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Olive Oil By-product Analysis and Recovery in Syria

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SUMMARY - The olive oil production represents for Syria an important agricultural sector rising up in the coming years. To minimize the environmental risks and to increase its ecological sustainability it is necessary to define the management strategy of the waste or, better, by-products disposal, using them as an improver for cultivated soil.
The activities related to this project framework at first have surveyed the availability of husk and olive mill waste waters in each mill of every region. Than, some recovery (re-use) system, such as husk composting simple method, olive mill waters (OMW) spreading on soil with modified tank, OMW management (GIS based models have been proposed).

Key words: OMW, husk, by-product re-use

RESUME - *La production de l'huile d'olive représente pour la Syrie un secteur agricole important, montant vers le haut en années à venir. Pour réduire au minimum les risques environnementaux et pour augmenter sa durabilité écologique il est nécessaire de définir la stratégie de gestion des pertes ou, meilleure, de la disposition de sous-produit, en utilisant les car amendant pour le sol cultivé. Les activités se sont reliées à ce cadre de projet au début ont examiné l'avaibility de l'eau usagée de moulin de cosse et d'olive dans chaque moulin de chaque région. Que, on a proposé un certain système de rétablissement (réutilisation), comme cosse compostant la méthode simple, eaux végétales écartant sur le sol avec le réservoir modifié, modèle basé par GIS de gestion d'eau usagée de moulin d'huile d'olive*

Mots-clés: *eau végétale, grignons, sous-produit*

Introduction

Olive fruit, and hence olive oil, represent a minimal part of the biomass produced in olive growing and olive oil production as a whole. Olive fruit are in fact equal in weight to olive pruning brush while olive oil represents approximately 20% of fruit weight.

The remaining biomass can be considered processing residue. If it is re-used, it can be considered a by-product. If not, it is defined as waste and has to be treated or disposed of according to specific rules and regulations.

Olive growing and olive oil production produce the following types of residue:

- orchard residue: unpicked olive fruit and pruning brush (wood and foliage).
- olive oil processing residue: olive husk and olive oil mill waste water.
- solvent extraction residue: exhausted (spent) pomace.

Having specified the types of residue, it is now a question of dividing them into by-products and wastes.

Olive fruit that are not picked are not worth recovering, and are therefore considered orchard residue. The organic matter they provide is totally irrelevant from every point of view, except that it could be an inoculum source for the development of generations of *Bactrocera oleae*.

Larger and smaller sized pruning wood is used almost exclusively as fuel; hence, to all effects it is a by-product.

Pruning foliage (leaves and shoots) is generally collected by hand or mechanically into piles at a distance from the trees and then burned; rarely is it shredded and incorporated into the soil. Some times it is recovered and re-used as fuel (after natural drying) or for animal feed.

Olive pomace, which still contains a small amount of oil, is used for the chemical or mechanical extraction of olive pomace oil or else it is composted for subsequent use as a soil conditioner.

Exhausted pomace is the residue left over after extracting olive pomace oil and is often used for fuel or as the basic organic matrix for composting.

Olive pomace definitely therefore has to be considered a by-product. Also olive oil mill waste waters (OMW), according to scientific literature and some EU legislations may be considered as by-product, spreading it, in controlled way and quantities, on the soil for agricultural purposes.

Project activities

Surveys and problems analysis

The project activities start with a survey of the mills in every major olive producing region in Syria (Lattakia, Tartous, Idleb, Aleppo, Homs, Daraa, Damascus, Hama) to understand the extent of the problem with regard to waste water and olive husk. The amounts of OMW and husk is shown in the following table 1.

Table 1: Output data from surveys. **Only centrifugal system.*

Region		Idleb	Aleppo	Lattakia	Tartous	Homs	Daraa	Damascus	Hama
total mills		124	325	114	237	35	33	16	23
surveyed mills	centrifugal system	67	25	14	89	15	33	11	16
	pressure system	5	16	10	140	5	-	1	-
	total	72	41	24	229	20	33	12	16
by-product	year	amount (ton)	amount (ton)	amount (ton)	amount (ton)	amount (ton)	amount (ton)	amount (ton)	amount (ton)
waste water*	2003	78.652	14.521	1.440	2.885	4.915	-	-	-
	2004	108.534	20.650	11.960	47.155	5.247	33.254	6.180	22.450
	2005	-	-	-	3.927	15.010	25.550	10.240	33.620
husk	2003	40.508	10.610	0.380	3.670	4.170	-	-	-
	2004	49.582	14.015	8.100	6.036	5.341	16.625	2.180	13.279
	2005	-	-	-	-	6.815	12.775	4.080	13.865

Olive husk is normally sold (1000 – 1800 sy p/ton) to factories where the residual oil is solvent-extracted (hexane, petrol) and then refined for human consumption instead of seed oils or for soap production. The exhausted husk that is left over is used above all as a fuel (3,000-4,000 kcal/kg) for food processing plants or to generate electricity.

Some farmers (41,6 %) know that husk (fresh or exhausted) could be used as a soil improver but they don’t know the necessary quantity or crop needs. None of them is able to start a composting process to stabilize the organic matter and to obtain a product ready to use.

Few farmers (2,5 %) use fresh husk for animal feeding.

Surveys underline also an increasing use of the fresh husks for a second mechanical extraction of the oil that involves the use of big volumes of hot process water and of big process lines (decanter), with a consequent meaningful energy employment. Besides, the so derived oil, over to introduce waxes levels, uvaolo and eritrodiolo similar to those found in the refined oils, it should not be considered of ready alimentary use if not after appropriate treatment. The growth of this phenomenon should be monitored and checked.

Contrarily, the suveys do not show any worthwhile use for OMW, which has to be disposed of in keeping with the pollution control regulations of the olive-producing countries.

The main problem about OMW is the uncontrolled effluent disposal by millers in the producing and processing area with the ensuing serious risk of polluting watercourses because, although it is not toxic, OMW has quite a high pollutant potential owing to its large content of organic matter.

Surveys observe that nobody knows any information about OMW disposal on agrarian soil, and there isn't any experience to deal with this problem. Most mills discard OMW in the water network (65,7%) and some of it into the river or agricultural lands without any control about quantities and growing crops.

The best way to protect the environment and to take advantage of the soil conditioning and fertilising properties of OMW and husk is through controlled spreading on cultivated soil. This practice is permitted in some olive-growing countries where it is regulated through appropriate legislation that specifies the maximum quantity of OMW or husk that may be spread on soil and the ways in which it may be spread.

Demonstration activities

Composting tests

Although the olive husk has a proper market tied to the production of refined oil and soap, certainly its re-use as a soil improver rich in organic substance in the agricultural chain and particularly olive oil would allow a them more correct use achieving a close farm loop (Amirante P and Montel GL, 1997).

