Proactive Producer and Processor Networks for

Troodos Mountains Agriculture

3PRO-TROODOS

Prot. No: INTEGRATED/0609/061

Deliverable type	*Report*
Work package number and name	*WP4: Assessing water resources and irrigation demand under current and future climate conditions*
Date	*April 2023*
Responsible Beneficiary	*HO: The Cyprus Institute*
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Classification of Dissemination	*Public*
Short description	*D4.2: Report with current (1980-2010) and future irrigation water requirements for Troodos mountain agriculture, for 2030-2060, under RCP8.5*

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2016-2020 RESTART RESEARCH

Version	Date	Changes	Partner
0.1	19/05/2023	-	HO

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Contents

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Introduction

The climate conditions of the Troodos Mountains provide a suitable growing environment for deciduous fruit such as apples, cherries and peaches, nut trees and vines. Vines are traditionally grown under rainfed conditions, but due to the professionalization and expansion of wineries, including the cultivation of non-indigenous varieties, many wine terraces are now provided with irrigation. While increasing temperatures are affecting the growing conditions in the plains, we also see a potential for more fresh vegetable cultivation in the mountains. Irrigation water in Troodos is pumped from groundwater or diverted from streams and stored in small reservoirs, ponds and dams. The Troodos ophiolite is part of an ancient oceanic crust that has gone through various tectonic and geologic formation processes. It forms a complex, compartmentalized and fractured aquifer system (Christofi et al., 2020). The changing climate is causing uncertainties for the water resources supply and demand in Troodos. Therefore, the objective of this study is to compute the agricultural water demand of 70 agricultural mountain villages on the Troodos ophiolite formation, for the 1980-2010 reference period and for the 2030-2060 future, as simulated by three Regional Climate Model (RCM) under RCP8.5.

Methods

Climate datasets

The selection, bias correction and downscaling of RCMs was described in D4.1. Here we summarize, improve and expand this work. Considering the relatively small difference between the spread of climate simulations of different RCM (Regional Climate Models) and the spread of different RCPs (representative concentration pathways) for the 2030-2060 future period, we selected one RCP and three RCMs for the analysis. We selected the RCP8.5 "business-as-usual" scenario, in light of current global development pathways. We used the simulations from the European (EURO) initiative of the Coordinated Regional Climate Downscaling Experiment (CORDEX) (Jacob et al., 2020) with a horizontal spatial resolution of 0.11° (~12 km) and a daily temporal resolution. We evaluated a set of 20 EURO-CORDEX climate simulations for the selection of the three model simulations that fulfilled the following criteria: (i) good performance over Cyprus for the 1980-2010 period; and (ii) coverage of a representative range of projected changes in average annual precipitation of the EURO-CORDEX simulations (see D4.1). The three RCMs that were selected for the modeling of the 2030-2060 future are: (i) KNMI-RACMO22E, driven by the MPI-M-MPI-ESM-LR global model, here referred to as RACMO; (ii) DMI-HIRHAM5, referred to as HIRHAM; and (iii) SMHI-RCA4, referred to as RCA. The last two RCMs were driven by the ICHEC-EC-EARTH global model. Out of 20 evaluated EURO-CORDEX simulations, RACMO was the best performing model over Cyprus, with less than 1 mm bias in average annual precipitation for the 1980-2010 reference period (see D4.1). The other two models were selected to cover the range of projected precipitation changes. The bias of these two RCM simulations was less than 100 mm. The decrease in average annual precipitation over Cyprus for 2030-2060, relative to 1980-2010, was less than 1% for RACMO, 8% for RCA and 15% for HIRHAM.

Because the copula bias correction method (D4.1) resulted in large deviations in the climate signal and did not simulate daily extremes well, we here bias-corrected and downscaled the 12-km data with the quantile delta mapping (QDM) algorithm (Cannon et al., 2015). The QDM method preserves the relative (precipitation) or absolute (temperature) changes in quantiles simulated by the RCM. The QDM has been found to reduce the inflation of relative changes in future precipitation extremes, which affects other quantile mapping methods (Maraun 2013; Cannon et al., 2015; 2018). We used the R MBC Package of Cannon (2022) for the quantile delta mapping.

We used the 1 × 1 km gridded dataset for daily precipitation and daily minimum and maximum temperature (Camera et al., 2014), hereafter called CYOBS, as the reference dataset. This high-resolution dataset covers the 1980-2010 period and was derived from the statistical interpolation of a dense network of rain gauges and weather stations. This dataset covers only the area of the island that is currently under the jurisdiction of the Republic of Cyprus.

We used a univariate approach to bias correct the 12-km RCM data for each 1-km grid cell. We used 55 land-based RCM grid cells to cover the CYOBS area. All CYOBS cells were assigned to the nearest RCM cell. As opposed to multi-variate bias correction approaches, the univariate approach conserves the temporal sequences of the RCM. In this way, we maintain the temporal consistency between the modeled large-scale circulation and the corrected local rainfall pattern (Cannon et al., 2016). We considered days with less than 0.1 mm rain as dry days. Values below the 0.1 mm threshold (trace) are set to zero after bias correction, thereby reducing the RCM's biases in wet day frequency (Cannon et al., 2015).

To ensure that bias-corrected values of the daily minimum temperature (Tmin) do not exceed those of the daily maximum temperature (Tmax), we bias corrected the diurnal temperature range (DTR = Tmax – Tmin) and the Tmax. Thrasher et al. (2012) found that bias-correcting Tmax and and computing the bias-corrected Tmin (Tmax – DTR) resulted in smaller errors than computing Tmax from Tmin. We evaluated the QDM bias-correction for the 1-km grid cells for the 1980-2010 period, with a comprehensive set of indices, similar to Gutierez et al. (2019).

