IRENES
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ANALYSIS AND MAPPING OF TRADE-OFFS BETWEEN RENEWABLE ENERGY AND ECOSYSTEM SERVICES

FIVE CASES FROM THE IRENES INTERREG PROJECT

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PROJECT COORDINATORS: Francesco Musco (Università IUAV di Venezia), Piercarlo Romagnoni (Università IUAV di Venezia), Matelda Reho (Università IUAV di Venezia).

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AUTHORS: Linda Zardo (Università IUAV di Venezia), Emanuele Giovannetti (Anglia Ruskin University), Francesco Musco (Università IUAV di Venezia), Piercarlo Romagnoni (Università IUAV di Venezia)

CONTRIBUTIONS: Francesco Musco, Piercarlo Romagnoni, Massimiliano Granceri Bradaschia, Elena Gissi, Giulio Segatto, Marta Eva Krakowiak, Ivan Boesso, Maria Sole D'Orazio, Francesca Maccatrozzo, Paul Bourgeois, Andrew Lovett, Gilla Sunnenberg, Trudie Dockerty, Julia Wiehe, Ole Badelt, Sylvia Herrmann, Christina Von Haaren Friederike Stelter, Eike Müller, Miguel Villoslada Pecina, Indrek Laas, Mihai Christian Adamescu, Tudor Racoviceanu, Elena Preda, Magda Bucur, George Guran, Mirela Cosovan

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7. ITALY, VENETO REGION

BY LINDA ZARDO, MASSIMILIANO GRANCERI BRADASCHIA, FRANCESCO MUSCO, PIERCARLO ROMAGNONI, ELENA GISSI, GIULIO SEGATTO, MARTA EVA KRAKOWIAK, IVAN BOESSO, MARIA SOLE D'ORAZIO AND FRANCESCA MACCATROZZO

First, a table (Table 2) provides a synoptic view of the main elements of the Italian case study discussed in this section. The table addresses four main fields (listed in the headings) discussing: the Policy instrument, the State of the art on mapping/assessment of ES, the RES development and the Socio-economic-environmental context.

POLICY INSTRUMENT	STATE OF THE ART ON MAPPING/ ASSESSMENT OF ES	RES DEVELOPMENT	SOCIO-ECONOMIC-ENVIRONMENTAL CONTEXT
The policy instrument considered is the POR-FESR. The analysis (SWOT, the SOTA and the ongoing work within IRENES), focused on the PI for 2014-2020 and other instruments are indirectly targeted. However, the main objective of the work is to make use of the analysis and work undertaken under IRENES to provide useful inputs for the POR-FESR 2020-2027.	In Italy the MAES process has been implemented at national level from several initiatives from the Ministry of the Environment and from ISPRA. The analysis of the state of the ecosystems and of ES is focused on understanding the relationship between ES and land consumption; the study was implemented at national scale and at regional scale. In Veneto Region, the Regional Environmental Agency has supported the analysis of MAES for the part of land consumption and soil ES in the provinces of Vicenza and Rovigo. The results of the analysis were included in the map of soils of the two provinces recently published. Soil ES were mapped and assessed through a system of indicators representing the capacity of different soils to provide ES. A series of research activities and projects on ES have considered the Region of Veneto of parts of it as case study areas.	The Veneto Region met the burden-sharing targets before 2020, however, given the new panorama and need to abate emissions and produce (clean) energy, targets changed and further efforts are needed. The Veneto Region in among the regions consuming the highest amount of energy in Italy (third, after Lombardia and Emilia Romagna), but presents a raking in terms of energy production from renewable resources which is lower than other italian Regions consuming less energy (PER-FER 2017). At present, RES production is led by hydroelectric, followed by energy produced from solar source and biomass. However, at present, the hydroelectric contribution cannot grow further. Hence, to meet the targets derived from burden sharing, the region bets on solar and biomass. For thermal purposes, the Region in its Regional Plan for Energy (2020), bets mainly on biomass (expected to provide RES for 49% on the total target needed)- For electric purposes, the Region bets mainly on biogas and biomass (39% and 21% respectively), while solar is considered only for the 12% (PERFER 2017).	Veneto is one of the richest regions in Italy, with an average monthly household ex penditure between 2500 and 3000 euro. Agricultural and zootechnical activities are still important, and are highly mechanised. There are numerous DOC and DOP products. Industry is mainly present in the western provinces and on the Adriatic coast; small companies specialise in the food, textile, footwear and furniture sectors. The tourism sector is also key, thanks to the presence of valuable landscapes (the Venice lagoon, the Dolomites, etc.) and architectural heritage (e.g. UNESCO sites). The territory is characterised by small to medium-sized urban centres and a highly built-up countryside. Pollution is a key issue.