On this subject it is opportune to underline the importance that the production of compost, beginning from this by-product, can have. The compost is a good organic modifier that, although not fully satisfying the crop's nutritive demands, can be very useful in achieving the aim of preserving and recovering the fertility of agrarian soil; its employment allows the realization of a model of sustainable agriculture, in which an equilibrium between collecting and restitution of organic material by the biosphere is reached. In support of this, the employment of this substance is favoured and in increasingly in demand in organic agriculture (Amirante P and Montel GL, 1998).

During the project activities, therefore, two heaps for the bioxidative treatment of the organic substance (composting) have been prepared starting from matrixes prevailing of mill solid residue from the crusher (fresh and exhausted husk) (Fig. 1).

Figure 1: Composting sites

In the detail, the composition of the starting matrix of each of the two heaps with trapezium base (2,5 x 1.5 x 1.5) is the following:

HEAP A	HEAP B
three phases **fresh** husk (85%) pruning brush (fresh and dry) fine cut (10 %) cow manure (5 %)	**exhausted** husk (85 %) pruning brush (fresh and dry) fine cut (10 %) cow manure (5 %)

The compost has been distributed to farmers. Other composting heaps in other villages (Salamieh, Daraa, Jeinderes, Maar Ballit) have been also prepared for demonstration action (Fig. 2). In the same villages demonstration tests have been undertaken about OMW spreading by-use a modified tank-truck which will be discussed subsequently. These villages have been chosen to create a Project pilot group as in the layout to apply the main rules of the strategic plan for improving olive oil quality proposed by the Cooperation Project

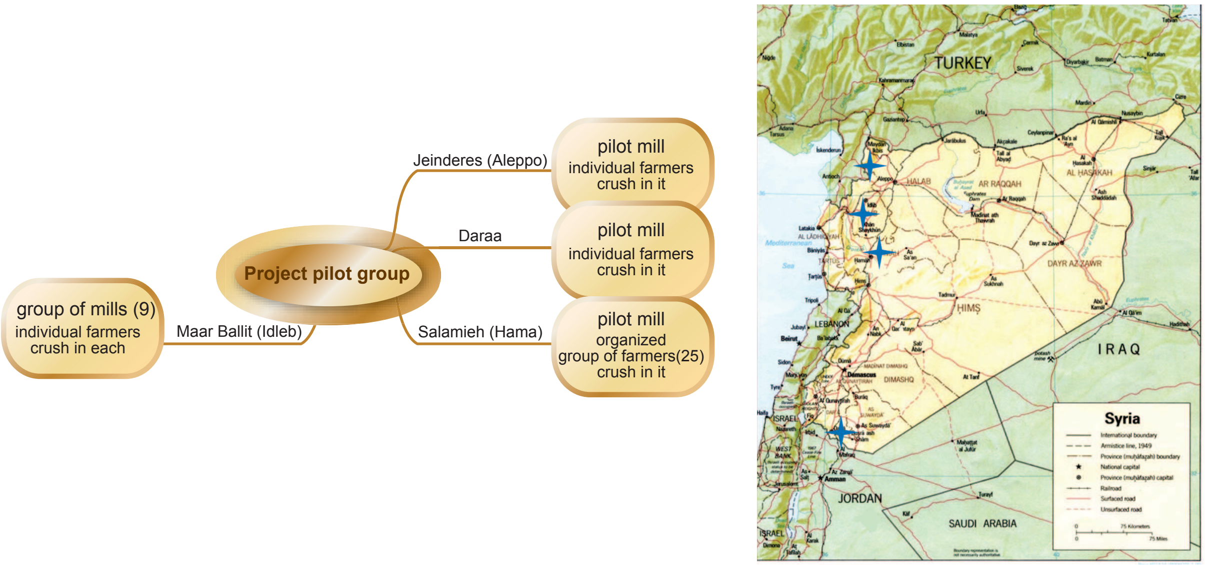


Figure 2: Demonstration layout – pilot group (sx) and sites map (dx)

OMW disposal

The waste water produced during olive oil extraction contains a large amount of organic matter that is acquired during the various stages of processing. Its disposal is a considerable problem because, besides its high organic matter content, OMW has a low biodegradability.

The practice of spreading waste on the soil is under careful study, no longer merely as a way of disposing of the waste but as a way of enhancing the physical and chemical properties of the soil and improving plant nutrition. OMW contains sizeable quantities of mineral nutrients that can replace some of the nutrients provided by conventional fertilisation. Specifically, it contains large amounts of potassium, and smaller amounts of nitrogen, phosphorus and magnesium. Moreover, because it consists mainly of organic matter, it is an excellent substrate for the development of the microflora that improve the physical-chemical properties of the soil (Amirante P & Pipitone F., 2002).

Experiments carried out by numerous authors concur that spreading 40-100 m^3 /ha of OMW on tree crops has several advantages: virtually all the nutrients are recycled (N, P, K), the organic load is metabolised and the salts present in the waste are absorbed. The problem is not if spreading OMW is a suitable practice, but the way of doing it: spreading must be uniform, homogeneous and with a specific volume that is non-toxic for crops.

A first simple model of waste water tank spreader has been set up and tried in the GCSAR Kfar

Yahmour station.

A 3,850 litres tank (Fig. 3 and 4), normally used for water transport by farmers, has been equipped/ modified as following:

- gasoline powered water pump Honda for pumping the waste water and loading the tank;
- iron disk 0,6 m diameter 120° inclined toward the exterior side with respect to the common water 3” spherical valve;
- water counter connected to an electric emptying pump to calculate exactly the residual water content in the tank after spreading.

The waste water has been spread at the air pressure.

In table 2 some key data about OMW disposal test are shown.

Table 2: Main data in waste water tank test

covered distance (m)	average time (s)	tractor speed (m/sec)	min width (m)	max width (m)	average width (m)	average surface (m^2)	OMW volume (m^3)
500	360	1,39	1,7	2,3	2	1000	2,85

The results are encouraging since the quantity spread per dnum is around 2,85 m^3 for waste water from the centrifugal process. This value is below the maximum international security parameters. If, after further trials, this simple type of waste water spreader will be accepted by farmers, it will be easy and cheap to transform the usual water tank to waste water spreading tanks making waste water disposal in the field both practical and convenient. The uniformity of spread has been acceptable and no sign of water excess has been noticed in a soil where last rainfall had been 4 days before.

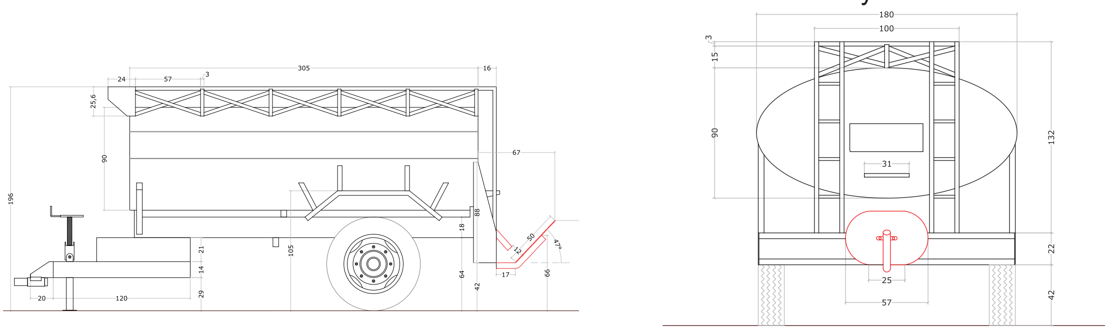


Figure 3: Tank truck design lateral (sx) and rear (dx) view

Figure 4: Tank-truck modified to spread OMW. full (sx), details (dx).

