SWIM-H2020 EFS-EG-1 “Improved Watershed Management (decentralized level), local governance and capacity building”

Organization of a geo-spatial database in GIS (Task 2.2)

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DISCLAIMER:

ABBREVIATIONS

GIS	Geographic Information System
GW	Groundwater
RB	River Basin
RBD	River Basin District
SW	Surface water
WFD	Water Framework Directive

1. INTRODUCTION

This report has been prepared as part of the SWIM-H2020 Expert Facility Activity EFS-EG-1: Improved Watershed Management (decentralized level), local governance and capacity building, with reference to Task 2.2 “Organization of a geo-spatial database in GIS”.

The overall goal of the report is to provide guidelines on how a GIS database containing information related to the compilation of water balances and the assessment of pressures on water resources should be developed.

Water balance includes both physical components (e.g. parameters of the hydrological cycle, natural inflows and outflows, etc.) and anthropogenic components (e.g. water abstractions, water returns), while the non-conventional resources also come into interplay. It is thus important to establish a common understanding on the data elements (primary and secondary) that support the development of water balances and how these should be integrated into a GIS database.

The collection and maintenance of information on the type and magnitude of the significant anthropogenic pressures to which water bodies in each river basin are liable to be subject is very important, in particular the identification of the significant point and non-point (diffuse) pollution source from urban, industrial, agricultural and other installations and activities. It is thus important to establish a common understanding on the data elements that support the analysis of pressures and how these should be integrated into a GIS database.

These guidelines can be followed by the Governorates in developing GIS databases which will be used as tools facilitating the development of the Governorate Water Resources Management Plans Databases.

1.1 PURPOSE AND SCOPE

The purpose of this Report is to provide guidelines for preparing a GIS database in Egypt, following a national harmonized methodology, which contains data relevant to systematically producing water balances and systematically analysis the pressures from point and diffuse pollution sources on the water bodies. Data elements are defined allowing the compilation of water balances and the pressures analysis at different spatial scales. A GIS database is useful both to those responsible for preparing and reporting the data and to those who use and analyse the data.

2. CARTOGRAPHIC DATASETS

This section provides an overview of the different spatial data sets that constitute the baselines layers of the GIS database. The unit of analysis for the water balances and the pressures defines the scale of these baseline datasets. The following are suggested, as presented in Table 2-1. These data should be reported as polygones or polylines (where applicable) and stored as .shp (shapefiles). Ideally, the analysis of the water balances and pressures should be performed at the river basin scale. The coarser spatial units (i.e. Governorate, River Basin District) are important for aggregation

purposes, and for drawing policy-relevant conclusions. The finer scale (i.e. sub-basin) is important in order to have an overview of the different sub-catchment within a river basin.

Table 2-1: Baseline cartographic dataset (definitions adopted from European Commission, 2016)

Spatial unit	Definition	Remarks	Data Format
Governorate	Administrative unit	Egypt is divided in 27 Governorates.	Polygons
River Basin District (RBD)	The area of land and sea, made up of one or more neighboring river basins together with their associated groundwaters and coastal waters, which is the main unit for management of river basins. This definition is applicable in the EU Water Framework Directive1 (WFD) and could be adopted accordingly if applicable in Egypt		Polygons
River Basin (or catchment)	The area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.		Polygons
Sub-basin (or sub-catchment)	The area of land from which all surface run-off flows through a series of streams, rivers and, possibly, lakes to a particular point in a water course (normally a lake or a river confluence).	Each sub-basins must be assigned to one and only river basin, and each sub-basin polygon must be contained by its river basin polygon	Polygons
Surface water body	A discrete and significant element of surface water such as a lake, a natural reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water.	Each surface water body must be assigned to one and only river basin, while surface water bodies must not overlap	Polygons (for lakes, reservoirs) Polylines (for rivers, streams, canals)
Groundwater body	A distinct volume of groundwater within an aquifer or aquifers.	The geometry of a body of groundwater may overlap the geometry of more than one RBD in the national territory. However, one groundwater body must be assigned to one and only one river basin district. If the different parts are managed separately (e.g. require different measures or have different competent authorities) then this cannot be treated as a single water body and needs to be split (not necessarily along the geographical borders of	Polygons