We computed gridded, daily reference evapotranspiration from the temperature data sets, using the Hargreaves equation (Allen et al., 1998). The Hargreaves equation has been found to give similar results as the FAO Penman-Monteith equation in semi-arid environments (Benli et al., 2010). The Hargreaves equation was also used to compute the reference evapotranspiration from the bias-corrected, downscaled future daily minimum and maximum temperature data sets.

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Irrigation water demand

Irrigation water demand for the 70 Troodos mountain villages, covering a 940-km^2 area, was computed with the Cyprus blue-green water model (Bruggeman et al., 2015). The model uses daily rainfall and reference evapotranspiration to compute blue and green water use, using the FAO56 dual crop coefficient approach (Allen et al., 1998). The model computes daily water balances and irrigation water demand for 30 hydrologic years for each crop plot. Annual water balance component (mm) are averaged for the 30-year period and written for each crop plot. In addition, the annual blue (irrigation) and green (rain) water use and yield reductions for rainfed crops are averaged over all crop plots of each crop type and written for each simulation year.

The location, area, and crop type of all crop plots of the Troodos mountain villages were taken from the 2020 data set from the Cyprus Agricultural Payment Organization (CAPO). These data are derived from farmers' applications for the Single Area Payment Scheme and are considered to cover around 95% of the agricultural area, according to CAPO officers. A number of crops of the 2020 census (Cystat). Soil texture and soil depth were taken from the high- resolution (25-m grid) soil map of Cyprus (Camera et al., 2017). These data are used to determine the available water storage capacity (field capacity minus wilting point) for each crop plot. The map has, however, a high uncertainty for the Troodos Mountains and does not identify the soils of anthropogenic terraces. Therefore, we considered that crop plots on areas without soil were agricultural terraces. For these terraces we assumed an available water capacity of 87 mm. The daily precipitation and reference evapotranspiration are taken from the 1-km gridded data. To improve the computational efficiency of the model, two new routines were made to identify the soil map grid cell and climate grid cell of each crop plot as input to the blue-green model, such that this has to be done only once for all climate simulations. There were 48 unique crops in the 2020 CAPO data set for the Troodos area. Crop coefficients were taken from Allen et al. (1998) and adjusted based on observations of crop characteristics, development and management in the Troodos area. There are a number of crops (e.g., cereals, olives, vines) that can be grown both under rainfed and under irrigated conditions. Here we used the irrigated area fractions of these crops as reported for the 2020 census (https://www.cystat.gov.cy/en/default). For these crops, all crop plots are simulated twice, once for irrigated and once for rainfed conditions, and the two areas are computed with the fractions. The crop coefficients and irrigated area fractions are presented in Annex 1.

Results

Climate datasets

The bias correction and downscaling results for daily precipitation and maximum temperature are presented in Figure 1 and 2. The QDM bias correction and downscaling evaluation criteria, are given in

Annex 2. We obtained excellent results for all indices. The future climate data for the HIRHAM RCM simulations are presented as example of the three RCMs in Figure 3 and 4.