Secondly, the Italian team identified and defined the **methods** for their analysis, in order to meet the policy demand and respond to the issues presented in table 1 (section 2 of this work). Based on the above-described premises, the scope of the ES trade-off analysis was defined for the Region. In particular, the goal is to assess and map suitability of areas for agricultural biomass production (from leftovers), and for solar farms, respectively. Then, the idea is to compare them.

The Research question shaping the analysis is "**How much area is considered suitable for agricultural biomass production and, similarly, for solar farms based on trade-offs with other ESs?**"

Figure IT 1, below, provides the key trade-offs, separately for agricultural biomass production and solar farms. Following Hastik et al. (2015) the trade-offs were identified for each of the two types of RES, and ranked from 0 to 2, (darker shading indicates greater conflict). In particular, trade-offs identification between RES and ES, include 5 ES (provision of agricultural products, water provisioning and filtering, climate regultation, habitat for flora and fauna, and cultural services). Findings suggest that this approach can help identify greater scope for use of renewables than a simple binary (yes/no) classification of suitable areas. In more detail, we can see that the more serious (light grey in this case) trade-offs with agricultural biomass production, are with: i) **"Water provisioning and filtering"** ES, due to pesticides releases and water eutrophication, linked to intensified agriculture; ii) **"Climate regulation"** ES, due to reduced soil carbon proportion, linked to intensified agriculture; iii) **"Habitat for flora and fauna"** ES, due to habitat loss in case of intensified agriculture, and to the effects of agro-biodiversity; iv) Less serious trade-offs were identified with **"Cultural services"** ES, due to landscape composition impacts possible.No trade-off was identified between Agricultural Biomass production and the: "Provision of agricultural products" ES, since the type biomass considered for this work is obtained by leftovers, not from dedicated crops, hence no conflict will occur with food provisioning.

Concerning solar farms, the Veneto study, identified as the more serious (dark grey in this case) trade-offs are with the: **i)"Provision of agricultural products"** ES, given the coemption for space between solar farms and crops; ii) Less serous trade-offs (light grey) were identified between solar farms and **"habitat for flora and fauna"** ES, where only minor impact is expected, when avoidance of important habitat is required; and with **"Cultural services"** ES, linked to the visual impacts on landscape composition; iii) the least affected trade-offs were identified between solar farms and: **"Water provisioning and filtering"** ES, due to their null or minor impact in the water cycles, and on **"Climate regulation"** ES, only emerging in case of inappropriate land-use change.

	PROVISION OF AGRICULTURAL PRODUCTS	WATER PROVISION AND FILTERING	CLIMATE REGULATION	HABITAT FOR FLORA AND FAUNA	CULTURAL SERVICES
AGRICULTURAL BIOMASS	No competition for agricultural products, as biomass will derive from left overs	Pesticide releases and eutrophication with intesified agriculture	Reduced level of soil carbon with intensified agricul-ture	Habit loss with intensified agricul-ture effects on agro-biodiversity	Possibile impacts of landscape composition and with emissions from biogas facilities
SOLAR FARMS	Competitiion with agricultural products possibile	No or only minor impacts on the water cycle	impacts in the case of inappropriate land use change	Only minor impacts expected avoidance of important habitat required	Visual Impacts on landscape composition

The second step of the analysis for the Veneto Region aimed at defining the level of potential of ESs provisioning of different landcover categories. To assign a score of ES production to different types of landcover, another matrix, which builds on the work of Burkhard et al. (2012), was adopted. Burkhard et al. (2012) assigned a score of ES potential provisioning to each landcover type, based on Corine landcover. The scores lied on a range between 0 to 5, where:

- 0 correspond to no ESs provided, and
- 5 correspond to the highest ES supply potential for that specifying landcover type

Only the 5 ESs selected in the first step and presented in figure above were selected from the original matrix of Burkhard et al. (2012). In order to harmonize the two different ranges of scoring for facilitating the coming steps of the methods, the Burkhard et al.'s was normalized (see table below) in the range 0 to 4, where:

- 0 corresponds to the non-provisioning of ES, and
- 4 correspond to a high provisioning of the ES).

