Minimum Mapping Unit (MMU) **Minimum Mapping Width (MMW)**	Class 1: ≥ 0.25 ha = 2,500 m² Class 2-5: ≥ 1 ha = 10,000 m²; ≥ 10 m	Class 1: 0.04 ha = 400 m² (exc. traffic islands) Class 2-5: 0.15 ha = 1.500 m² ≥ 5 m
Geometry Type	Area geometry only	Area geometry for urban coverage Line and Point Geometry for accompanying features (e.g. networks)
Additional data source	Navigation data or OSM for road network; Topographic maps for interpretation of objects; EU Imperviousness layer for sealing density	Plan D'Aménagement Urbain de la Commune de Monastir (PAU); SHP-File containing the locations of critical infrastructure
Thematic Accuracy	Class 1: ≥ 85% Class 2-5: ≥ 80% Overall: ≥ 80%	Class 1: ≥ 85% Class 2-5: ≥ 80% Overall: ≥ 80%
Positional Accuracy	< +/-5 m	< +/-5 m (exc. Buildings)*
Mapping scale on screen	1 : 5,000	1 : 1,500

* Buildings as taken from PAU were not corrected regarding their position with respect to the satellite imagery

The following datasets are strictly defined in the UDRASP data model.

- Urban
- Additional
- Administration

4.1 All datasets related to risk, exposure, hazard are defined without any restrictions and could be easily modified according to needs of the maintenance of the data. Details of the data model is set out in the chapter 8.8 UDRASP Data Model

.

Provision of further documents to support and help with the GIS related activities

Documents	Content
GIS_Training_July2018	Presentations of the GIS advanced training (July 2018)
Arcgis-data-reviewer-checks.pdf	Overview table of the main quality checks, executable by the tool Data Reviewer
ESRI_topology_rules_poster.pdf	Overview with main topology related rules
UDRASP_Technical_Documentation_Extract_for Training_I1.pdf	Overview with main mapping and data extraction criteria (UDRASP)
Urban_Atlas_2012_mapping_guide_v4.7.pdf	Mapping guide for data extraction and classification in urban zones, based on the international standard "Urban Atlas" V4.7

Presentations of the GIS advanced training (July 2018)

Documents	Content
0_20180723_S1_UDRASP_GIS_Training_Introduction_IABG_I1.pdf	General Introduction
1_20180723_S1a_UDRASP_Introduction_SIG_enUrbanisme_I1.pdf	GIS and its application in urbanism
2_20180723_S2_UDRASP_ArcGIS_Fonctions_I1.pdf	GIS functionality
3_20180723_S2_UDRASP_Workflow_Data_I1.pdf	Workflow and UDRASP data
4_20180724_S2_SaisieDonneesSpatiales_I1.pdf	Update of UDRASP data
5_20180725_S1_MiseAJour_I1.pdf	Quality Assurance
6_20180725_S2_Assurance_de_la_qualite_fr_I1.pdf	Application of the tool "Data Reviewer"
7_20180726_S1_DataReviewer_fr_I1.pdf	Information about metadata
8__20180726_S2_UDRASP_Metadata_I1.pdf	Risk Assessment (UDRASP)
9__20180727_S1_UDRASP_RiskFlower_I1.pdf	Consideration of the organization of a municipal GIS unit
10__20180727_S2_UDRASP_OrganisationTechnique_I1.pdf	Implementation of the UDRASP web system
11_20180725_UDRASP_WebViewer.pdf	

5 Workflow

A complex workflow has been developed in the project. In dependency of the original datasets, different approaches to prepare and integrate the provided data has been chosen.