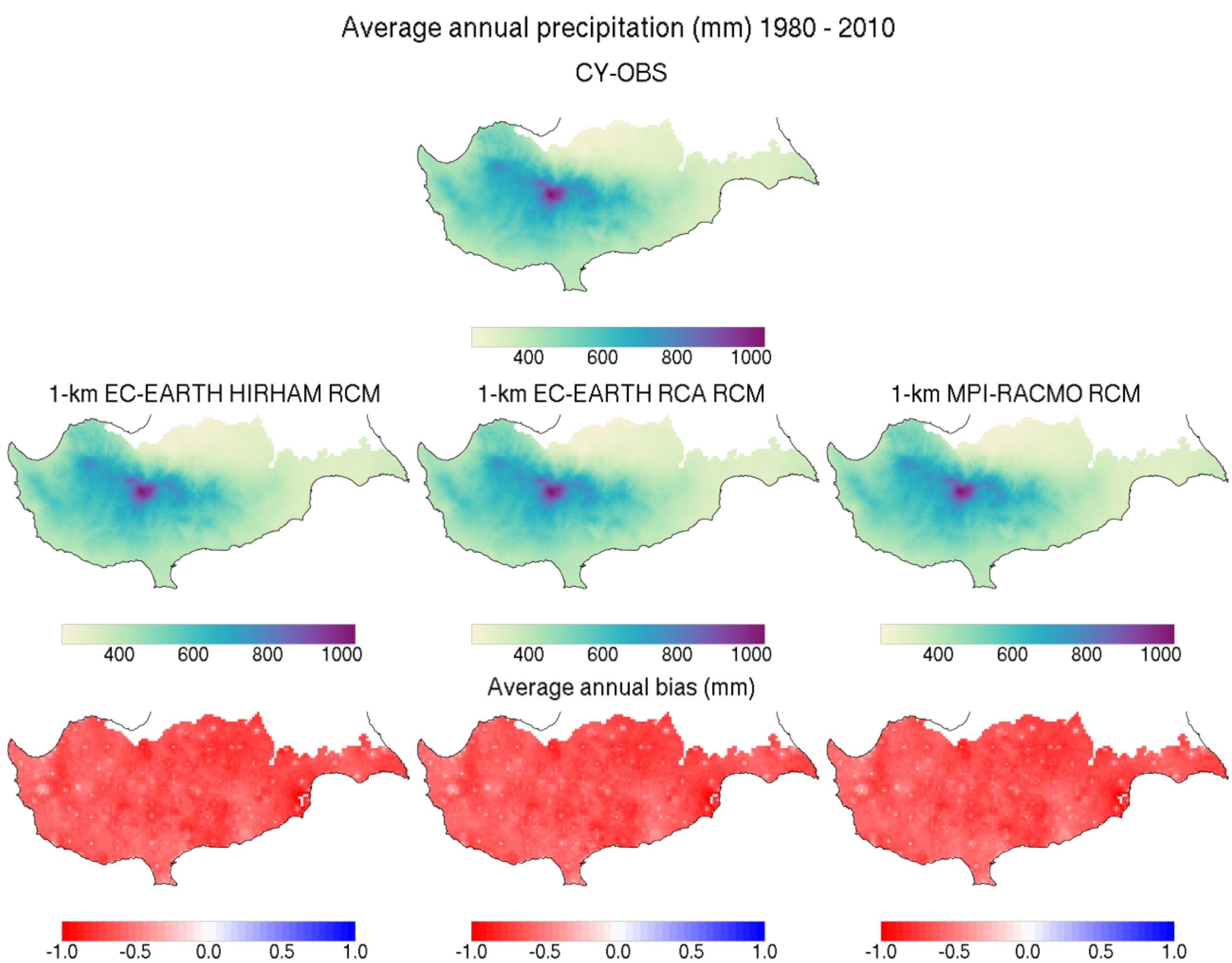

Figure 1. Average annual precipitation for the 1980-2010 reference period, computed from the 1-km gridded daily observations (CY-OBS) and from the three bias-corrected and downscaled Regional Climate Models (RCM) and the bias between CY-OBS and the three RCMs.

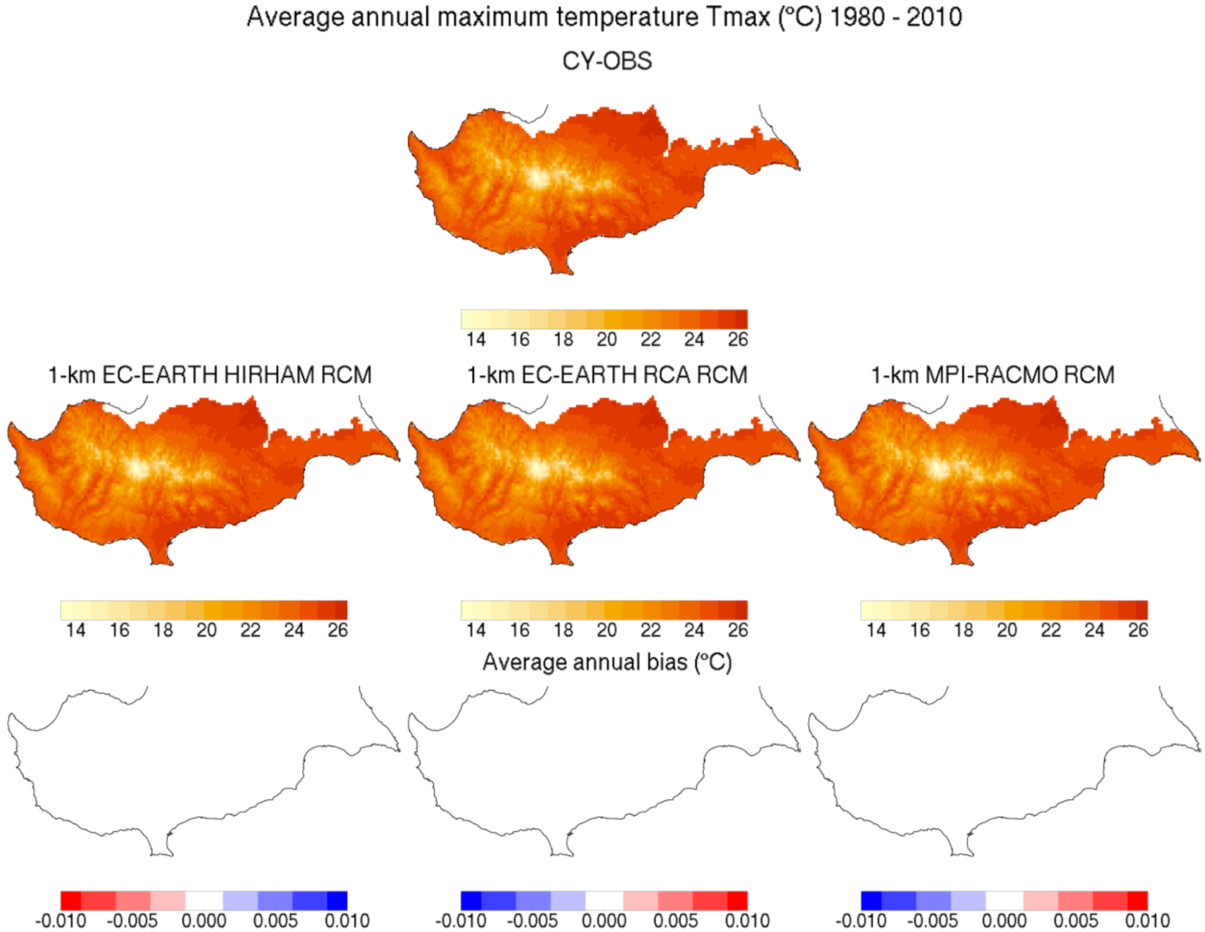

Figure 2. Average annual daily maximum temperature for the 1980-2010 reference period, computed from the 1-km gridded daily observations (CY-OBS) and from the three bias-corrected and downscaled Regional Climate Models (RCM) and the bias between CY-OBS and the three RCMs.