Third step combined the identification and quantification of trade-offs (obtained from step 1 adopting the findings from Hastik et al. 2015) with ESs supply scores based on landcover (obtained from step 2 adopting the findings from Burkhard et al. 2012). Specific objective this step was to assign a level of RES production non-suitability. For getting these non-suitability scores, for each ES, the trade-offs score with to either solar or biomass production was multiplied with the potential of land-cover type to produce that specific ES. Making a long story short, by multiplying the trade-off's score by the ES supply's score, we obtain a level of negative impact of specific RES provisioning on a specific ES provisioning, which determines a non-suitability. All results were normalized in a scale from 0 to 4, where 0 corresponds to no impact of the RES on other ES provisioning, (hence suitability of the area for RES production), and 4 corresponds to the highest negative impact of the RES on other ES provisioning, (hence non-suitability of the area for RES production) (see table below). In particular, values under the column "average" represent average values for non-suitability, calculating first the average values given from the 5 ES values for each Res from non-normalized values, and then normalizing results to get values from 0 to 4.

These tables were used to produce through GIS maps that assign the level of non-suitability (or "risk") to each land cover type, for solar farms and agricultural biomass respectively. Disaggregated maps, one per ES for each RES, presenting non-suitability of areas (where the score 0 indicates suitable areas for RES production, and score 4 indicates the highest level of non-suitability for RES production). In this way, a set of 5 maps (one per ES) was obtained for each of the two RES. Then, two maps (one per RES) were also produced considering the average scores for level of non-suitability, and one final map overlaying average non-suitability map for agricultural biomass, with average non-suitability map for solar farms. To produce credible results, the layer of "protected areas" was added, in order to also exclude them from the list of "suitable areas for RES production" emerging from the GIS ES trade-offs analysis.

LEVEL OF POTENTIAL ES PROVISIONING, BASED ON CORINE LAND COVER (LEVEL 2)

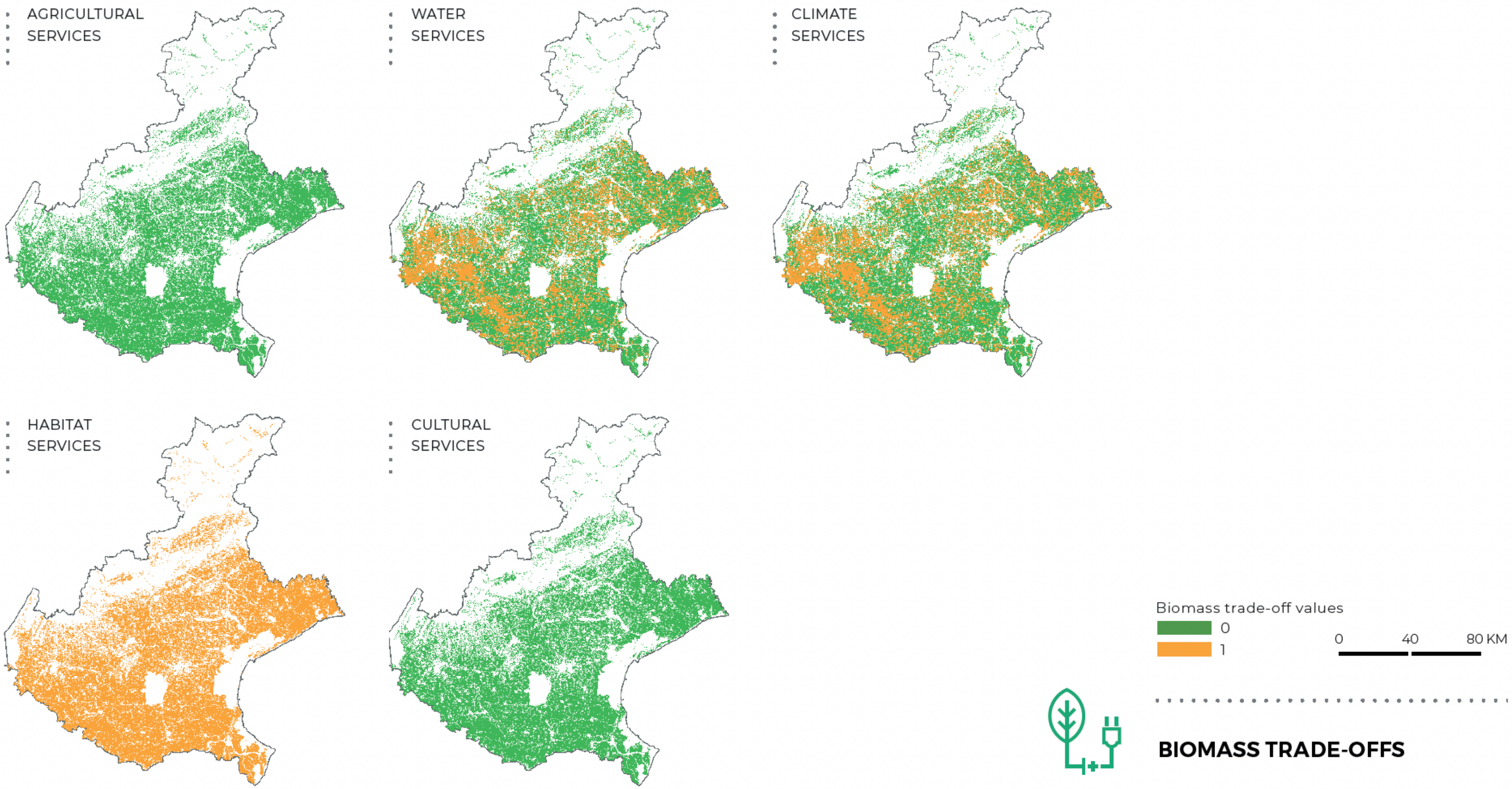
CLC_liv III	DESCRIPTION	PROVISION OF AGRICULTURAL PRODUCTS (CROPS)	WATER PROVISION AND FILTERING	CLIMATE REGULATION (GLOBAL)	HABITAT FOR FLORA E FAUNA	CULTURAL SERVICES (RECREATIONAL AND AESTHETIC VALUE)
211	Non-irrigated arable land	0	0	0	1	0
212	Permanently irrigated land	0	0	0	1	0
213	Rice fields	0	0	0	1	0
221	Vineyards	0	0	0	1	0
222	Fruit trees and berry plantations	0	1	1	1	0
223	Olive groves	0	0	0	1	0
224	Other permanent crops	0	1	1	1	0
231	Pastures	0	0	0	1	0
232	Other pastures	0	0	0	1	0
241	Annual crops associated with permanent crops	0	0	0	1	0
242	Complex cultivation patterns	0	0	0	1	0