- **Imagery:**
  - **World View 3** data to be used as baseline for mapping and derivation of the digital terrain model (DTM)
  - **Landsat Data** (1975 – 2017) to derive the past urban development
  - **Aerial Photographs** (1962, 1984, 2005) – to support urban development analysis

- **CAD data** (plan d'aménagement - PAU): has to be integrated as official dataset of a Tunisian municipality. Main challenge is the data transfer from a CAD structure to a GIS database logic. This was executed by a software-based way through the application of FME[10]. In any case, several data cleaning steps were necessary to further exploit the available data.
- **Additional data** have been validated and created as separate datasets so that they could be used in the project.
- Relevant and further data layers have been produced by **modelling and automated image analysis** (e.g. flash flood modelling, retrospective analysis of urban development, coastal erosion analysis,). The processed data were then included in the risk assessment: exposure analysis, vulnerability and risk analysis.

The interaction and complexity of the individual work steps is illustrated in the technical workflow in Figure 10.

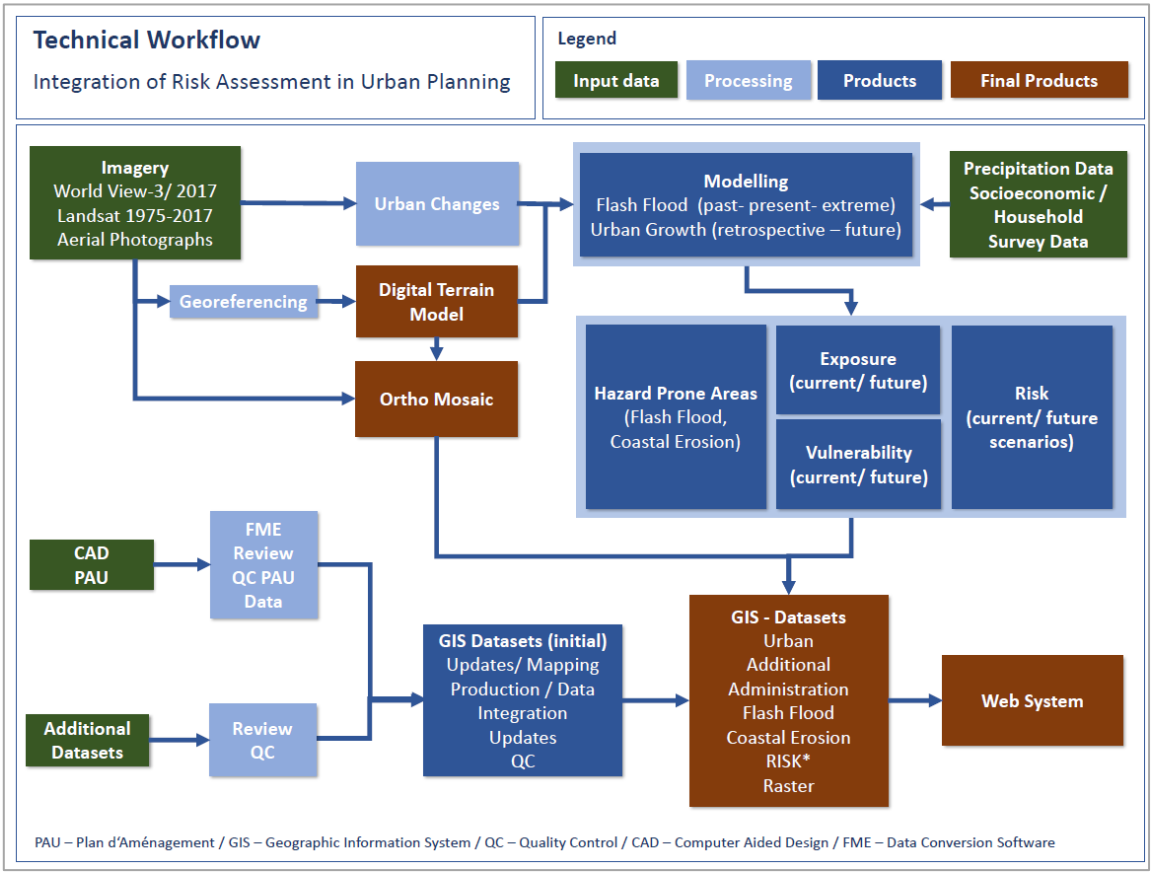


Figure 10: UDRASP workflow to provide all project related geodata

Finally, all data was collected and managed in the UDRASP-GIS. This main database delivers selected data layers via a web map service in the web information system (see Figure 11).