[1] EC, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

Spatial unit	Definition	Remarks	Data Format
		the RBD but rather according to the different identification of measures).	
Protected areas	Areas requiring special protection. These may include: – areas designated for the abstraction of water for human consumption (Drinking Water Protected Areas) – areas designated for the protection of economically significant aquatic species (freshwater Fish and Shellfish); – bodies of water designated as recreational waters, including areas designated as Bathing Waters – nutrient-sensitive areas, including areas identified as Nitrate Vulnerable Zones or areas designated as sensitive to wastewater – areas designated for the protection of habitats or species		Polygons

3. WATER BALANCE DATASETS

When analyzing the water balance, we need to properly assess the water availability side and the water demand-related side of the balance. The water demand side of the water balance equation relates to the water abstraction. The main parameter to be evaluated in the volume of freshwater abstraction from the surface and from the groundwater sources separately. Additional important parameters to know are the losses which occur during the transport and use stages, since those may actually represent a return flow to the groundwater, as well as the non-freshwater resources in case they exist (e.g. brackish water) since part of this water may also end up in the system through returns. Groundwater available for annual abstraction is also relevant to define. Illegal abstractions are important in the water balance equation since, if not incorporated under the total volume of abstracted water, the equation can result in a misleading equilibrium. How to calculate them in practice is challenging (e.g. through past data on illegal water use, via satellite data on soil moisture, via proxies comparing existing registered abstractions to water demand, etc.), and this adds, of course, uncertainty to the water balance accuracy. Finally, water use information is also relevant. To underpin the development of spatial scale water balances point measurements of the hydrological parameters (i.e. precipitation, streamflow, water level, etc.) are indispensible. All water balance relevant parameters are summarized in the Figure below. It is acknowledged that not all of the parameters are suitable to be included in a GIS database (e.g. the timeseries of precipitation data) and some are products of external calculations. In the following sections, the most relevant datasets to be included in the GIS database (in relation to the water balance) are suggested.