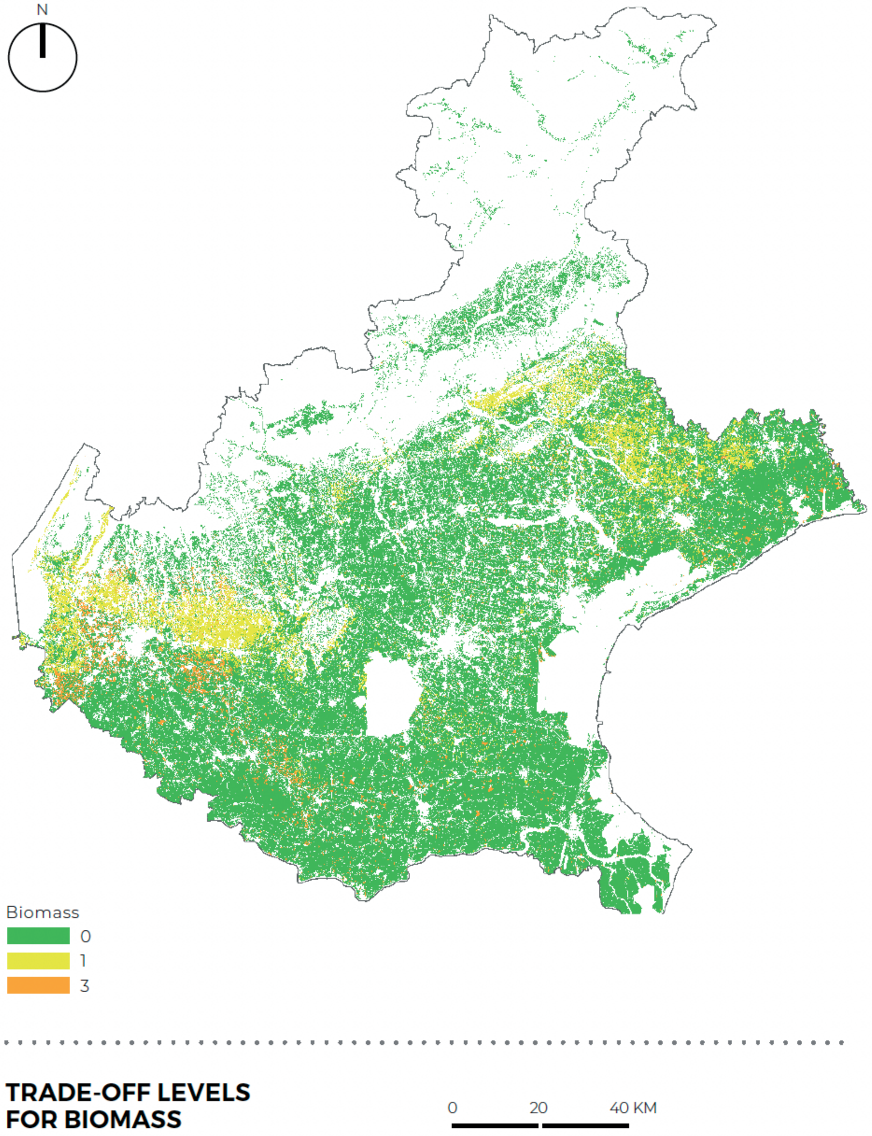
NON-SUITABILITY SCORES FOR (AGRICULTURAL) BIOMASS

CLC_liv III	DESCRIPTION	PROVISION OF AGRICULTURAL PRODUCTS (CROPS)	WATER PROVISION AND FILTERING	CLIMATE REGULATION	HABITAT FOR FLORA E FAUNA	CULTURAL SERVICES	AVERAGE
211	Non-irrigated arable land	4	0	0	1	0	1
212	Permanently irrigated land	4	0	0	1	0	1
213	Rice fields	4	0	0	1	0	1
221	Vineyards	4	0	0	1	1	2
222	Fruit trees and berry plantations	4	0	0	1	1	4
223	Olive groves	4	0	0	1	1	2
224	Other permanent crops	4	0	0	1	1	4
231	Pastures	0	0	0	1	1	0
232	Other pastures	0	0	0	1	1	0
241	Annual crops associated with permanent crops	4	0	0	1	0	1
242	Complex cultivation patterns	4	0	0	1	0	1

By applying the methods above described, a set of maps and figures to provide technical support to decision-makers were obtained.

The first set of 5 maps presents results disaggregated by ES, where it is visible that the highest level of non-suitability (which is still low and correspond to level 1) is given by trade-offs between the provisioning of habitat services and the provisioning of agricultural biomass. Intermediate situations can be seen for water services and climate service, while no trade-offs (hence, 0 level of non-suitability) can be seen for agricultural services and cultural services.





