Improving Climate Resilience of Vulnerable Communities and Ecosystems in the Gandaki River Basin, Nepal

Annex 2c: A Note on Evapotranspiration Calculation – Methods and Data

i) Dominant crops: There are three physiographic regions in the Gandaki River Basin (GRB) - Mountain, Hill and Terai (as shown in Tables 6 and 7 of FP) and four seasons from a precipitation perspective (pre-monsoon (MAM), monsoon (JJAS), post-monsoon (ON) and winter (DJF)). Summer (monsoon and post-monsoon) and winter (winter and pre-monsoon) are two crop growing seasons. Crops grown in a larger area as a major staple food are considered as dominant crops. Five main crops namely paddy, wheat, maize, millet and potato are included as dominant crops. Paddy is a dominant summer crop in all regions in the plain lands, and maize is a dominant summer crop in the slopy lands in hills and mountains. Wheat is a dominant winter crop in all the regions in both plain and slopy lands. Millet is a dominant crop in between summer and winter in the hills and mountains as a rainfed crop in slopy lands. Potato is a dominant crop in the mountains in between winter and summer as a rainfed crop. Paddy is not cultivated in mountain and millet is not cultivated in Terai.

ii) Reference crop evapotranspiration (ET0): Daily time series of temperature, relative humidity, wind speed and sunshine hours were used to estimated ET0 using FAO's ET0 calculator (http://www.fao.org/land-water/databases-and-software/eto-calculator/en/). This calculator uses the Penman-Monteith Method for calculating ET0. For historical (or baseline) ET0, observed data from the Nepalese Department of Hydrology and Meteorology (DHM) were used. Three stations representing Mountain (Chame), Hill (Khudi) and Rampur (Terai) were selected for reference.

The data period varied for the three stations due to data availability. Data was used between 1990-2011 for st816 (Chame); between 1983-2013 for st802 (Khudi), and between 1996-2014 for st902 (Rampur). For future estimates, daily time series of precipitation and temperature (max and min) were taken as an ensemble of outputs from following three regional climate models (RCMs): ACCESS-1, CNRM-CM5 and MPI –ESM-LR. Outputs of the climate models under RCP4.5 scenarios were downloaded from the South Asia CORDEX data portal (http://cccr.tropmet.res.in/home/index.jsp), and then bias-corrected against observed historical time series at the three stations using the Quantile Mapping method. ET0 for the near future (2016-2045) and under RCP4.5 scenarios was then estimated at the three stations, using the bias-corrected daily time series of projected future temperature and precipitation. Daily time series of ET0 for historical and future periods were then aggregated to compute average monthly and seasonal values. The difference of projected future ET0 with respect to the baseline ET0 was reported as the projected change in ET0 value due to climate change.

iii) Crop-specific evapotranspiration (ETcrop): A generalized cropping calendar (see Annex 2a FS Section 2.7.4) for the Mountain, Hill and Terai regions of the basin were prepared for the five dominant crops mentioned above based on local knowledge and literature review. FAO's CROPWAT 8.0 tool was used to estimate ETcrop, based on the Penman-Monteith method. Comparable historical and future time periods were used in estimating ETcrop as for ET0.

Mean monthly precipitation for the historical period at the three stations (Chame, Khudi, Rampur) were estimated based on observed daily precipitation data obtained from the DHM. The identical data set, time period and scenarios were used as for the temperature data. Mean monthly ET0 calculated from the FAO ET0 calculator was used as input data, along with precipitation into CROPWAT8.0. Medium soil properties as defined in FAO's database were used. Apart from crop specific planting dates and crop growth duration periods, all other parameters were accepted in the CROPWAT software database. Planting dates and duration (days) from planting to harvesting were varied with crops and physiographic regions, as defined in Table 1, based on suitability to the study area. The CROPWAT8.0 model was run separately for different crops, different regions, and different time periods (historical and future). Finally, crop water requirements (or ETcrop) across the months estimated for different crops were aggregated together to estimate seasonal values of ETcrop for historical and future periods. Changes in future estimated ETcrop with respect to the historical baseline were reported as climate change impact on ETcrop.

Table 1: Planting date and duration (days) from planting to harvesting in different regions of GRB

Region	Parameters	Paddy	Wheat	Maize	Millet	Potato
Mountain	Planting date	-	5th Nov	1st Feb	1st Apr	1st Feb
	Duration	-	180	180	150	180
Hill	Planting date	1st July	10th Nov	1st Mar	1st Jun	20th Jan
	Duration	150	160	160	125	160
Terai	Planting date	10th July	15th Nov	1st Apr	-	20th Jan
	Duration	130	130	125	-	130

Notes: Days for Paddy are without considering seedling preparation period;