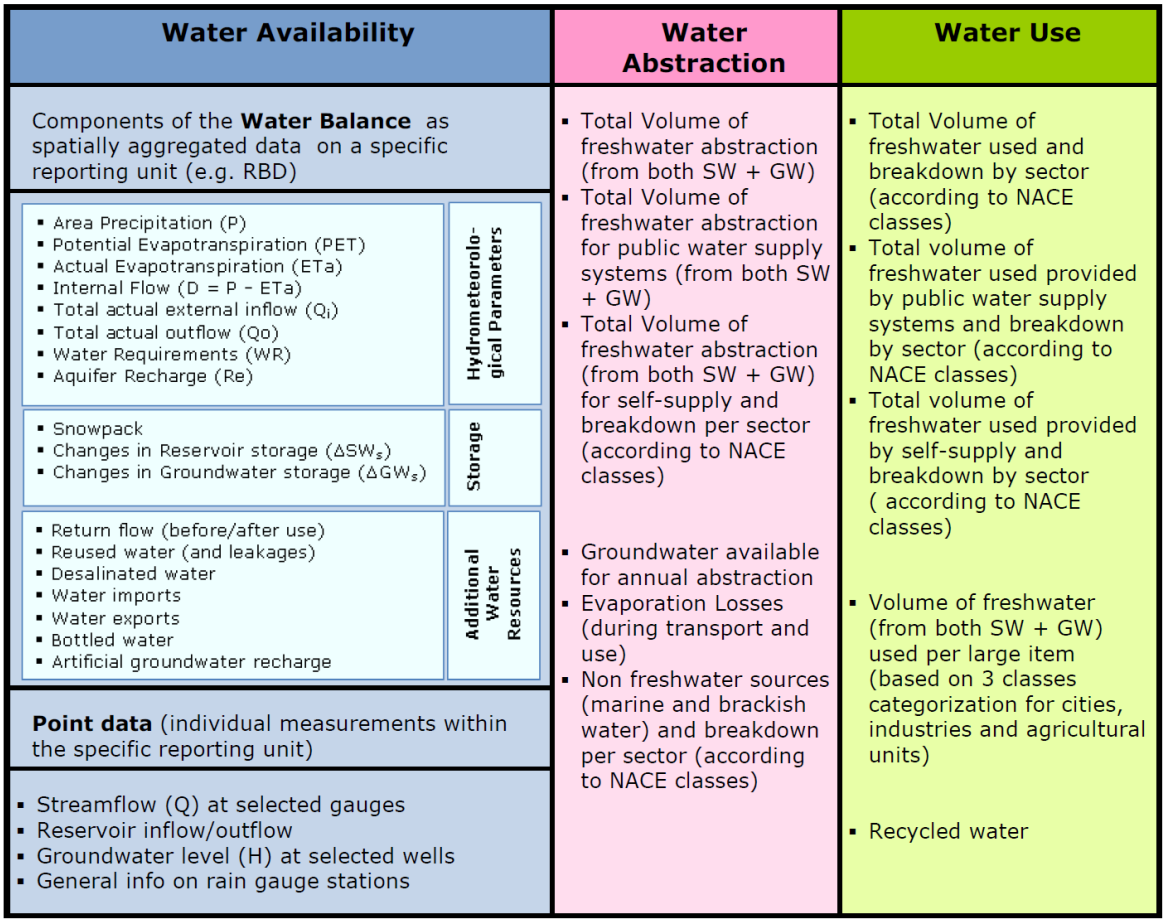

Figure 3-1: Overview of the water balance related data (Source: Kossida, 2009)

3.1 POINT DATA

Point hydrometeorological data are important inputs in calculating areal estimates (e.g. from point precipitation data from different rain gauge stations located with the river basin we can calculate the areal precipitation in the entire basin). It is understood that hydrometeorological timeseries (especially daily or hourly) constitute very long records, and thus their inclusion in a GIS database is not relevant since they require customized databases. Significant water abstractions for urban, industrial, agricultural and other uses, as well as water uses are very important to identify and register. What is thus relevant to include in the GIS database is the location of the monitoring stations, the main abstraction points, and the main users, as presented in the following table. These data should be reported as points (coordinates, name) or polygons (where applicable) and stored as .shp (shapefiles).

Table 3-1: Point dataset related to the water balance

Dataset	Definition	Remarks	Data format
Precipitation rain gauges	The locations of the precipitation station located within the different spatial units of Table 2-1 (i.e.	Point data with information on coordinates, name, and other relevant elements	Point data

Dataset	Definition	Remarks	Data format
	Governorate, RBD, river basin, sub-basin)		
Temperature monitoring stations	The locations of the precipitation station located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements	Point data
Streamflow gauges	The locations of the streamflow monitoring stations located within the different spatial units of Table 2-1(i.e. lakes, rivers, reservoirs), including stations that monitor inflows and outflow from reservoirs and spring discharges located within the reporting unit (i.e. Governorate, RBD, rver basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements	Point data
Reservoirs (artificial)	The locations of all the reservoirs (artificial) within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin) Note that the natural reservoirs (lakes) are reported under the baseline cartographic datasets.	Point data or polygons, with information on coordinates, name, and other relevant the characteristics of these reservoirs (e.g. max storage capacity etc.)	Point data or Polygons
Springs	The locations of the springs located within different spatial units of Table 2-1 (i.e Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements	Point data
Monitoring stations for chemical and / or ecological monitoring of Surface Water Bodies	The locations of the monitoring stations (chemical, ecological) of surface water bodies (rivers, lakes, reservoirs, coastal water bodies) located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. which water quality parameters are being monitored)	Point data
Monitoring stations for quality and / or quantity monitoring of Groundwater bodies	The locations of the groundwater quality and / or quality monitoring stations located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. which water quality parameters are being monitored)	Point data
Surface water abstraction stations	The locations of the surface water abstraction stations located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. volumes abstracted annually, which users are these intended for, etc.)	Point data

Dataset	Definition	Remarks	Data format
Groundwater abstraction wells	The locations of the groundwater abstraction wells located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. volumes abstracted annually, which users are these intended for, etc.)	Point data

3.2 SPATIAL DATA

The datasets suggested to be included in the GIS Database are presented in the Tables 3-2 and 3-4 below. The datasets related to water abstraction (Table 3-2) are considered as priority 1 (i.e. primary data) while the datasets related to the water availability (Table 3-3) are considered as priority 2 (i.e. secondary data) at this stage. These data should be reported as polygons (and stored as .shp (shapefiles).