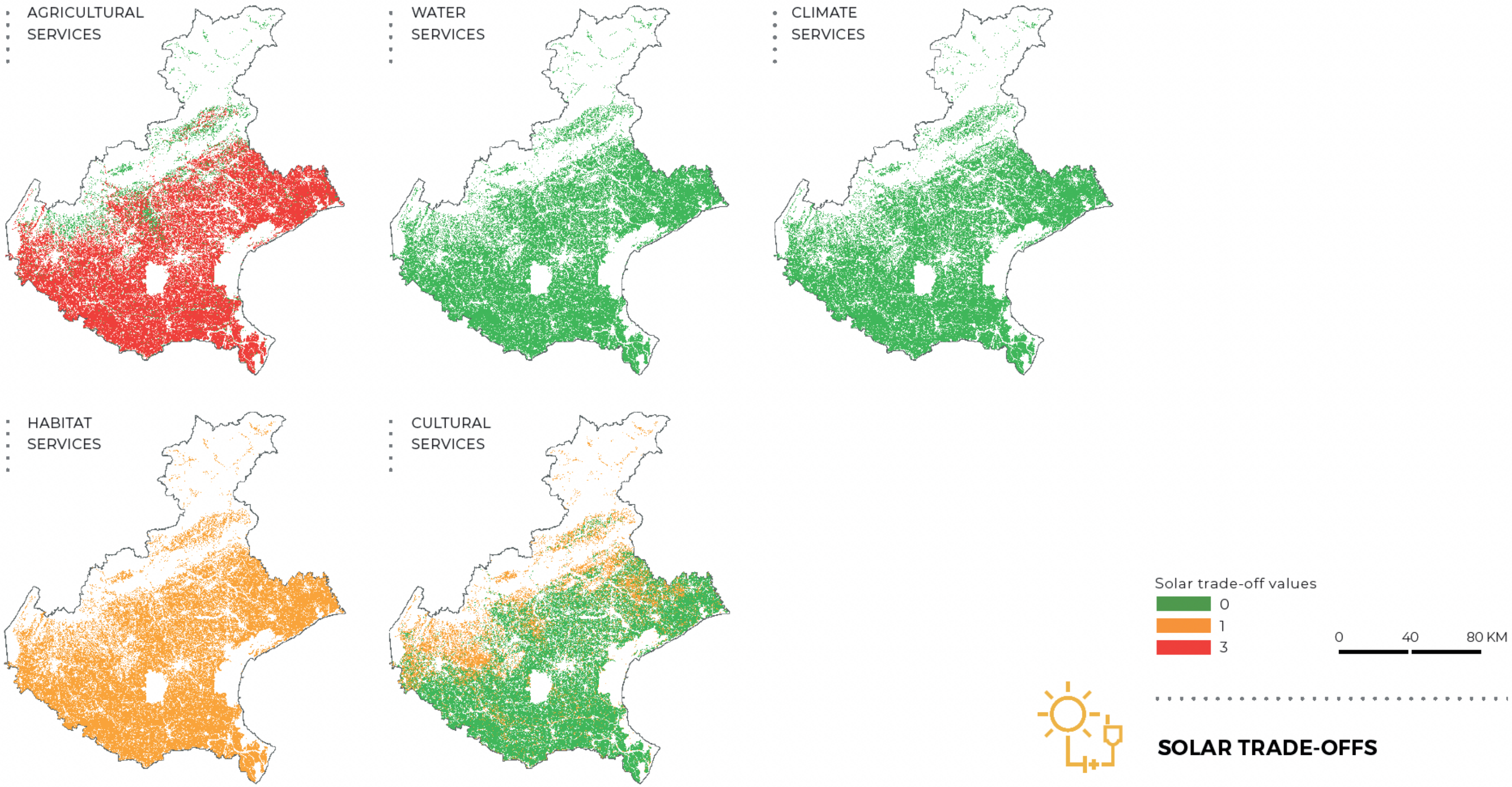
The map below presents average values combining all 5 ES. Considering average values, 86% of the total agricultural land (corine level 2), excluding protected areas, is suitable (level 0 of non-suitability) for agricultural biomass production from left-overs. Which means a total surface of 763298,15 hectares. Then, 10% of the surface present level 1 of non-suitability, which corresponds to 86638,27 hectares, no land presents level 2, approx. 4% presents level 2, which corresponds to 33292,69 hectares, and no land presents level 4.

