



Impact of climate change on water resources of Haryana

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Abstract: The potential changes was assessed assuming existence of forest in different districts of Haryana, based on simulated forests under current as well as projected A1B scenario climatology. This analysis helps to assess the potential impacts of climate change for any future afforestation/reforestation programmes. It can be observed from Figure 38 that any afforestation programme undertaken in future, in the districts of Karnal, Panipat, Jind, Bhiwari, Sonapat, Gurgaon, etc., could be vulnerable to future climate impacts. The environmental conditions that induce heat stress on dairy animals can be calculated using temperature humidity index (THI). The heat stress begins to occur in dairy cattle wherein the THI is more than 72 (<72 no stress, 72 -79 mild, 80 -89 moderate, 90-98 severe and above 98 danger). The decreases in milk production can range from 10 to 25%. It has been estimated that with a temperature rise of 1.0 or 1.2°C with minor change in precipitation during May to August, milk productivity is likely to be marginally affected and during other months productivity will remain relatively unaffected. The negative impact of temperature rise on total milk production for India has been estimated about 1.6 million tonnes in 2020 and more than 15 million tonnes in 2050. An average adult cow or buffalo producing 10-15 lit milk per day requires about 40-45 lit/day as drinking water on hot days and about 40-60 lit for other related work thus requiring a minimum of 100 lit/ day/ animal. An organized animal farm following standard management practices and disposal of animal wastes requires additional water about 50-100 lit/day/animal. Any deficiency in water availability will certainly lead to decline in milk productivity.

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Introduction:

Climate change may also markedly change the seasonal variation in river-flow. Higher temperatures will push the snow limit upwards in northern Europe and in mountainous regions. This, in conjunction with less precipitation falling as snow, will result in a higher winter run-off in northern European and mountain-fed rivers, such as the Rhine, the Rhône, the Po, and the Danube. Moreover, earlier spring melts will lead to a shift in peak flow levels. As a result of the declining snow reservoir and decreasing glaciers, there will be less water to compensate for the low flow rates in summer.¹

Climate change tends to increase the frequency and intensity of rainfall; there may be an increase in the occurrence of flooding due to heavy rainfall events. Groundwater recharge may also be affected with a reduction in the availability of groundwater for drinking water in some regions.

Changes in average water availability in most European river basins are estimated to be relatively small for the next 30 years. However, in the long-term most climate change scenarios predict that northern and eastern Europe will see an increase in

annual average river flow and water availability. In contrast, average run-off in southern European rivers is projected to decrease. In particular, some river basins in the Mediterranean region, which already face water stress, may see marked decreases of water availability.²

While climate change repercussions are predicted to be varied and ubiquitous, it is the fate of water that deserves highest consideration, as the prosperity of communities —and countries — hangs in the balance.

Today, the forecasted and observed long-term climate change is becoming the most critical international problem of the 21st century. According to NASA's research, the last five years have been considered the hottest in the history of observations¹. Among the inevitable consequences of climate change, the most important is its impact on water resources — the basis of environmental well-being, economic growth, and global security².

The main effect of climate change on the water resources of the entire planet is the disruption of the hydrological cycle. Thus, the rise in temperature leads to an increase of the water vapor

content in the atmosphere, a change in the regime and intensity of precipitation, an increase in evaporation from the earth's surface, a decrease in snow cover, and melting of glaciers. The impacts of climate change on water resources, in turn, affect all major sectors of the economy.

Melting of glaciers and snow cover as a result of rising temperatures leads to a decrease in water supplies, thereby reducing water availability during warm and dry periods in regions supplied with meltwater from mountain ranges. Over the past decade, the volume of the Himalayan glaciers has decreased by two-thirds, while the glaciers in the Andes have almost disappeared⁴. Thawing of permafrost leads to an increase in landslides and thereby poses a threat to infrastructure in permafrost regions.