Table 3-2: Spatial datasets related to water abstraction

Dataset	Definition	Remarks	Data format
Surface water abstraction	The volume of all the surface water abstractions located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Total volume of surface water abstraction from public supply system per source (i.e. river, lake, reservoir) Total volume of surface water abstraction from self-supply per source (i.e. river, lake, reservoir) To include coordinates, name, and other relevant elements (e.g. which users are these abstractions intended for, etc.)	Polygons
Groundwater abstraction	The volume of all the groundwater water abstractions located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Total volume of ground water abstraction from public supply system per source (i.e. per groundwater body) and the safe yield (per groundwater body) Total volume of surface water abstraction from self-supply per source (i.e. groundwater body) and the safe yield (per groundwater body) To include coordinates, name, and other relevant elements (e.g. which users are these abstractions intended for, safe yields, etc.)	Polygons
Main urban water users	The locations of all the main urban water users (e.g. cities, villages, touristic resort, etc.) located within the different spatial units of Table 2-1 (i.e.	Polygon data with information on coordinates, name of city or village, volumes supplied annually/ monthly, source of	Polygons

Dataset	Definition	Remarks	Data format
	Governorate, RBD, river basin, sub-basin) and respective water use volumes	water, water supplier	
Main industrial water users	The locations of all the main industrial water users (e.g. individual industrial facilities, industrial areas) located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin) and respective water use volumes	Point or Polygon data with information on coordinates, name of city or village, volumes supplied annually/ monthly, source of water, water supplier	Point data or polygons
Main agricultural water users	The locations of all the main agricultural water users (e.g. agricultural areas, large groups of farmers, etc.) located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin) and respective water use volumes	Point or Polygon data with information on coordinates, name of city or village, volumes supplied annually/ monthly, source of water, water supplier	Point data or polygons

Table 3-3: Spatial datasets related to water availability (Source: Kossida, 2009)

Dataset	Definition	Data format
Areal Precipitation (P)	Total volume of atmospheric wet precipitation (rain, snow, hail etc.). Precipitation is usually measured by meteorological or hydrological institutes	Polygons
Potential evapotranspiration (PET)	The maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground and well supplied with water.	Polygons
Actual Evapotranspiration (ETa)	Total volume of evaporation from the ground, wetlands and natural water bodies and transpiration of plants. According the definition of this concept in hydrology, the evapotranspiration generated by all human interventions is excluded, except rain-fed agriculture and forestry. The “actual evapotranspiration” is measured or calculated using different types of mathematical models, ranging from very simple algorithms (Turc, Penmann, Budyko, Turn Pyke, etc) and corrections related to vegetal cover and season to schemes that capture the hydrological cycle in detail.	Polygons
Internal flow (D = P - ETa)	Total volume of river run-off and groundwater generated, in natural conditions, exclusively by precipitation into a territory. The internal flow is equal to precipitation less actual evapotranspiration and can be calculated or measured. If the river run-off and groundwater generation are measured separately, transfers between surface and groundwater should be netted out to avoid double counting.	Polygons
Total actual external inflow (Qi)	Total volume of actual flow of rivers and groundwater, coming from neighbouring territories (e.g. RBDs) within or outside the country.	Polygons
Total actual outflow (Qo = Qo,s + Qo,n) of which Qo,s into the sea of which Qo,n into	Actual outflow of rivers and groundwater into the sea plus actual outflow into neighbouring territories (within or outside the country). Total actual outflow – of which into the sea: The total volume of actual outflow of rivers and groundwater into the sea. Total actual outflow – of which to neighbouring territories: The total	Polygons