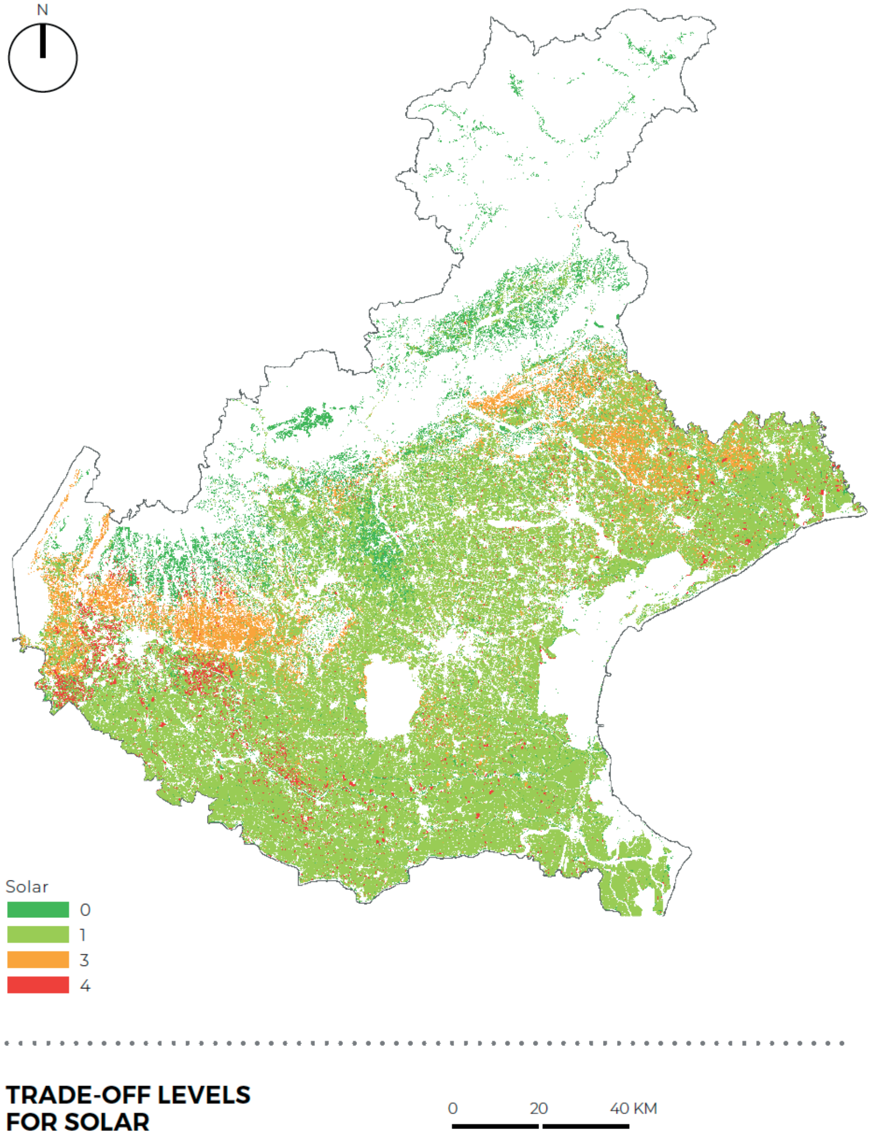
TRADE-OFF LEVELS FOR BIOMASS

NON-SUITABILITY FOR BIOMASS

The set of five maps below presents results disaggregated by ES under the trade-off analysis regarding solar farms. It is visible that the highest level of non-suitability (level 4) is given by trade-offs between agricultural production and the provisioning of energy through solar farms. Intermediate situations can be seen for habitat services and cultural services, while no trade-offs (hence, 0 level of non-suitability) can be seen for water services and climate services.

The map below presents average values combining non-suitability deriving from ES trade-off analysis of all 5 ES for solar farms production. Considering average values, 73% of the total agricultural land