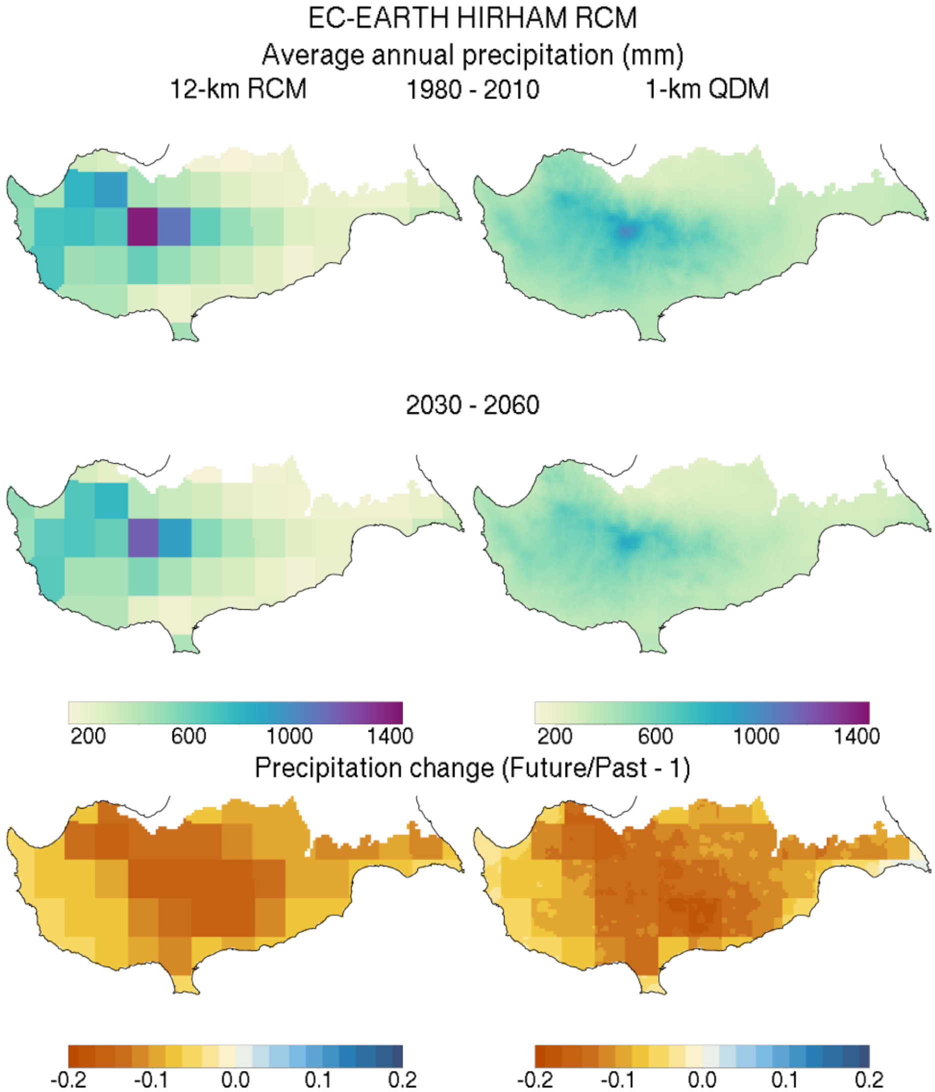

Figure 3. Average annual precipitation for the 1980-2010 reference period (top), the 2030-2060 future under RCP8.5 (middle) and the change between these two (bottom), for the 12-km resolution HIRHAM Regional Climate Models (left) and for the bias-corrected and downscaled 1-km gridded data (right).

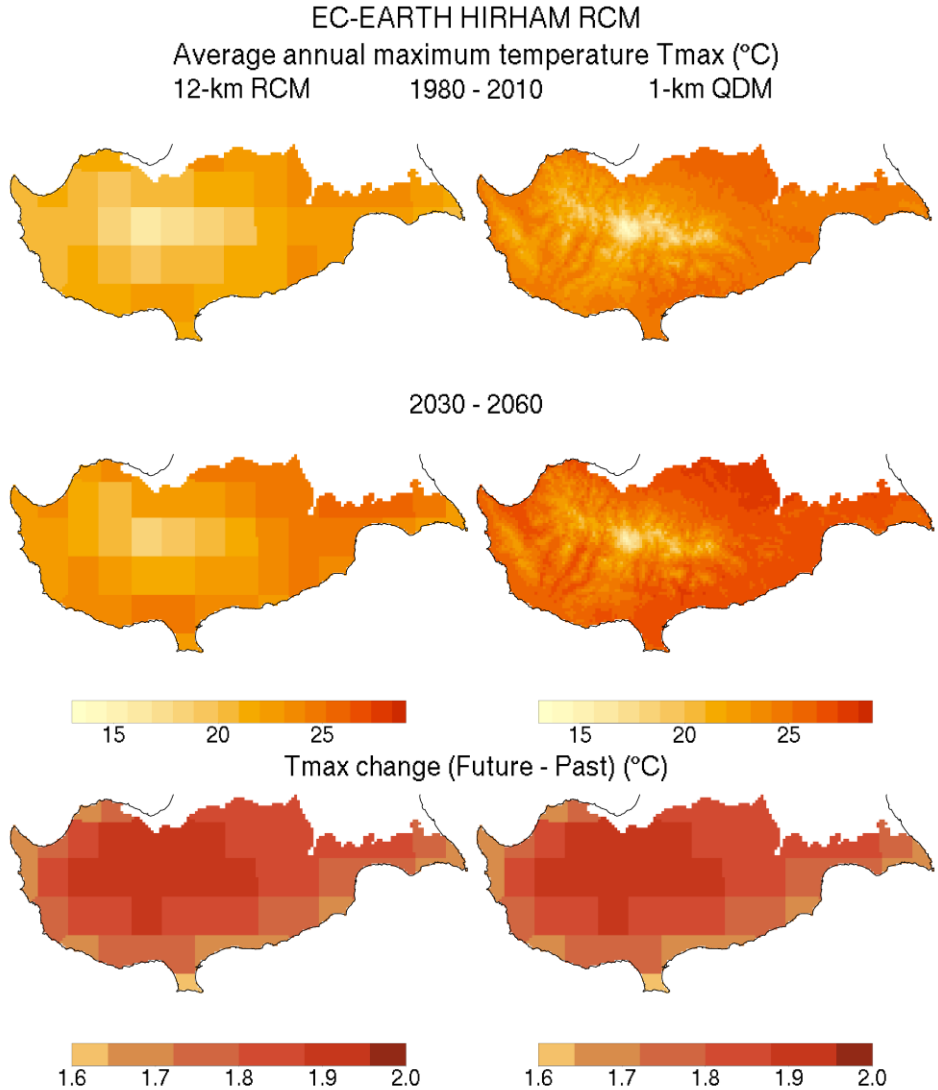

Figure 4. Average annual daily maximum temperature for the 1980-2010 reference period (top), the 2030-2060 future under RCP8.5 (middle) and the change between these two (bottom), for the 12-km resolution HIRHAM Regional Climate Models (left) and for the bias-corrected and downscaled 1-km gridded data (right).