[10] FME – Solution for Complex Integration and Data Conversion - www.safe.com

Technical descriptions and details of the overall procedure of data transfer, mapping and data processing is explained in more detail in the deliverable D1.1 Technical Documentation.

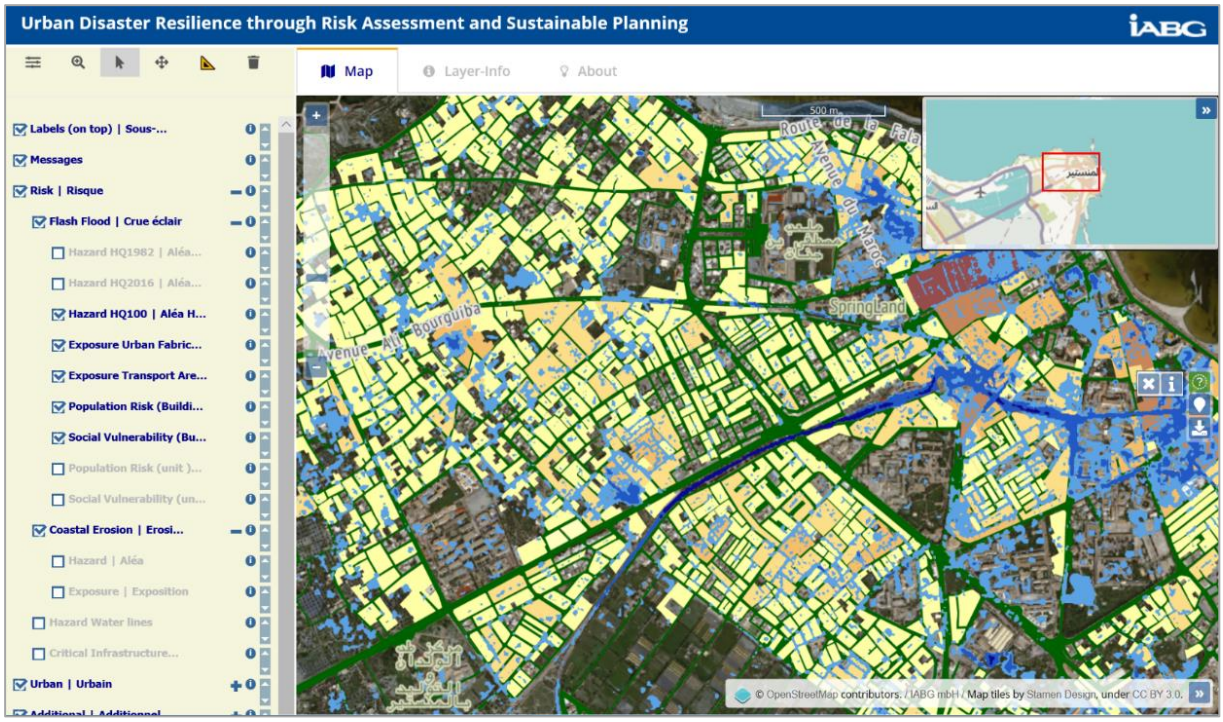


Figure 11: UDRASP Web Information System

6 Application of the UDRASP-GIS environment

The UDRASP-GIS environment provides main tools, files and data for updating and maintenance purpose if there is a modification need of the following use cases:

(1) Baseline for adaption of the digital terrain model
(2) Baseline for modelling of flash flood hazards prone areas
(3) Baseline for urban growth modelling
(4) Baseline for coastal erosion hazard prone areas
(5) Baseline for exposure analysis, vulnerability and risk assessment

7 Documentation and Guidances

More information and documentation are available:

(1) Technical Documentation – Deliverable [D1.1] UDRASP project
(2) GIS Training content and presentations - Deliverable [D6.2] UDRASP project
(3) Mapping Guide for an European Urban Atlas (v4.7 / 2012): Mapping Guide and class description for the product "Urban Atlas " of the Copernicus Project © European Union, 2016
(4) ESRI Help http://desktop.arcgis.com/en/arcmap/
(5) FME – Solution for Complex Integration and Data Conversion - www.safe.com

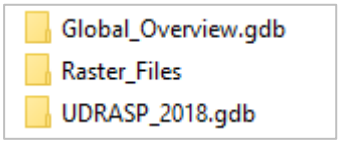
(6) General standards for geo data are describe in the documentation "ISO 191XX Series" www.iso.org

8 Overview Delivery

8.1 UDRASP Map Templates

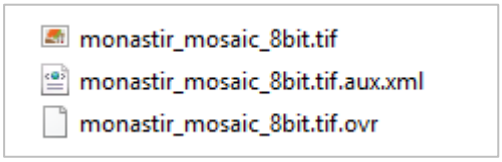
Template	Notes
UDRASP_Template.mxd	– for mapping, quality assurance and data maintenance purpose, – must be connected to the UDRASP_2018.gdb
UDRASP_Map_template.mxd	– for layout and map generation purpose – Must be connected to the UDRASP_2018.gdb and Global_Overview.gdb.

8.2 UDRASP Geodatabases and raster layers

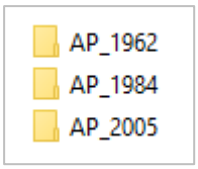


Database	Notes
UDRASP_2018.gdb	– for mapping, quality assurance and data maintenance purpose, – must be connected to the UDRASP_Template.mxd
Global_Overview.gdb	– For visualization of an overview map within the map generation – Must be connected within the UDRASP_Map_Template.mxd.
Raster files	– Results of Flood modelling in 3 periods (1982 – 2016 – HQ100) represented as raster files – Results of Urban Growth Modelling (in 2 sets and 5 different scenarios) represented as raster files – Digital Terrain Model, derived from satellite imagery WorldView 3, actuality: 2017 – Satellite Images – Mosaic. The image mosaic was created from *World View 3* scenes (2017).

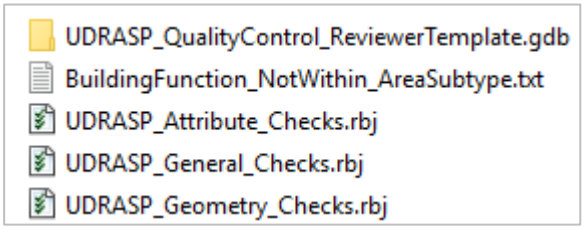
8.3 Satellite Images – Mosaic



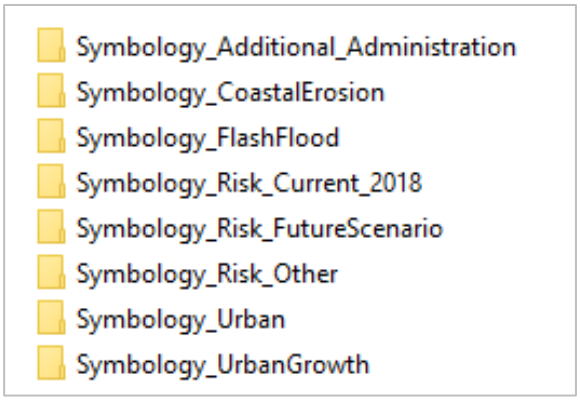
8.4 Aerial Photographs



8.5 UDRASP Reviewer Batch Jobs and Reviewer Template Geodatabase



8.6 UDRASP Layer files



Symbology_Urban

- A_110_TissuUrbain.lyr
- A_120_IndComPubPriv.lyr
- A_122_Transport.lyr
- A_130_ZonesOuvertes.lyr
- A_140_ZonesVertes_Urbaines.lyr
- A_150_Bâtiment.lyr
- A_200_Agriculture.lyr
- A_300_Naturel.lyr
- A_400_ZonesHumides.lyr
- A_500_Eaux.lyr
- A_900_Divers.lyr
- L_120_IndComPubPriv.lyr
- L_122_Transport.lyr
- L_500_Eaux.lyr
- P_500_Eaux.lyr
- P_IndComPubPriv.lyr