To maintain the continuity of the demonstration action, in some pilots sites the metallic disks have been distributed for allowing the change of existing tank-truck making them so fit to the OMW spreading.

OMW management

To minimize the environmental risks and to increase its ecological sustainability the management strategy of the OMW disposal, spreading it on cultivated soil, has been defined.

In particular, then a GIS based olive mill waste water (OMW) application plan in Daraa region has been implemented. For its definition has been considered suitable for spreading only on olive orchards, omitting areas close to the cities and to the watercourses.

This study has been necessary to define whether the total amount of OMW produced and uniformly spread within the specific areas of influence of a single mill ever exceed a predefined limit value, in view of agronomic needs.

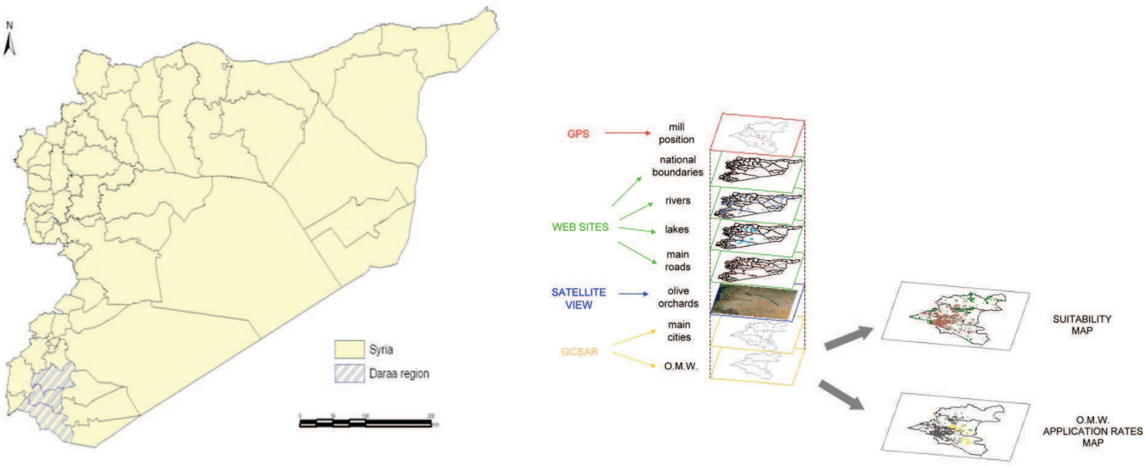


Figure 3: Territorial arrangement (sx). GIS layering model (dx).

The main cartographic data is the 3 bands “Terra MODIS” satellite view of the 4th of May 2003, projected according to the “North American 1927” geographic referring system. Such projection turns out to be common to all the other maps used in the GIS project, whether already existing or newly produced; only in such way the homogeneity of the data is guaranteed.

With the aid of such imaging the olive orchard map of the region was plotted; such mapping has been realized creating a new “shapefile” containing the significant polygons drawn in coincidence of a specified green coloured areas of the satellite image.

The General Commission of Scientific Agricultural Research (GCSAR) of the Syrian Ministry of Agriculture has been the main source of the data regarding the localization of the more important cities, the volumes of OMW produced in every oil mill, referred to the olive oil production in the years 2004 – 05 and the mill type used.

The localization of the 33 oil mills present in the region has instead been derived in situ through GPS survey. The other territorial data, such as the national and regional borders, the localization of rivers, lakes and main roads, have been supplied both by the aforesaid Ministry and by web cartography sites.

All the data has been implemented in a territorial information system and the suitability map for OMW application on soil and the OMW real application rates for the more suitable areas maps have been plotted.

To define the maps only the olive orchard areas has been considered useful for the practice of OMW spreading on soil; those areas derived by the satellite survey as previously described, considering all the green areas as standing crop areas, presumably olive orchards. This approximation has been necessary because of the lack of aerophotogrammetry maps and/or soil use maps.

In Fig. 6 (sx) the areas in which the presence of standing growing (presumably olive-orchards) has been pointed out; of the same areas in Fig. 6 (dx) the degree of OMW spreading suitability is defined.

To originate the spreading suitability map has been considered lowly suitable:

- the cropped areas situated at a distance less than 200 meters from every city maximum expansion (for everyone of which it has been preventively determined a medium radial extension);
- the cropped areas situated on lands with slope higher than 8 %;
- the cropped areas situated at a distance less than 300 meters from the catchment points of waters destined to the human consumption;
- the cropped areas situated at a distance more than 7 km from every mill (mill's functional area).

The first three exclusion criteria are taken from the 574/96 Italian law, (the only complete enough regulation about OMW spreading on cultivated soil); the last criterion depends on the average speed of the spreading machine (normally tank): it is the maximum distance of a daily route.

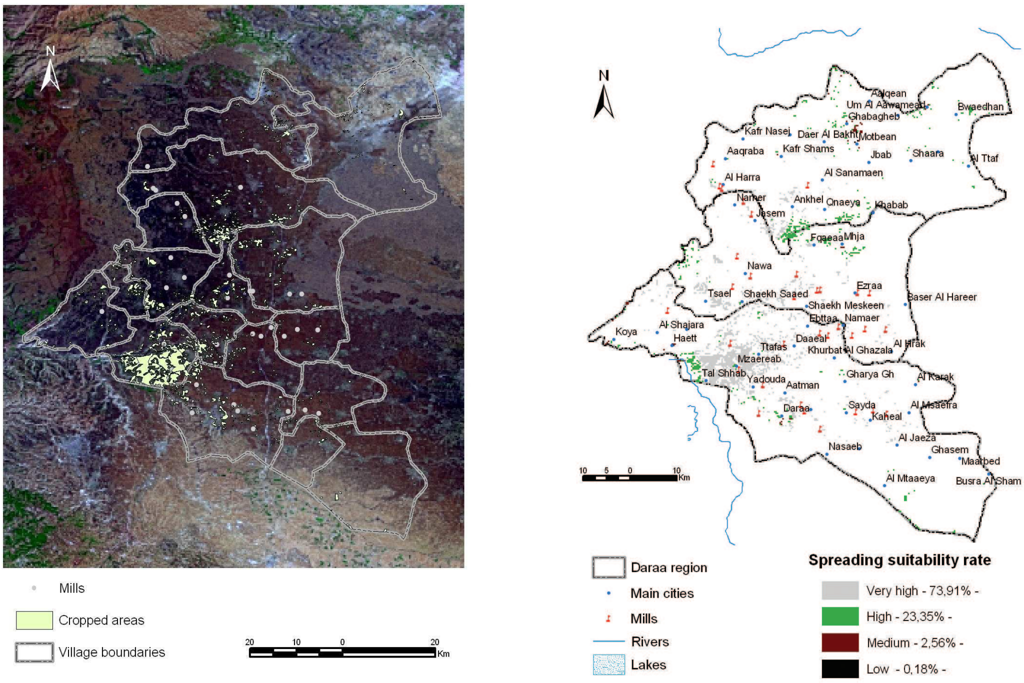


Figure 6: Cropped areas available to spread OMW map (sx). Spreading suitability map (dx).