Irrigation water demand

The 70 Troodos mountain villages hosted 20095 individual crop plots. Of these plots, 52 plots are purely rainfed, i.e., traditional grapes (6 ha), green manure (2 ha) and pastures (1 ha). Part of the wine grapes, cereals, vetches, cactus, carob, almonds and olive plots are rainfed, part are irrigated. The rainfed area of these crops was estimated as 1154 ha and the irrigated area as 331 ha. This resulted in a total rainfed area of 1163 ha and a total irrigated area of 1660 ha for the Troodos mountain villages.

The modeling results for the irrigated plots are summarized in Table 1. Future rainfall is becoming less and irrigation demand is going up over all crop areas for all three RCM simulations. The irrigation water demand of the different crops is affected by their location in the higher or lower rainfall areas in the mountains. The highest irrigation water users were alfalfa and walnuts. The total irrigation demand was 12.7 Mm^3 for the 1980-2010 reference period (CYOBS) and increased to 13.5 Mm^3 (RCA), 14.0 Mm^3 (HIRHAM) and 15.0 Mm^3 (RACMO) for the 2030-2060 future. Thus, the average increase in irrigation water demand (1.4 Mm^3) was smaller than the range of water demand modeled with the climate data from the three RCMs (1.5 Mm^3), which is indicative of the uncertainty of these climate projections.

The total irrigation demand was higher than the precipitation over the cropped area. The percentage increased from 115% in 1980-2010 to a range of 128 to 194% under the three climate simulations for 2030-2060. Drainage from the crop plots was 54% of the precipitation for 1980-2010 and remains relatively stable (50-53%) for the future simulations. Drainage as a fraction of irrigation was 47% for 1980-2010, indicating that almost half of the irrigation water originated from precipitation falling on the cropped areas. This fraction goes down under the future simulations, ranging between 26% for RACMO to 40% for RCA.

The total annual blue (irrigation) and green water (rainfall) water use for irrigated and rainfed crop plots for the 1980-2010 reference period (CYOBS) and for the 2030-2060 future as projected by the RACMO RCM are presented in Figure 5. The irrigation water demand for 2030-2060 is clearly higher than for 1980-2010 while the green water use is lower. The annual water use of the future period is slightly less variable than for 1980-2010.

Table 1. Average precipitation, irrigation water demand and drainage (mm) for all crop groups in the Troodos mountains, total volumes in Mm^3 and as fraction of each model's precipitation, for 1980-2010 (CYOBS) and for 2030-2060 from three regional climate model simulations under RCP8.5 (RCA, HIRHAM, RACMO).

Crop	Area	Precipitation				Irrigation				Drainage			
	ha	CYOBS	RCA	HIRHAM	RACMO	CYOBS	RCA	HIRHAM	RACMO	CYOBS	RCA	HIRHAM	RACMO
		mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm	mm
Deciduous fruit trees	909.6	713	685	609	469	846	893	931	1,025	387	354	325	225
Olives	223.3	592	550	501	478	537	579	609	612	291	256	244	247
Vegetables	206.4	624	569	519	439	635	672	685	709	400	352	334	272
Orchard (mixed)	135.9	602	561	514	490	940	991	1,024	1,013	288	248	242	242
Wine Grapes	73.8	690	650	587	497	511	545	568	615	386	346	324	264
Table Grapes	21.1	704	671	594	456	633	672	698	752	391	358	326	228
Citrus, oranges	53.5	587	524	481	397	809	864	908	1,008	261	205	206	164
Walnuts	17.5	658	621	556	478	986	1,040	1,077	1,102	326	289	271	230
Rosa damascene	15.4	706	641	588	393	801	843	867	965	409	344	330	188
Nuts, carob, fig, cactus	2.4	620	568	521	463	704	749	781	794	285	237	235	208
Cereals, vetches	0.8	492	445	421	577	194	228	249	208	206	167	180	304
Alfalfa, clover	0.2	539	470	453	409	1,156	1,219	1,260	1,215	224	158	184	173
Total (Mm^3)	**1,660**	**11.12**	**10.52**	**9.45**	**7.74**	**12.74**	**13.49**	**14.03**	**15.05**	**6.03**	**5.41**	**5.04**	**3.90**
Fraction of precip.						1.15	1.28	1.48	1.94	0.54	0.51	0.53	0.50
Fraction of irrig.										0.47	0.40	0.36	0.26