Changes in precipitation patterns due to climatic factors also affect soil moisture. Insufficient replenishment and increased evaporation in the long-term absence of precipitation cause the prolonged droughts that threaten water and food security. By mid-century, rising temperatures and the associated decrease in soil moisture in the Eastern Amazon are expected to gradually replace the rainforest, which plays an important water-regulating role with savanna³.

According to forecasts, as a result of climate change by 2050, annual average river runoff and water availability will increase at high latitudes and in wet tropical regions. In mid-latitudes and dry tropical regions, on the contrary, these indicators will decrease, causing a reduction in the amount of available water resources.

Methods and Models:

An assessment of the impact of projected climate change on water resources in Haryana is made using the hydrologic model SWAT (Soil and Water Assessment Tool). The model requires information on terrain, soil profile and land use of the area as input which have been obtained from the global sources. These three entities are assumed to be static for future as well.

The Yamuna river and Indus river basin which have their tributaries in Haryana has been modelled using the following:

Spatial data and the source of data used for the study areas include:

- Digital Elevation Model: SRTM, of 90 m resolution⁵
- Drainage Network – Hydrosched⁵
- Soil maps and associated soil characteristics (source: FAO Global soil)⁶
- Land use (source: Global landuse)⁷

The Hydro-Meteorological data pertaining to the river basin required for modelling, includes daily rainfall, maximum and minimum temperature, solar radiation, relative humidity and wind speed. Climate Change PRECIS Regional Climate Model outputs for Baseline (1961–1990, BL), near term (2021–2050, MC) and long term or end-century (2071–2100, EC) for A1B IPCC SRES scenario (Q14 QUMP ensemble) has been used.

Impacts of Climate Change on Water Resources

The climate change impact assessment on water resources of Haryana has been taken from the recent study conducted (Gosain et al, 2011)⁸ as part of the NATCOM Phase II study of MoEF. For the present, analysis pertains to the modeling of River Yamuna and Indus using the hydrologic model SWAT has been used. Discussions on the impact assessment is provided below.

For the Yamuna and Indus basins lying within Haryana, analysis projects an increase in annual precipitation of about 9% (72 mm) by mid century, this results in 46% (33 mm) increase in runoff to the stream flow and 7% (5 mm) increase in baseflow, negligible decrease to the ground water recharge is projected. Evapotranspiration is projected to increase by 39% (28 mm). During the monsoon months (JJAS) increase in precipitation is projected to be about 10% (64 mm) and increase in evapotranspiration by 11% (17 mm). The indication is that in parts of the basin surface runoff would be increased under the A1B mid century scenario (Figure 1). Similarly during the Rabi season (OND), precipitation is projected to increase by 23% (17 mm) resulting in increase in runoff by 48% (8 mm) and negligible change in ground water recharge. Evapotranspiration is projected to increase by 25% (4 mm) and baseflow is projected to increase by 17% (3 mm).