The spreading suitability rate depends on the number of the conditions that are fulfilled in each cultivated area. The soil that respects at the same time all the four exclusion criteria is the most suitable for spreading, while those that only respect one will be classified as less suitable.

From the cartography it is underlined that the areas that don't involve some type of limitation greater than 70% of the available area, becoming more than 90% if those areas in with only one of the exclusion criteria are added. These last areas could be considered suitable for OMW spreading if procedures for taking care the environmental problems are followed.

Moreover, the study aims to identify in the cropped areas having maximum suitability the OMW real spread rate (OMW volume that potentially could be spread in the area). In order to obtain this, considering that each mill's functional area has a radius of 7 km (maximum distance of daily route), has been necessary to identify each mill's functional area that does not overlap with other functional areas (when the mills have a distance between them of more then 7 km) from those in which the overlapping between the mill's functional areas exists once, twice or more (Fig. 7 sx).

In unoverlapped functional areas, the total amount of OMW volume will be the total amount of OMW produced every year by the mill.

In overlapped functional areas, the total amount of OMW volume will be the sum of a percentage of the OMW volume produced by every single mill (two or more) located in the area according to its the percentage of overlapping.

Then, reading Fig. 7 (dx), is underlined that with an accurate and homogeneous OMW spreading, the load on the agrarian soil primarily become around 15-20 m^3/ha (1,5 – 2 m^3/dnum), a value considerably smaller than the volumes held harmful for the crops and for the pedofauna, according to generally held views in the scientific literature.

All considered, assuming the above mentioned approximations, (that is that all the areas recovered green have been considered as olive orchard), the results obtained fall within the OMW management proposed model. The model suggests, respecting the logic of “restore the olive growing removals”, the OMW re-use as ferti-irrigation in the areas of function of the mill what has been produced by them, considering OMW spreading on the agrarian soil a resource, not a potential environmental pollution.

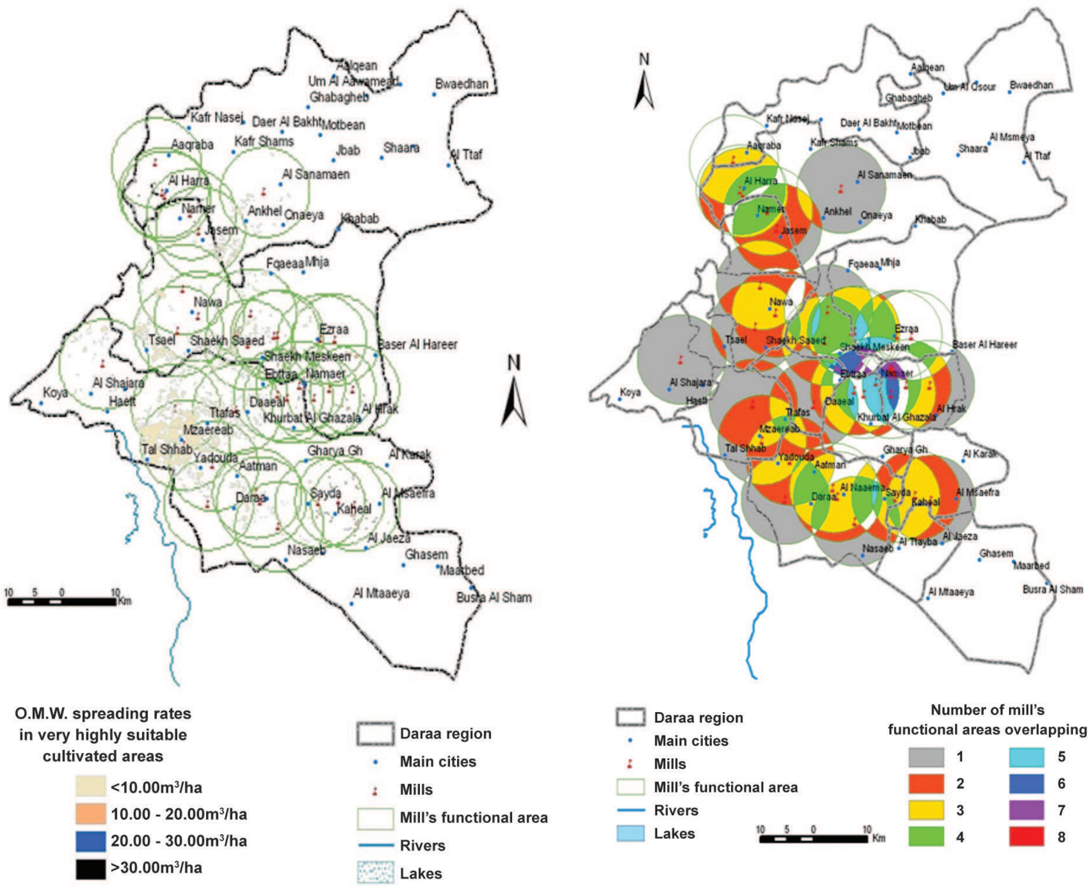


Figure 7: Overlapped areas map (sx). OMW actual spreading rate map (dx).

The limit of this practice, as already underlined in other scientific notes (Montel GL et al., 2005; Amirante P. et al., 2004; Bianchi B. et al., 2003; Scarascia Mugnozza G. et al., 2000) is based on the uniformity of the distribution. It would be necessary to mechanical control systems, over how legislative, of the waste volumes distributed per hectare and per agrarian year, not to incur in the risk of crop damage and/or agrarian soil pollution.

For this last point, a detailed study should exclude from the spreading practice, even though “checked”, those olive orchard areas with hydrogeologic risks caused by superficial phreatic surface stratum and very superficial soil. The proposed model must be integrated and improved with a most detailed knowledge of the soil use, also with aerophotogrammetry map availability, with the aim of achieving a more careful system forecast ability.