Symbology_Additional_Administration

- A_UrbanZones.lyr
- Arrondissement.lyr
- CensusParcel.lyr
- CityLimit.lyr
- Climate.lyr
- DeepGroundwater.lyr
- Geology.lyr
- Governorat.lyr
- IrrigationZones.lyr
- Landcover.lyr
- Limit_Delegation.lyr
- Sector_Governorate.lyr
- SectorMunicipality.lyr
- ShallowGroundwater.lyr
- UrbanDevelopment.lyr
- Watershed_Bassins_versants_Monastir.lyr

Symbology_Coastal Erosion

- CE_Exp_LUCType.lyr
- CE_Haz_Assigned_c.lyr

Symbology_Flash Flood

- FF_Exposure_Transport.lyr
- FF_ExUF_ExposedPoppBB.lyr
- HQ100_brit_DF.lyr
- HQ100_brit_DF_classes.lyr
- HQ100_maxdepth.lyr
- HQ100_vmax.lyr

Symbology_Risk other

- Coastal_Line.lyr
- FF_Water_Course.lyr
- Infrastructure critique.lyr
- Socio-economic profile (expert-based)_SubUnits.lyr
- Units_Pop.lyr
- Zone_bleue_CP.lyr

Symbology_Risk Current 2018

- Risk (flash flood)_BBlocks.lyr
- Risk (flash flood)_SubUnits.lyr
- Social vulnerability to flash floods (2018)_BBlocks.lyr
- Social vulnerability to flash floods (2018)_SubUnits.lyr
- Socio-economic profile (expert-based)_SubUnits.lyr

Symbology_Risk Future Scenario

- BusinessAsUsual
- ScenarioA
- ScenarioB
- ScenarioC
- ScenarioD

- Future exposure to flash floods (urban area) (2030) - Business as Usual .lyr
- Risk (flash flood) (2030) - Business as Usual.lyr
- Social vulnerability to flash floods (2030) - Business as Usual .lyr
- Future exposure to flash floods (urban area) (2030) - Scenario A.lyr
- Risk (flash flood) (2030) - Scenario A.lyr
- Social vulnerability to flash floods (2030) - Scenario A.lyr
- Future exposure to flash floods (urban area) (2030) - Scenario B.lyr
- Risk (flash flood) (2030) - Scenario B.lyr
- Social vulnerability to flash floods (2030) - Scenario B.lyr
- Future exposure to flash floods (urban area) (2030) - Scenario C.lyr
- Risk (flash flood) (2030) - Scenario C.lyr
- Social vulnerability to flash floods (2030) - Scenario C.lyr
- Future exposure to flash floods (urban area) (2030) - Scenario D.lyr
- Risk (flash flood) (2030) - Scenario D.lyr
- Social vulnerability to flash floods (2030) - Scenario D.lyr

Symbology_Urban Growth

- UrbanGrowth_Prohabilistic_urban-Scenario-A.tif.lyr
- UrbanGrowth_Prohabilistic_urban-Scenario-B.tif.lyr
- UrbanGrowth_Prohabilistic_urban-Scenario-BaU.tif.lyr
- UrbanGrowth_Prohabilistic_urban-Scenario-C.tif.lyr
- UrbanGrowth_Prohabilistic_urban-Scenario-D.tif.lyr
- UrbanGrowth_urban_P-Mon.tif.lyr
- UrbanGrowth_urban-S(A)-Mon.tif.lyr
- UrbanGrowth_urban-S(B)-Mon.tif.lyr
- UrbanGrowth_urban-S(C)-Mon.tif.lyr
- UrbanGrowth_urban-S(D)-Mon.tif.lyr