Dataset	Definition	Data format
neighbouring territories	volume of actual outflow of rivers and groundwater into neighbouring territories (RBDs or Countries if Country level is reported).	
Snowpack (estimates of changes in storage; volume of snow)	Volume of snow accumulated stored over a period which can result (fully or partially) in snow melted water. It does not include the glaciers, and it is measured at a reference time.	Polygons
Changes in reservoir storage	Volumetric change of the water stored in a reservoir (natural and manmade) at a given time	Polygons
Changes in groundwater storage	Volumetric change of the groundwater stored in a groundwater body at a given time	Polygons
Return flow (amount & to which hydrological unit, if different than where abstracted)	Water abstracted from any fresh water source and discharged into fresh waters before or after use. Discharges to the sea are excluded. It can further be broken down to: 1. Returned Before Use (Leakage Losses) (amount & to which hydrological unit, if different than where abstracted) 2. Returned After Use (amount & to which hydrological unit, if different than where abstracted)	Polygons
Reused water (amount & to which recipient)	Water that has undergone wastewater treatment and is delivered to a user as reclaimed wastewater. This means the direct supply of treated effluent to the user. Excluded is waste water discharged into a watercourse and used again downstream.	Polygons
Recycled water (i.e. agriculture drainage water)	Water that comes from agricultural drainage and it is being recycled	Polygons
Desalinated water (amount & to which recipient)	Total volume of water obtained from desalination processes	Polygons
Water imports (amount & from which hydrological unit)	Traded bulk water from another territory outside the specific reporting unit (bottled water is not included)	Polygons
Water exports (amount & to which hydrological unit)	Traded bulk water to another territory outside the specific reporting unit (bottled water is not included)	Polygons

4. PRESSURES DATASETS

The collection and maintenance of information on the type and magnitude of the significant anthropogenic pressures to which water bodies in each river basin are liable to be subject is very important, in particular the identification of the significant point and non-point (diffuse) pollution source from urban, industrial, agricultural and other installations and activities. The relevant datasets are presented in the following table.

Table 4-1: Pollution sources dataset

Datasets	Definition	Remarks	Data format
Industrial Facilities	The locations of the industrial facilities located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, type of industry, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Mines and Quarries	The locations of the mining and quarrying sites located within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Intensive rearing facilities	The locations of the rearing facilities located (e.g. poultry, cattle, etc.) within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Livestock units	The locations of the livestock (e.g. poultry, cattle, etc.) within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Aquaculture units	The locations of the aquaculture units within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Landfills	The locations of the landfills within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Uncontrolled Waste Disposal (UWD)	The locations of the UWD sites within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Disposal or recovery of hazardous waste Facilities	The locations of the hazardous disposal facilities within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Disposal or recycling of animal carcases and animal waste Facilities	The locations of the animal waste facilities within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Waste Transfer Stations	The locations of the waste transfer stations within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data

Datasets	Definition	Remarks	Data format
Urban waste water treatment plants (UWWTP)	The locations of the UWWTP within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Desalination Units	The locations of the desalination units within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Point data with information on coordinates, name, and other relevant elements (e.g. activity level, yields, etc.)	Point data
Agricultural areas	The location of the agricultural areas within the different spatial units of Table 2-1 (i.e. Governorate, RBD, river basin, sub-basin)	Areal data (geometries) with information on name, crop types, other relevant elements (e.g. activity level, yields, pesticides applied, irrigation practices, etc.)	Polygons

An example of a GIS map with the main pressures/ pollution sources in Cyprus is provided in the following Figure.