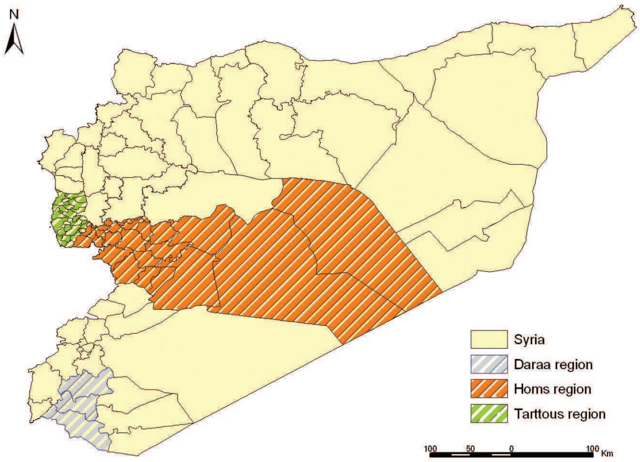
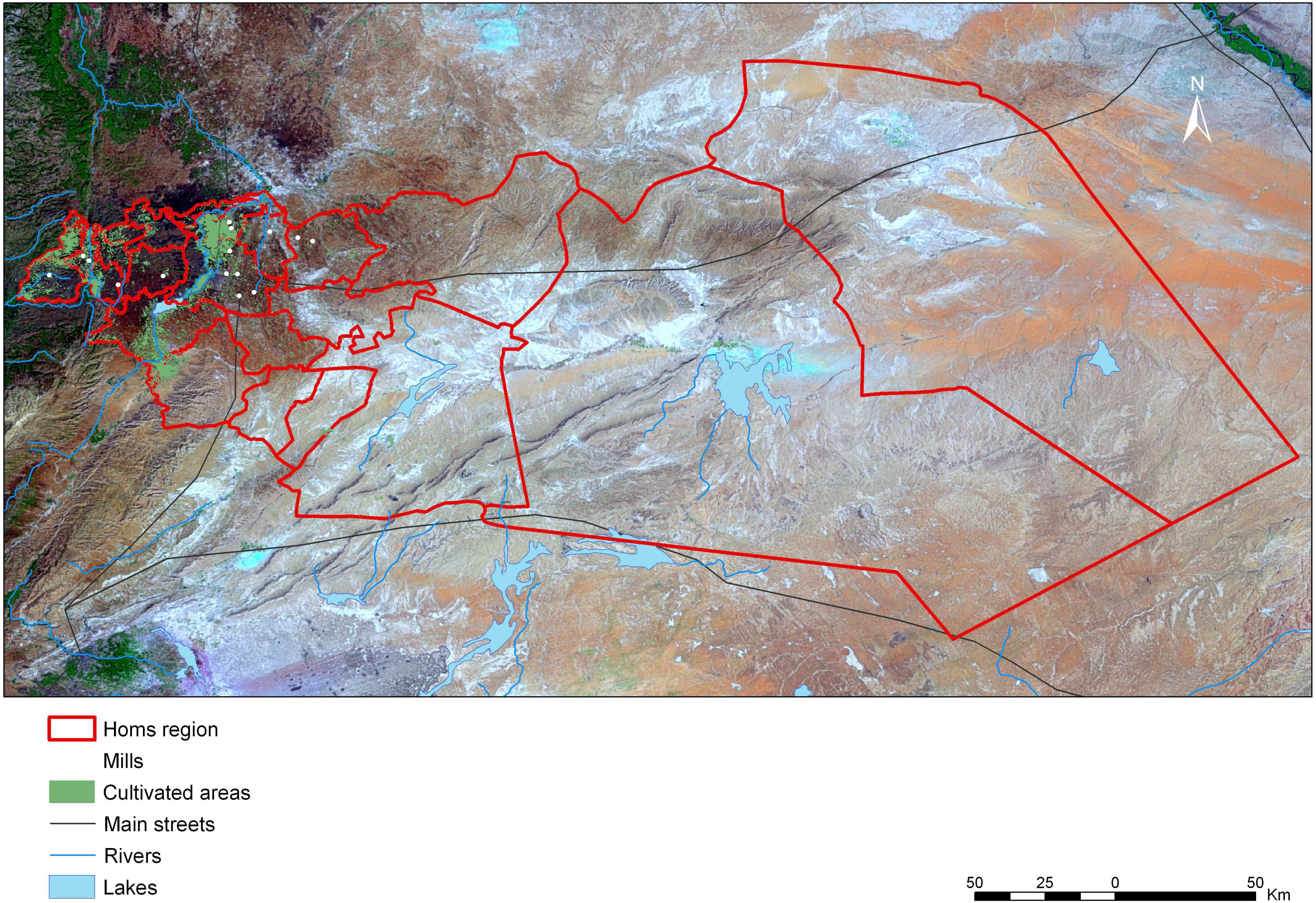


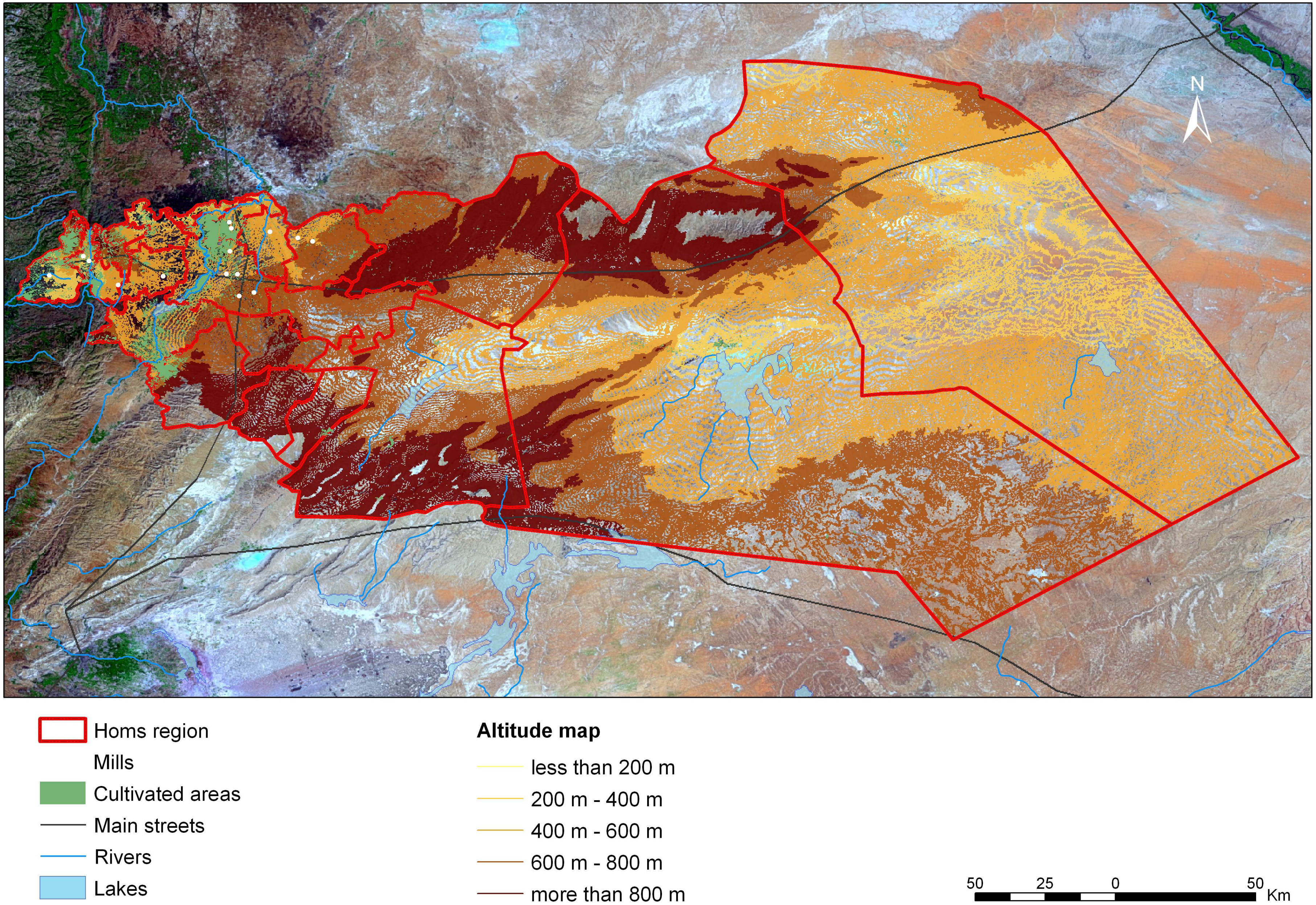
Figure 8: Ongoing activities territorial arrangement.