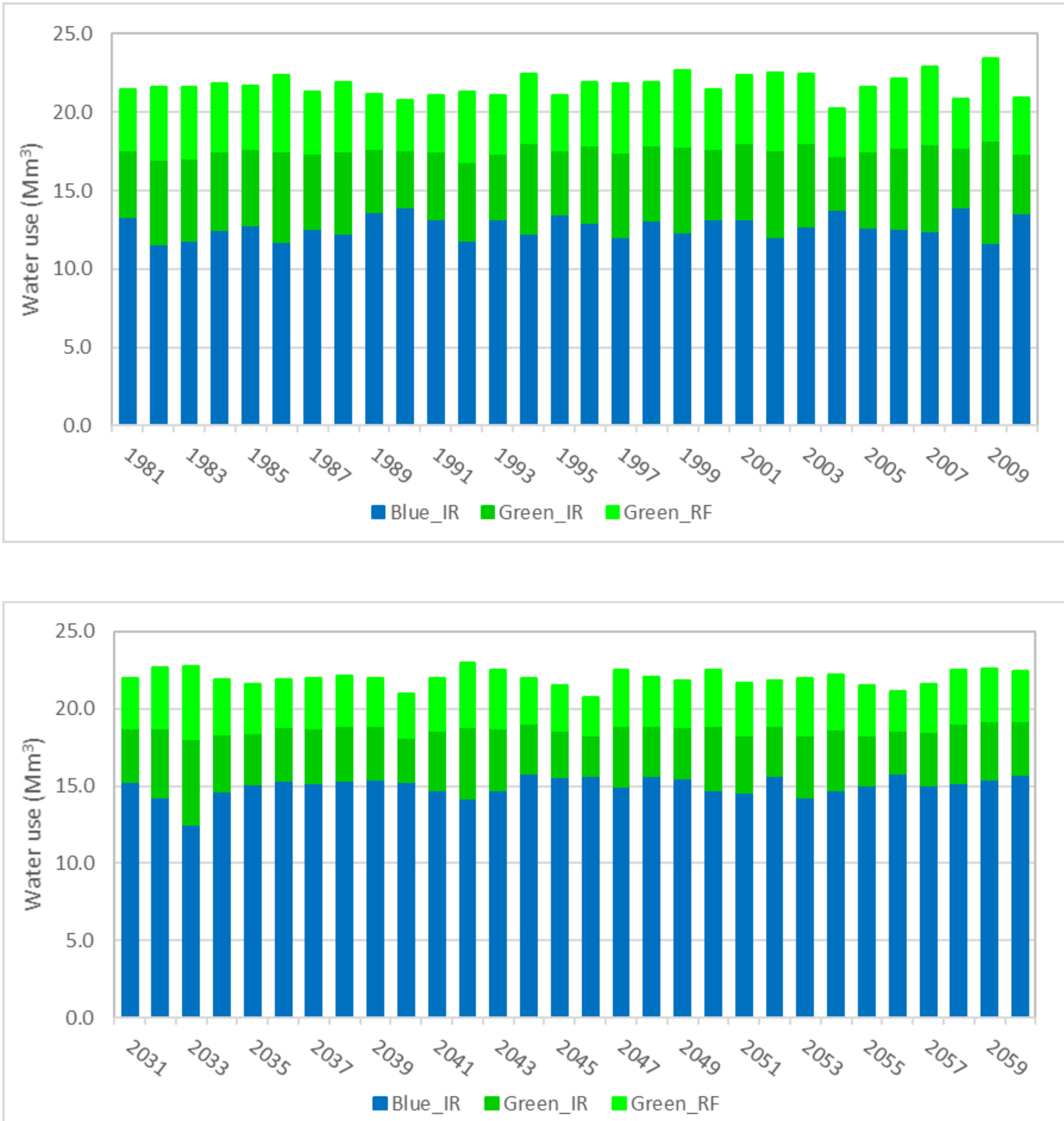

Figure 5. Irrigation water demand (Blue_IR) and rain water use of irrigated crop plots (Green_IR) and rain water use of rainfed crop plots (Green_RF) for the 1980-2010 reference period (top) and the 2030-2060 future period for the RACMO Regional Climate Model (bottom).

Conclusion

The 940-km^2 mountain of the 70 agricultural mountain villages on the Troodos ophiolite contained 20095 individual crop plots in 2020 with a total irrigated area of 16.6 km^2. The irrigation water demand of thes plots was computed to amount to 12.7 Mm^3 for the observed 1980-2010 reference period. For the 2030-2060 future period, using the the bias-corrected and downscaled EURO-CORDEX RMC simulations as forcing data for the blue-green water model, we found an irrigation water demand of 13.5 to 15.0 Mm^3. For the 1980-2010 period, drainage amounted to 47% of the irrigation demand, indicating that almost half of the irrigation water could originate from the precipitation falling on the crop area. This fraction decreased to range between 26% and 40% for the simulated 2030-2060 future under RCP8.5.

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Annex 1: Crop coefficients used for the blue-green water model

Table A1.1 Description of the headers of the crop coefficient input file used for the blue-green water model.

Header	Description
Cropcode	CAPO crop code
Perennial	1: perennial, 0: annual crops
Pl day	Calendar day of planting
Pl mo	Calendar month of planting
L ini	Length of initial stage
L dev	Length of development stage
L mid	Length of mid stage
L late	Length of late stage
Kcb ini	Crop coeffient for initial stage
Kcb mid	Crop coeffient for mid stage
Kcb end	Crop coefficient at end
p	Depletion fraction at which stress starts
Ky	Yield reduction coefficient
Height	Height of crop (m)
fw	Fraction of wetted area
Fr_irrig	Fraction of crop area irrigated
Group	Crop group code