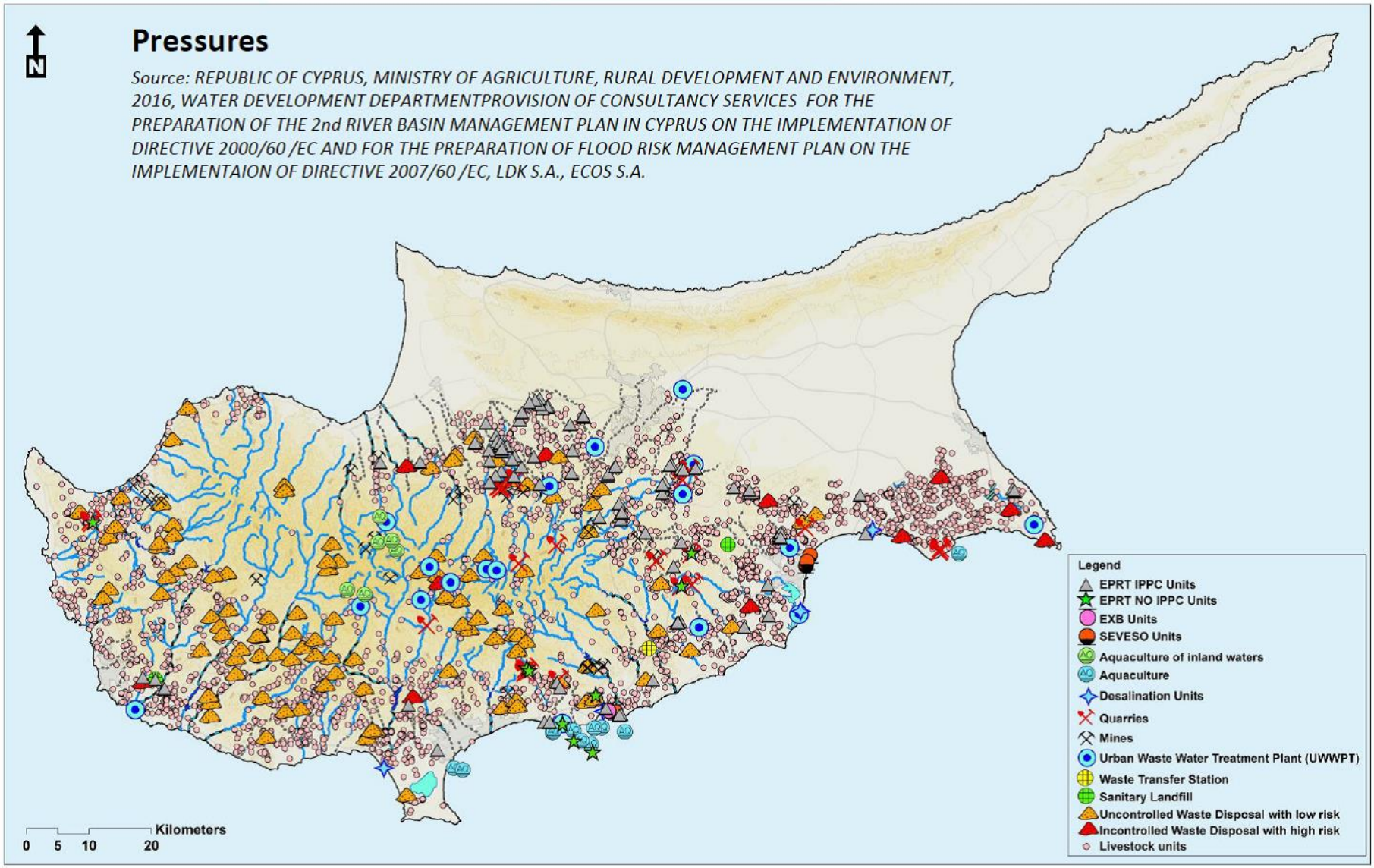

Figure 4-1: GIS map of the main pressures in Cyprus (Source: Republic of Cyprus, 2016)

5. REFERENCES

European Commission, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy

European Commission, 2015. Guidance document on the application of water balances for supporting the implementation of the WFD. Technical Report-2015-090, Final – Version 6.1 – 18/05/2015

European Commission, 2016. WISE GIS Guidance on the reporting of spatial data to WISE

Version 6.0.6, 2016-04-29

Kossida M., 2009. WISE-SoE WQ Data Request-Data Input Tool for the WISE-SoE#3 "State and Quantity of Water Resources" User Manual 2009. Publication for the EEA, Copenhagen

Republic of Cyrpus, Ministry of Agriculture, Rural Development and Environment, Water Development Department (WDD), 2016. Provision of consultancy services for the preparation of the 2nd River Basin Management Plan in Cyprus on the implementation of Directive 2000/60/EC and for the preparation of the Flood Risk Management Plan on the implementation of the Directive 2007/60/EC. LDK S.A., ECOS S.A., 2016.