The GIS bases model has been also implemented in Idleb, Hama and Homs regions (Fig. 8) which have different olive and oil production issues, such as orchards age with regard to processing or plant; a thorough investigation is now ongoing in the Tartous region considering its high hydrogeological and environmental risks. Following some output maps of the ongoing activities.

Basic data layers in the Homs region



Homs olive areas



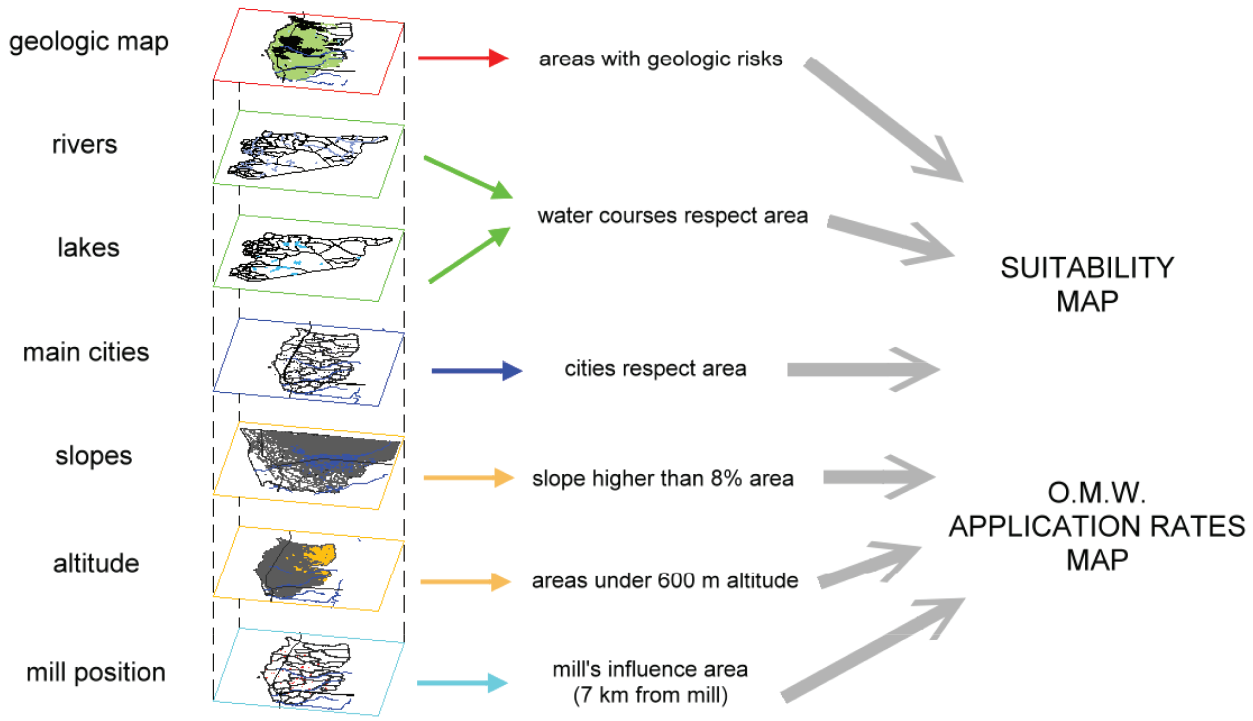
Homs elevation lines

Tartous basic data layers

Tartous olive areas

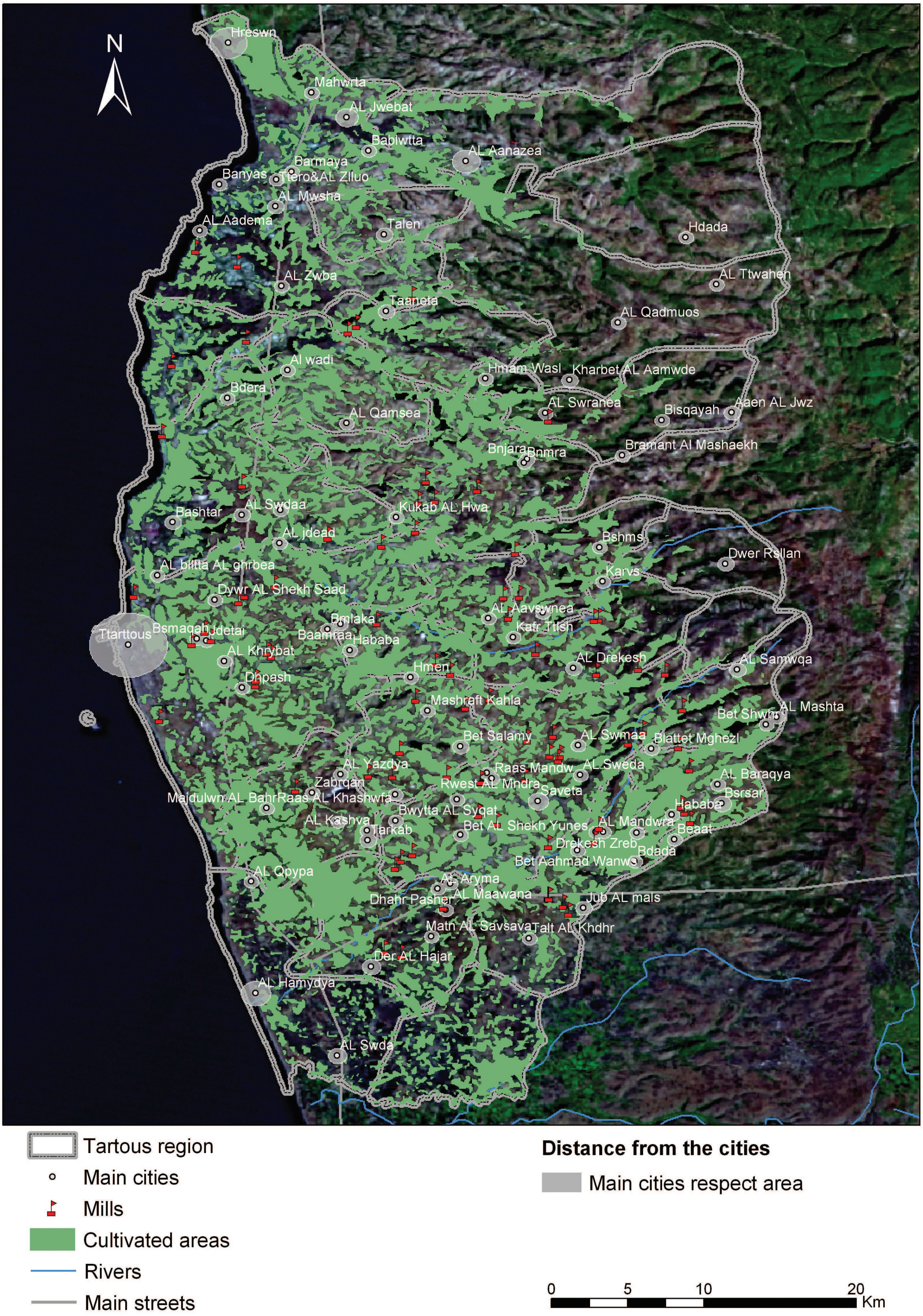
Tartous elevation lones

Exclusion/ inclusion criteria analysis in the Tartous region



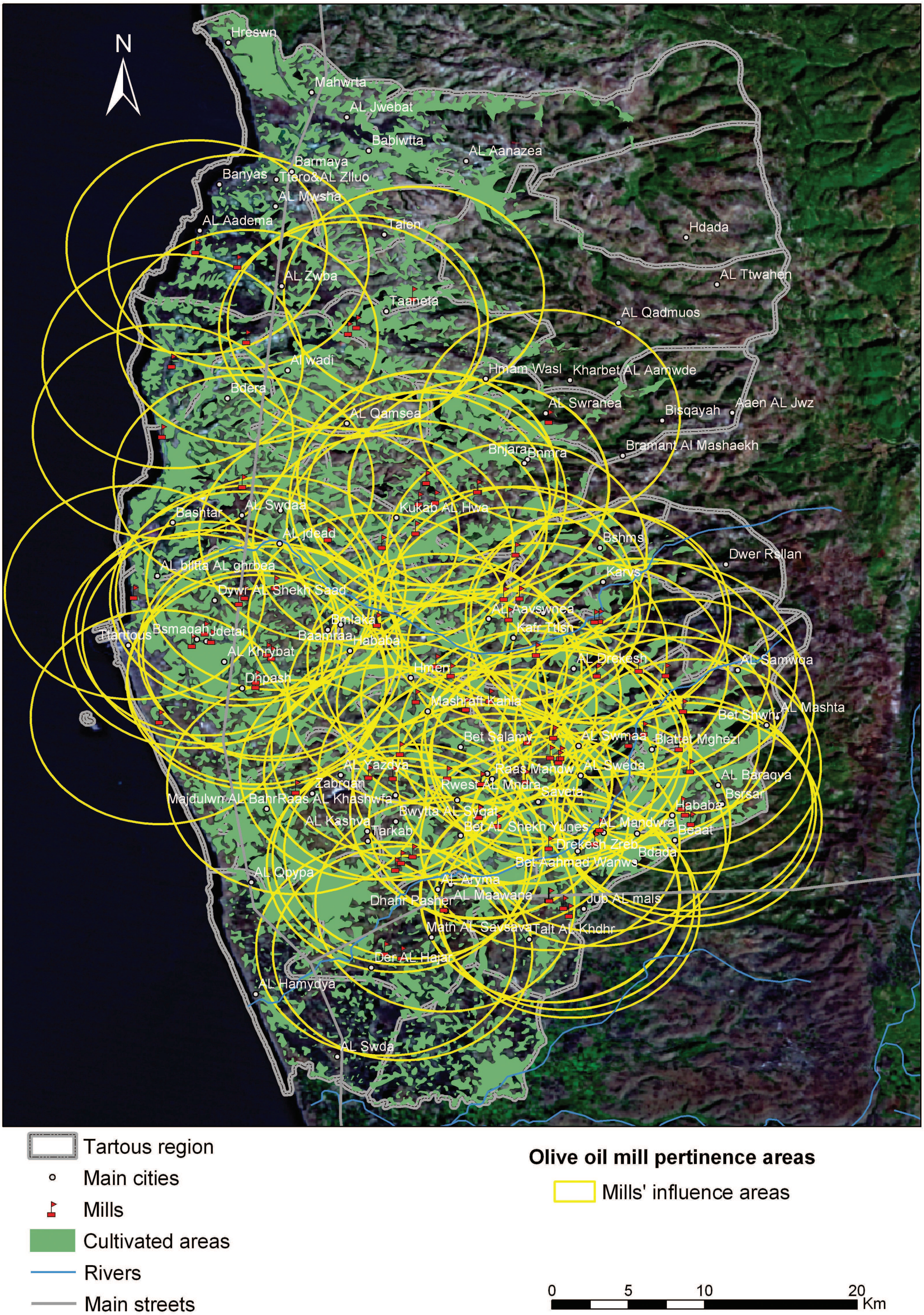
Tartous geological risk map

Tartous river buffer



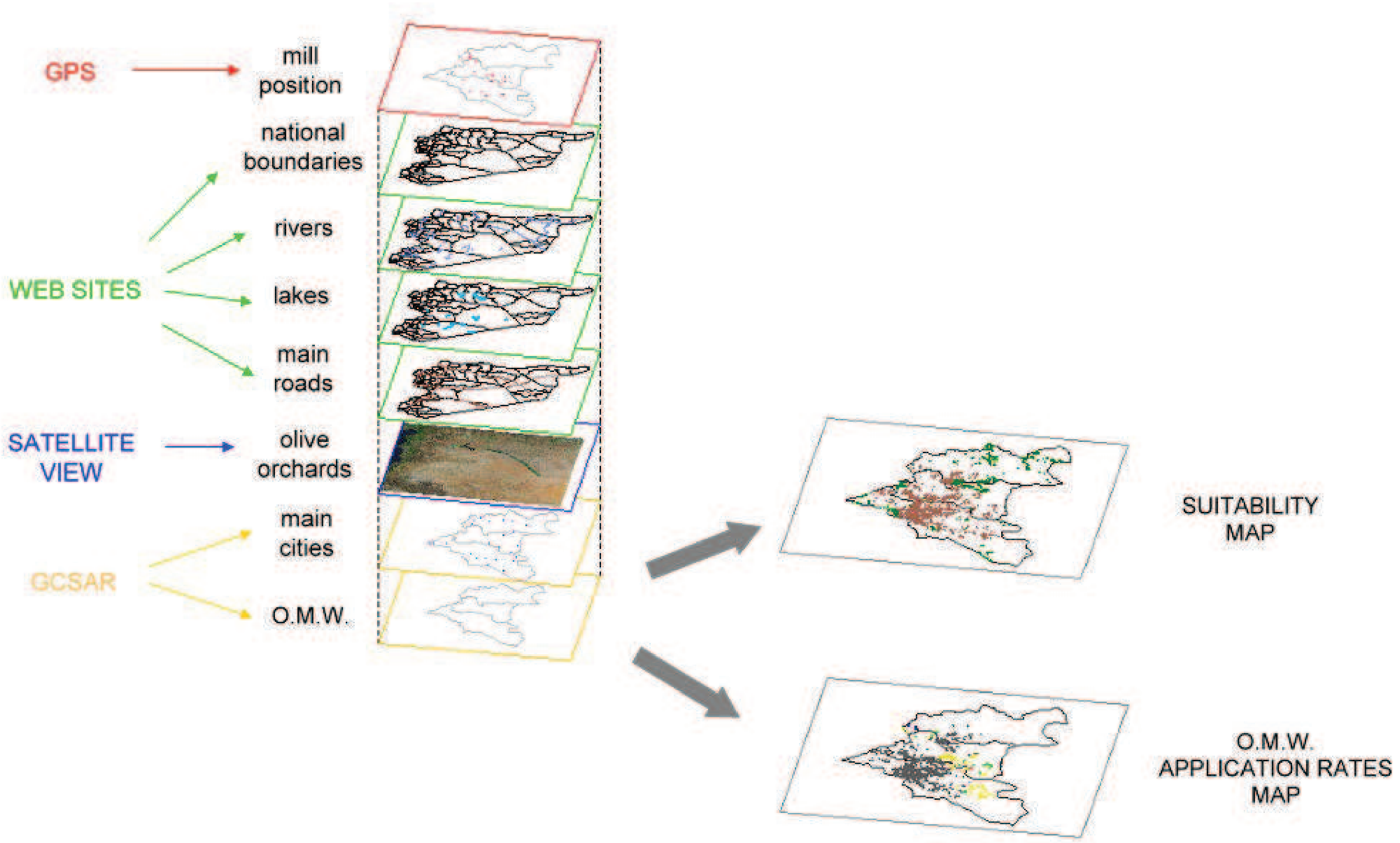