8.7 Guidelines / Presentations

- GIS_Training_July2018
- Arcgis-data-reviewer-checks.pdf
- ESRI_topology_rules_poster.pdf
- UDRASP_Technical_Documentation_Extract_for Training_I1.pdf
- Urban_Atlas_2012_mapping_guide_v4.7.pdf

- 0_20180723_S1_UDRASP_GIS_Training_Introduction_IABG_I1.pdf
- 1_20180723_S1a_UDRASP_Introduction_SIG_enUrbanisme_I1.pdf
- 2_20180723_S2_UDRASP_ArcGIS_Fonctions_I1.pdf
- 3_20180723_S2_UDRASP_Workflow_Data_I1.pdf
- 4_20180724_S2_SaisieDonneesSpatiales_I1.pdf
- 5_20180725_S1_MiseAJour_I1.pdf
- 6_20180725_S2_Assurance_de_la_qualite_fr_I1.pdf
- 7_20180726_S1_DataReviewer_fr_I1.pdf
- 8__20180726_S2_UDRASP_Metadata_I1.pdf
- 9__20180727_S1_UDRASP_RiskFlower_I1.pdf
- 10__20180727_S2_UDRASP_OrganisationTechnique_I1.pdf
- 11_20180725_UDRASP_WebViewer.pdf
- Technical_Documentation_Extract_for Trainingdocx_I2.pdf

8.8 UDRASP Data Model

UA Nomenclature		Feature Class	UA Nomenclature		Subtype (Subdivision)	UA_Code
1. Artificial surface	1.1 Urban Fabric	A_110_Urban Fabric	1.1.1 Continuous Urban Fabric		Continuous Urban Fabric	11100
			1.1.2 Discontinuous Urban Fabric	1.1.2.1 Discontinuous Urban Fabric 50 – 80 %	Discontinuous Urban Fabric 50 – 80 %	11210
				1.1.2.2 Discontinuous Urban Fabric 30 – 50 %	Discontinuous Urban Fabric 30 – 50 %	11220
				1.1.2.3 Discontinuous Urban Fabric 10 – 30 %	Discontinuous Urban Fabric 10 – 30 %	11230
				1.1.2.4 Discontinuous Urban Fabric 0 – 10 %	Discontinuous Urban Fabric 0 – 10 %	11240
			1.1.3 Isolated Structures		Isolated Structures	11300
	1.2 Industrial, commercial, public, military, private and transport units	A_120_IndComPubPriv	1.2.1 Industrial, commercial, public, military and private units	1.2.1.1 Industrial	Industrial	12100
				1.2.1.2 Commercial	Commercial	12100
				1.2.1.3 Public	Public	12100
				1.2.1.4 Private	Private	12100
				1.2.1.5 Civil Protection	Civil Protection	12100
				1.2.1.7 Embankment	Embankment	12100
				1.2.1.8 Dam	Dam	12100
		L_120_IndComPubPriv	Wall		Wall	12100
			Fence		Fence	12100
			Sea wall		Sea wall	12100
			Supply network		Supply network	12100
			Embankment		Embankemnt	12100
		P_120_IndComPubPriv	Mast		Mast	12100
			Memorial		Memorial	12100
		A_122_Transportation	1.2.2 Road and rail network and associated land	1.2.2.1 Fast transit roads and associated land	Fast transit roads and associated land	12210
				1.2.2.2 Other roads and associated land	Other roads and associated land	12220
				1.2.2.3 Railways and associated land	Railways and associated land	12230
			1.2.3 Port areas		Port areas	12300
			1.2.4 Airports		Airports	12400
			1.2.5 Associated road objects		Associated road objects	12200
		L_122_Transportation	Road and rail network and associated land	Fast transit road axis	Fast transit road axis	12210
				Other road axis	Other road axis	12220
				Railway	Railway	12230
				Path	Path	12500
	1.3 Mine, dump and construction sites	A_130_OpenSpace	1.3.1 Mineral extraction and dump sites		Mineral extraction and dump sites	13100
			1.3.3 Construction sites		Construction sites	13300
			1.3.4 Land without current use		Land without current use	13400
	1.4 Artificial non-agriculture vegetated areas	A_140_GreenSpace	1.4.1 Green urban areas		Green urban areas	14100
			1.4.2 Sports and leisure facilities		Sports and leisure facilities	14200
	1.5 Buildings	A_160_Buildings			Buildings	15000
2. Agricultural areas	2.1 Arable land (annual crops)	A_200_Agriculture			Arable land (annual crops)	21000
	2.2 Permanent crops				Permanent crops	22000
	2.3 Pastures				Pastures	23000
	2.4 Complex and mixed cultivation				Complex and mixed cultivation	24000
	2.5 Orchards				Ochards	25000
3. Natural and semi-natural areas	3.1 Forest	A_300_Natural			Forest	31000
	3.2 Herbaceous vegetation associations				Herbaceous vegetation associations	32000