Table A1.2 Crop coefficient input file used for the blue-green water model

Crop code	Perennial	Pl day	Pl mo	L ini	L dev	L mid	L late	Kcb ini	Kcb mid	Kcb end	p	Ky	Height	fw	Fr_irrig	Group	Crop
1	0	15	11	30	90	50	25	0.15	1.1	0.15	0.55	1.05	1	1	0.02	1001	Durum wheat, wheat
3	0	15	11	30	85	35	20	0.15	1.1	0.15	0.55	1	0.7	1	0.02	1001	Barley
4	0	15	11	30	90	40	20	0.15	1.1	0.15	0.55	1.05	0.7	1	0.02	1001	Oats
8,177	0	15	11	30	80	40	10	0.15	1.1	0.5	0.45	1.05	0.3	1	0.03	1002	Peas (Pisum arvense), vicia, legume fodder
211,212	0	15	11	30	85	35	20	0.15	1.1	0.15	0.55	1	0.7	1	0.03	1002	Mixed vetches-barley/wheat
150,152,161	0	15	11	30	80	40	10	0.15	1.1	0.5	0.45	1.05	0.3	1	0	1002	Green manure (vetches, beans)
5	0	1	4	30	35	45	30	0.15	1.15	0.5	0.55	1.25	2	1	1	1003	Maize
231	0	1	1	30	30	275	30	0.3	1	0.9	0.55	1.1	0.7	1	1	1003	Alfalfa, Medicago sativa Clover (Trifolium)
9	0	1	4	15	45	60	0	0.15	1.1	1.05	0.45	1.05	0.6	0.35	1	1004	Broad beans/ fresh
36	0	15	4	20	30	30	0	0.15	1	0.55	0.4	0.85	0.5	0.35	1	1004	Cowpeas
40	0	15	4	25	30	45	30	0.15	1.1	0.65	0.35	1.1	0.6	0.35	1	1006	Potatoes/spring
25	0	15	4	30	40	60	30	0.15	1.1	0.7	0.4	1.05	0.6	0.35	1	1007	Tomatoes
26	0	15	4	15	15	40	15	0.15	0.95	0.7	0.5	1.1	0.3	0.35	1	1007	Cucumbers
29	0	15	4	25	40	50	20	0.15	1	0.8	0.45	1.1	0.8	0.35	1	1007	Eggplants
31	0	1	5	20	40	40	30	0.15	0.95	0.7	0.4	1.1	0.4	0.35	1	1007	Watermelons
32	0	1	5	30	30	50	30	0.15	1	0.7	0.4	1.1	0.3	0.35	1	1007	Melons
34	0	2	9	40	50	120	30	0.15	1	0.8	0.45	0.95	0.7	0.35	1	1007	Artichokes
35	0	15	4	30	30	30	10	0.15	1	0.8	0.45	0.85	0.4	0.35	1	1007	Beans
41	0	15	4	15	40	120	10	0.15	0.8	0.7	0.2	1.2	0.2	0.35	1	1007	Strawberries
111	0	15	4	30	60	60	20	0.15	0.95	0.85	0.35	1.1	0.3	0.35	1	1007	Various vegetables
189	0	15	4	30	40	60	20	0.15	0.95	0.85	0.35	1.1	0.3	0.35	1	1007	Carrot
194	0	15	4	30	60	90	20	0.15	0.95	0.9	0.2	1.1	0.6	0.35	1	1007	Coriander
197	0	15	4	15	20	40	15	0.15	0.9	0.7	0.35	1.1	0.4	0.35	1	1007	Courgette
198	0	15	4	15	20	40	15	0.15	0.9	0.7	0.35	1.1	0.4	0.35	1	1007	Squash

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Crop code	Perennial	Pl day	Pl mo	L ini	L dev	L mid	L late	Kcb ini	Kcb mid	Kcb end	p	Ky	Height	fw	Fr_irrig	Group	Crop
199	0	15	4	15	20	40	15	0.15	0.9	0.7	0.35	1.1	0.4	0.35	1	1007	Lagenaria (calabash)
200	0	15	4	15	25	70	40	0.15	0.95	0.65	0.3	1.1	0.4	0.35	1	1007	Onion varieties
202	0	15	3	40	50	45	15	0.15	0.95	0.85	0.45	0.95	0.4	0.35	1	1007	Brassicaceae
210	0	1	4	20	30	15	10	0.15	0.95	0.9	0.2	1.1	0.6	0.35	1	1007	Lettuce, FAO56
219	0	15	4	20	30	35	15	0.15	1.1	1.05	0.35	1.15	0.5	0.35	1	1007	Pea, Cystat
224	0	15	4	25	40	45	15	0.15	0.95	0.9	0.2	1.1	0.4	0.35	1	1007	Celery, FAO56
228	0	15	4	10	15	25	10	0.15	0.9	0.85	0.2	1.1	0.3	0.35	1	1007	Spinach, Cystat
229	0	15	4	25	30	25	10	0.15	1	0.85	0.5	1.1	0.4	0.35	1	1007	Beetroot, Cystat
237	0	15	4	30	30	90	30	0.15	0.9	0.85	0.4	1.05	0.5	0.35	1	1007	Mixed Multi-crop
110	0	15	4	30	60	90	0	0.15	1	1	0.4	1.2	0.5	0.35	1	1008	Various flowers
236	0	1	1	90	60	120	95	0.2	0.8	0.5	0.4	1.2	0.6	0.35	1	1008	Rosa damascene
70	1	15	11	160	65	60	80	0.2	0.65	0.2	0.5	0.85	1.5	0.35	0.08	1011	Wine Grapes
71	1	15	10	190	65	60	50	0.2	0.8	0.2	0.4	0.85	2	0.35	1	1011	Table Grapes
173	1	1	10	155	85	35	90	0.2	0.65	0.2	0.5	0.85	1.5	0.35	0	1011	Grapes (traditional)
68	1	1	1	90	60	120	95	0.75	0.7	0.75	0.5	1.2	3	0.5	1	1012	Citrus/Oranges
56	1	1	10	185	90	60	30	0.35	0.8	0.6	0.7	1	3	0.5	1	1013	Figs
65	1	1	10	155	90	60	60	0.5	0.5	0.5	0.6	1	3	0.35	0.5	1013	Prickly Pear (Opuntia ficus-indica)
155,233	1	15	11	135	60	120	50	0.35	0.9	0.35	0.5	1.2	4	0.5	1	1013	Deciduous fruit tree, Orchard (mixed)
46	1	1	11	155	60	90	60	0.35	1.05	0.6	0.5	0.9	4	0.5	1	1014	Walnuts
47	1	1	10	185	90	30	60	0.35	0.8	0.55	0.4	0.85	3	0.5	1	1014	Pistachios
67	1	1	11	155	90	60	60	0.35	1	0.6	0.45	0.8	7	0.5	0.22	1014	Carobs
184	1	1	10	185	90	30	60	0.35	0.8	0.55	0.4	0.85	5	0.5	0.16	1014	Traditional trees, almond
42	1	1	12	95	90	90	90	0.45	0.5	0.5	0.65	0.75	3	0.5	0.7	1015	Olives
76,170	1	1	12	105	45	185	30	0.35	1	0.7	0.5	1	0.2	1	0	1015	Pasture, grasses, other herbaceous fodder