Tartous city buffer

Tartous slope map

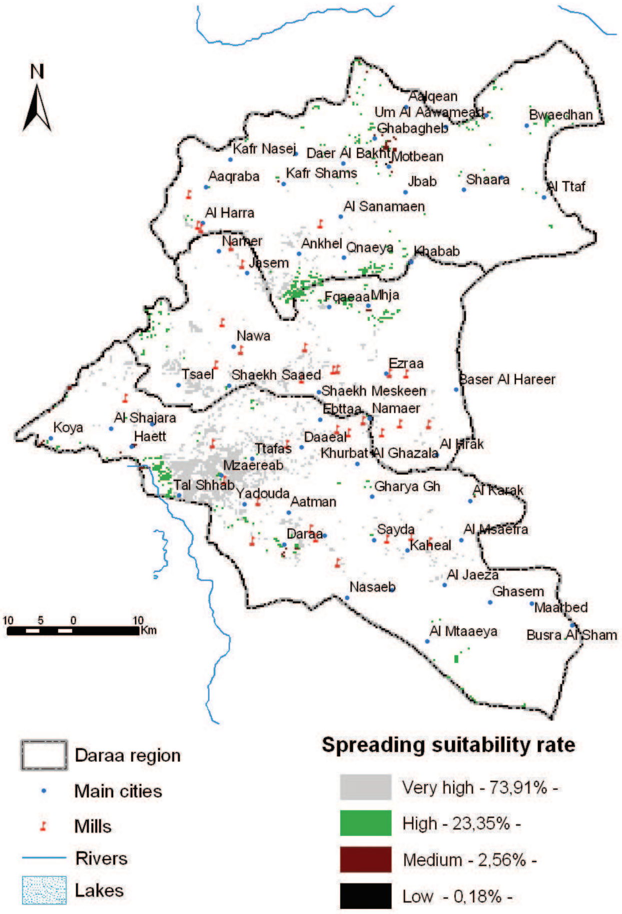


Tartous mill influence areas

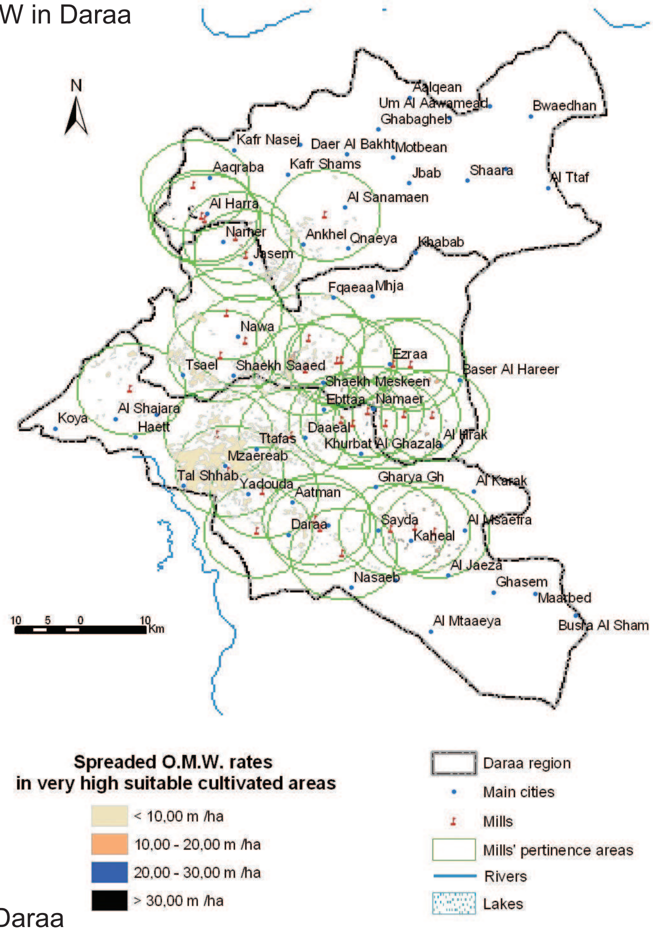
GIS based model of olive oil mill waste water spreading on soil in the Daraa region



Materials and methods Daraa



Spreading rates of OMW in Daraa



Qualified spreading sites Daraa

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