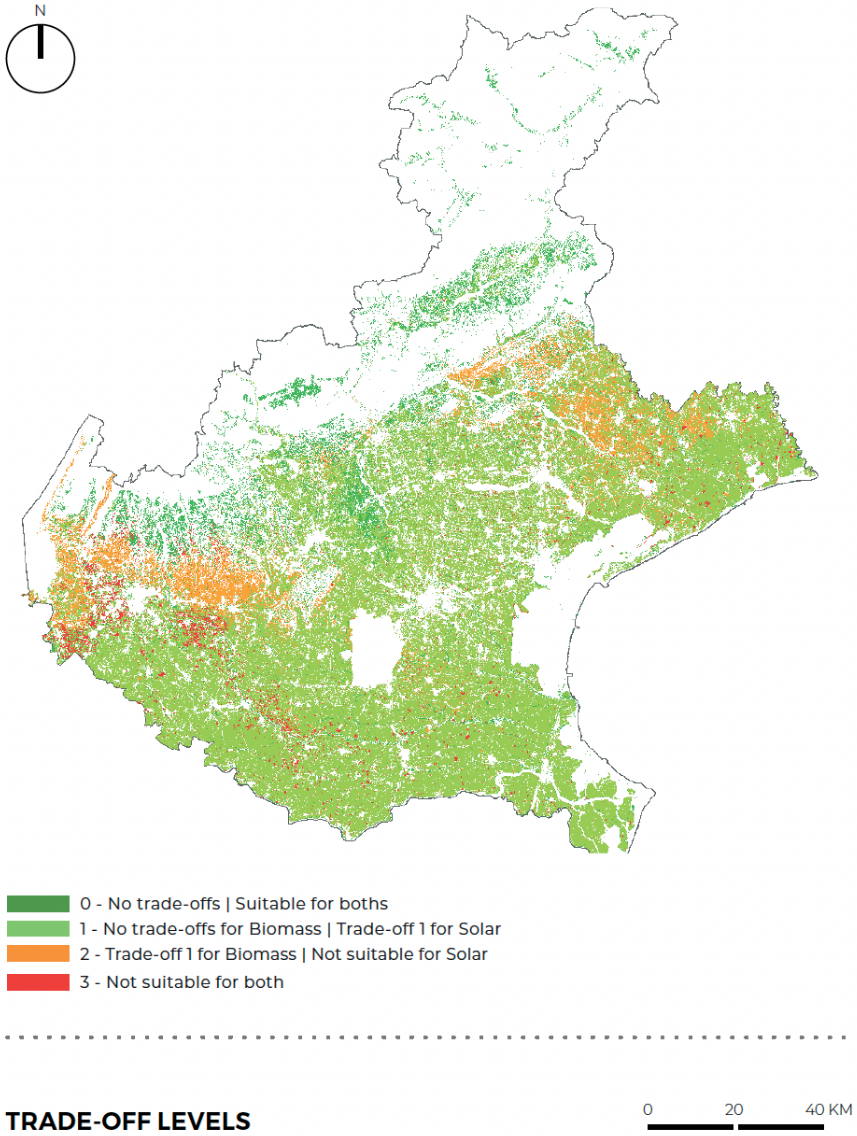


(corine level 2), excluding protected areas, presents a level 1 of non-suitability. Which means a total surface of 653765,13 hectares. Then, 13% of the surface present level 0 of non-suitability, which corresponds to 109533,02 hectares, and 10% presents level 2 of non-suitability , which corresponds to 86638,27 hectares. No surface presents a level 3, while 4% present a level 4 of non-suitability (33292,69 hectares). Still, it is key to remember that even where average values present level 0 of non-suitability, it does not mean the absolute absence of trade-offs (for example, trade-off with agricultural production is always present).

TRADE-OFF LEVELS FOR SOLAR

NON-SUITABILITY FOR SOLAR

The graph below compares results presented by maps produced from agricultural biomass, and by maps produced for solar farms. On the y axis, values indicate the percentage of the total agricultural land (corine level 2, excluding protected areas) falling under level 0, level 1, level 2, level 3 and level 4 of non-suitabilility. Figure 6 shows that the majority of land present 0 non-suitability level (hence, it is suitable) for agricultural production from left-overs. Regarding solar farms, the majority of land present non-suitability level 1, due to important trade-offs with the agricultural production and cultural services.



NON-SUITABILITY LEVELS FOR BIOMASS AND SOLAR COMPARED

TRADE-OFF LEVELS

The last map here below combines results from trade-off analysis for agricultural biomass and solar farms (average values), and assigns 0 level of non-suitability to land where both agricultural biomass and solar farms presents no-trade-offs (level 0 of non-suitability). Such type of areas corresponds to the 13% (113227,24 hectares) of the total. Level 1 of overall non-suitability is assigned in the map where agricultural biomass presents 0 level of non-suitability and solar farms presents level 1 of non-suitability. Such type of areas corresponds to 74% (650070,91 hectares).

There are no cases of land with level 1 of non-suitability for agricultural biomass and 0 level of non-suitability for solar farms. Level 2 in the map is assigned to land with level 1 of non-suitability for agricultural biomass and non-suitability (from level 2 above) for solar farms. Which corresponds to 10% (86638,27 hectares) of total land. Level 3 in the map is assigned to land which is non-suitable (non-suitability levels from 2 above) for both types of RES, which corresponds to 4% (33292,69 hectares) of total land.