3PRO-TROODOS

Annex 2: Bias correction and downscaling evaluation

Table A2.1. Evaluation of the QDM bias correction and downscaling approach for the 31 years with daily data for the 6900 1-km grid cells over Cyprus

Criterion	Description	CYOBS	Evaluation	RCA	HIRHAM	RAMCO
PRCPTOT	mean annual precipitation	470	QDM/OBS	1.00	1.00	1.00
PRCPTOT_std	mean annual prcp standard deviation	132	QDM/OBS	0.84	0.76	1.02
PRCPmon_1	Jan mean precipitation	92	QDM/OBS	1.01	1.20	1.12
PRCPmon_2	Feb mean precipitation	79	QDM/OBS	0.95	0.95	0.76
PRCPmon_3	Mar mean precipitation	53	QDM/OBS	1.12	1.06	0.85
PRCPmon_4	Apr mean precipitation	25	QDM/OBS	1.47	1.30	1.19
PRCPmon_5	May mean precipitation	17	QDM/OBS	1.20	1.32	1.20
PRCPmon_6	Jun mean precipitation	7	QDM/OBS	0.32	0.23	0.53
PRCPmon_7	Jul mean precipitation	3	QDM/OBS	0.17	0.15	0.24
PRCPmon_8	Aug mean precipitation	2	QDM/OBS	0.22	0.08	0.74
PRCPmon_9	Sep mean precipitation	6	QDM/OBS	1.03	0.59	0.67
PRCPmon_10	Oct mean precipitation	27	QDM/OBS	1.01	0.62	0.94
PRCPmon_11	Nov mean precipitation	59	QDM/OBS	1.04	0.90	1.10
PRCPmon_12	Dec mean precipitation	98	QDM/OBS	0.87	0.98	1.12
R01mm	annual # days > 0.1 mm	75	QDM/OBS	1.00	1.00	1.00
R1mm	annual # days > 1 mm	52	QDM/OBS	1.00	1.00	1.00
R10mm	annual # days > 10 mm	14	QDM/OBS	1.00	1.00	1.00
R20mm	annual # days > 20 mm	5	QDM/OBS	1.00	1.00	1.00
RX1D	maximum precipitation of 31 years	106	QDM/OBS	1	1	1

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continued from previous page

Criterion	Description	CYOBS	Evaluation	RCA	HIRHAM	RAMCO
TMAX	mean annual daily max temperature	23.7	QDM-OBS	0.0	0.0	0.0
TMAX_std	mean annual Tmax standard dev.	0.7	QDM/OBS	0.77	0.79	1.02
TMAXmon_1	Jan mean Tmax	14.1	QDM-OBS	-0.4	-0.5	-0.1
TMAXmon_2	Feb mean Tmax	14.4	QDM-OBS	0.3	0.8	0.2
TMAXmon_3	Mar mean Tmax	17.3	QDM-OBS	0.5	0.8	0.2
TMAXmon_4	Apr mean Tmax	21.6	QDM-OBS	0.5	1.0	0.2
TMAXmon_5	May mean Tmax	26.1	QDM-OBS	-0.4	-0.1	-0.6
TMAXmon_6	Jun mean Tmax	30.4	QDM-OBS	0.2	0.0	-0.3
TMAXmon_7	Jul mean Tmax	33.1	QDM-OBS	0.2	0.2	0.0
TMAXmon_8	Aug mean Tmax	33.1	QDM-OBS	0.3	0.4	-0.2
TMAXmon_9	Sep mean Tmax	30.4	QDM-OBS	0.0	0.0	0.0
TMAXmon_10	Oct mean Tmax	26.3	QDM-OBS	-0.2	-0.4	0.4
TMAXmon_11	Nov mean Tmax	20.4	QDM-OBS	-0.5	-1.2	0.2
TMAXmon_12	Dec mean Tmax	16.0	QDM-OBS	-0.4	-0.9	-0.1
FA30	Tmax>30 frequency (days/365)	0.27	QDM/OBS	1.00	1.00	1.00
TXx	maximum Tmax of 31 years	41.5	QDM-OBS	0.0	0.0	0.0
TMIN_m	mean annual daily min temperature	12.59	QDM-OBS	0.0	0.0	0.0
TMIN_std	mean annual Tmin standard dev.	0.61	QDM/OBS	0.76	0.73	0.90
TMINmon_m_1	Jan mean Tmin	5.5	QDM-OBS	-0.4	-0.8	-0.4
TMINmon_m_2	Feb mean Tmin	5.3	QDM-OBS	0.3	0.4	-0.4
TMINmon_m_3	Mar mean Tmin	6.8	QDM-OBS	0.8	0.7	-0.2
TMINmon_m_4	Apr mean Tmin	10.0	QDM-OBS	0.7	1.1	0.2
TMINmon_m_5	May mean Tmin	13.7	QDM-OBS	0.2	0.3	-0.2
TMINmon_m_6	Jun mean Tmin	17.8	QDM-OBS	0.3	-0.1	-0.2
TMINmon_m_7	Jul mean Tmin	20.5	QDM-OBS	-0.4	-0.3	-0.3
TMINmon_m_8	Aug mean Tmin	20.6	QDM-OBS	-0.4	0.0	-0.3
TMINmon_m_9	Sep mean Tmin	17.9	QDM-OBS	0.1	0.5	0.5
TMINmon_m_10	Oct mean Tmin	14.6	QDM-OBS	-0.1	0.0	0.8
TMINmon_m_11	Nov mean Tmin	10.3	QDM-OBS	-0.5	-0.8	0.7
TMINmon_m_12	Dec mean Tmin	7.1	QDM-OBS	-0.6	-0.9	-0.1
FB0	Tmin<0 frequency(days/365)	0.01	QDM/OBS	0.7	2.9	3.0
TNn	minimum Tmin of 31 years	-3.9	QDM-OBS	0.0	-1.3	-3.5