UA Nomenclature		Feature Class	UA Nomenclature		Subtype (Subdevision)	UA_Code
	3.3 Open space with little or no vegetation				Open space with little or no vegetation	33000
4. Wetlands	4.1 Inland wetlands	A_400_Wetlands			Inland wetlands	41000
	4.2 Coastal wetlands				Coastal wetlands	42000
5. Water	5.1 Sea	A_500_Water			Sea	51000
	5.2 Lake				Lake	52000
	5.3 River				River	53000
	5.4 Canal				Canal	54000
	5.5 Reservoir				Reservoir	55000
	5.6 Pond				Pond	56000
	Culvert	L_500_Water			Culvert	50000
	Coastline				Coastline	50000
	Culvert	P_500_Water			Culvert	50000
	Well				Well	50000
	Storage tank				Storage tank	50000
	Cistern				Cistern	50000
	Fontain				Fontain	50000
9. No data	9.1 Clouds and shadows	A_900_Miscellaneous			No data (Clouds and shadows)	91000
	9.2 Missing imagery				No data (Missing imagery)	92000

Feature Class	Subtype (Subdevision)	UA_Code	Attributes	DataType
A_110_Urban Fabric	Continuous Urban Fabric	11100		
	Discontinuous Urban Fabric 50 – 80 %	11210		
	Discontinuous Urban Fabric 30 – 50 %	11220		
	Discontinuous Urban Fabric 10 – 30 %	11230		
	Discontinuous Urban Fabric 0 – 10 %	11240		
	Isolated Structures	11300		
A_120_IndComPubPriv	Industrial	12100		
	Commercial	12100		
	Public	12100		
	Private	12100		
	Civil Protection	12100		
	Embankment	12100		
	Dam	12100		
L_120_IndComPubPriv	Wall	12100		
	Fence	12100		
	Sea wall	12100		
	Supply network	12100	NETWORK_TYPE	CodeList
			PROVIDOR	CodeList
	Embankemnt	12100		
P_120_IndComPubPriv	Mast	12100		
	Memorial	12100		
A_122_Transportation	Fast transit roads and associated land	12210		
	Other roads and associated land	12220		
	Railways and associated land	12230		
	Port areas	12300		
	Airports	12400		
	Associated road objects	12200	OBJECT_TYPE	CodeList
L_122_Transportation	Fast transit road axis	12210		
	Other road axis	12220		
	Railway	12230		
	Path	12500		
A_130_OpenSpace	Mineral extraction and dump sites	13100		
	Construction sites	13300		
	Land without current use	13400		
A_140_GreenSpace	Green urban areas	14100	GREEN_TYPE	CodeList
	Sports and leisure facilities	14200	SPORTS_TYPE	CodeList
A_160_Buildings	Buildings	15000	FUNCTION	CodeList
			NAME	Text
A_200_Agriculture	Arable land (annual crops)	21000		
	Permanent crops	22000		
	Pastures	23000		
	Complex and mixed cultivation	24000		
	Ochards	25000		
A_300_Natural	Forest	31000		
	Herbaceous vegetation associations	32000		
	Open space with little or no vegetation	33000	OPENSPACE_TYPE	CodeList
A_400_Wetlands	Inland wetlands	41000		
	Coastal wetlands	42000		