Then preliminary conclusions from the Veneto's team suggest that 13% of total land is suitable for both types of RES, 74% of land suitable for agricultural biomass and solar farms can be considered if measures to minimize impacts on agricultural production and cultural services are taken. The 10% of land is suitable for agricultural biomass if measures to minimize impacts on habitat, water and climate services are taken, while it is not suitable for solar farms. The remaining 4 % of land is not suitable for either of the two RES production.

More in detail, it is possible to state that:

- Trade-offs analysis considers agricultural biomass from leftovers to be much less impactful than ground-based solar farm.
- In the region, production of energy from agricultural biomass has high potential to negatively impact on habitat services, followed by water-related and clmate-related services.
- In the region, production of energy from solar farms has high potential to negatively impact in agricultural production, followed by habitat services and then cultural services.
- Overall, the trade-offs analysis seems to detect a low risk of trade-offs. This is due to the aggregation of the results for the individual services into an average value. The disaggregated values help a more critical reading of results.

The key implications suggest that:

- Where non-suitability level scores from 2 above, we discourage the RES production, unless careful EIA and mitigation measures are put in place to ensure that ES provisioning is protected and ensured
- Even when average non-suitability level scores 0, there is need to double check the provisioning of ES that presents higher score of trade-offs with that specific RES
- Present indications from the Regional Energy Plan (PER, 2017) set very similar constrains to produce energy from biomass and for solar farms, as if the negative impacts they trigger are almost the same. Based on the present analysis, it would be interesting to further analyze the present policy constrains for energy production from RES, to better understand whether and how they can be updated and adjusted.
- The interlinkage provided by the presented methodology between CORINeland-cover types, and non-suitability for Res production, can , support land use-related policies. For example, the tables above show that land cover types 2.2. tend to be more impacted by both agricultural biomass provisioning and solar farms installation.