Feature Class	Subtype (Subdevision)	UA_Code	Attributes	DataType
A_500_Water	Sea	51000		
	Lake	52000		
	River	53000		
	Canal	54000		
	Reservoir	55000		
	Pond	56000		
L_500_Water	Culvert	50000		
	Coastline	50000		
P_500_Water	Culvert	50000		
	Well	50000		
	Storage tank	50000		
	Cistern	50000		
	Fontain	50000		
A_900_Miscellaneous	No data (Clouds and shadows)	91000		
	No data (Missing imagery)	92000		

GlobalID
FCSUBTYPE
UA_CODE
NOM_DEL_FR
TEXT

all Feature Classes

Dataset	Feature Class	Source
FlashFlood	HQ100_Hazard_Vector	Analysis
FlashFlood	FF_Exposure_UrbanFabric_Distribution	Analysis
FlashFlood	FF_Exposure_UrbanFabric	Analysis
FlashFlood	FF_Exposure_UTRansport	Analysis
Coastal_Erosion	CE_Hazard_Exposure	Analysis
Risk_Current	BuildingBlocks_Vulnerability_Risk_2018_15units	Analysis
Risk_Current	BuildingBlocks_Vulnerability_Risk_2018_ALLblocks	Analysis
Risk_Current	SubUnits_socioeconomic_profile_2018_ALLunits	Analysis
Risk_Current	SubUnits_Vulnerability_Risk_2018_15units	Analysis
Risk_Future_Scenario	Units_FutureRisk_15	Analysis
Risk_Other	A_CriticalInfrastructure	Analysis
Risk_Other	A_FlashFlood_ZoneBleue_CivilProtection	Analysis
Risk_Other	A_Units_Pop	Analysis
Risk_Other	L_Coastal_Line	Analysis
Risk_Other	L_Hazard_Watercourse	Analysis
Raster	FF_HAZARD_1982_BRIT	Modelling
Raster	FF_HAZARD_2016_BRIT	Modelling
Raster	FF_HAZARD_HQ100_BRIT	Modelling
Raster	UrbanGrowth_Prohabilistic_urban_Scenario_A.tif	Modelling
Raster	UrbanGrowth_Prohabilistic_urban_Scenario_B.tif	Modelling
Raster	UrbanGrowth_Prohabilistic_urban_Scenario_C.tif	Modelling
Raster	UrbanGrowth_Prohabilistic_urban_Scenario_D.tif	Modelling
Raster	UrbanGrowth_Prohabilistic_urban_Scenario_BaU.tif	Modelling
Raster	UrbanGrowth_urban_P_Mon.tif	Modelling
Raster	UrbanGrowth_urban_S_A_Mon.tif	Modelling
Raster	UrbanGrowth_urban_S_B_Mon.tif	Modelling
Raster	UrbanGrowth_urban_S_C_Mon.tif	Modelling
Raster	UrbanGrowth_urban_S_D_Mon.tif	Modelling

Dataset	Feature Class	Source
Administration	A_CityLimit	Data Collection
Administration	A_CensusParcel	Data Collection
Administration	A_District	Data Collection
Administration	A_Governorate	Data Collection
Administration	A_LimitDelegation	Data Collection
Administration	A_SectorGovernorate	Data Collection
Administration	A_SectorMunicipalite	Data Collection

Dataset	Feature Class	Source
Additional	A_Watersheds	Data Collection
Additional	A_Climate	Data Collection
Additional	L_Faults Tunesia	Data Collection
Additional	A_Geology	Data Collection
Additional	A_ShallowGroundwater	Data Collection
Additional	A_DeepGroundwater	Data Collection
Additional	A_Landcover	Data Collection
Additional	A_IrrigationZones	Data Collection
Additional	A_UrbanDevelopment	Analysis
Additional	A_UrbanZones	PAU
Additional	AOI	Other