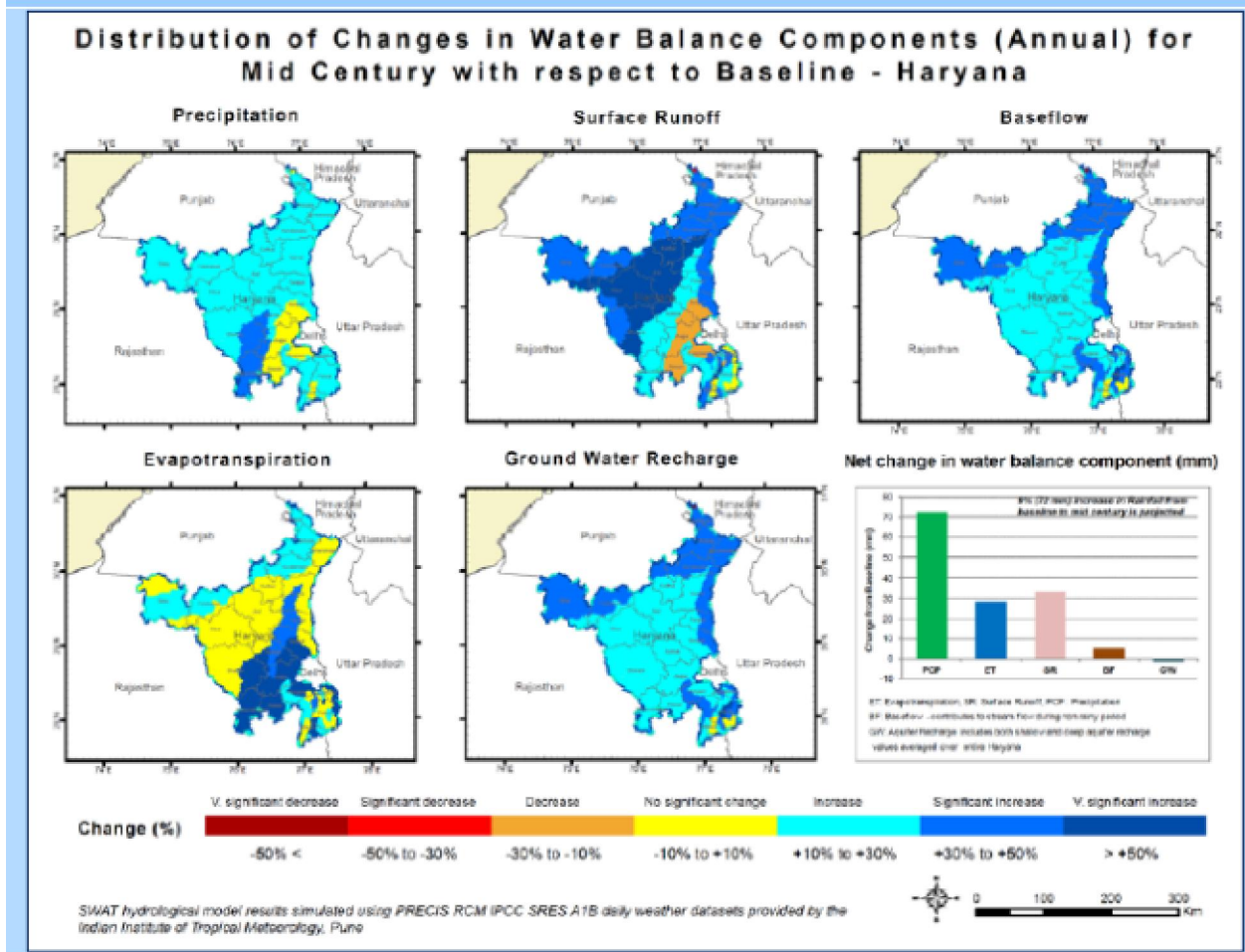


Fig. 1 Change in water availability towards 2030s with respect to 1970s (IPCC SRES A1B scenario) in Haryana.

Increase in annual precipitation of about 23% (186 mm) by end century is projected, resulting in increase in runoff by 58% (108 mm) and about 6% (11 mm) returns to stream as baseflow. Evapotranspiration is projected to increase by 25% (46 mm). Negligible changes in ground water recharge is projected. During the monsoon months (JJAS) increase in precipitation is projected by about 27% (178 mm), most of this results in runoff (57%, 102 mm) and baseflow (4%, 7 mm) contributing to the stream flow. About 2% (4 mm) of this increase in precipitation is contributed to the ground water

recharge. Increase in evapotranspiration is projected by 34% (19 mm). The indication is that in parts of the basin surface runoff would be increased under the A1B end century scenario and would offer opportunities for increased water harvesting and groundwater recharge (Figure 2). Similarly during the Rabi season (OND), precipitation is projected to increase by 9% (7 mm) resulting increase in baseflow contribution to the stream flow. Reduction in ground water recharge and substantial increase in evapotranspiration is projected.

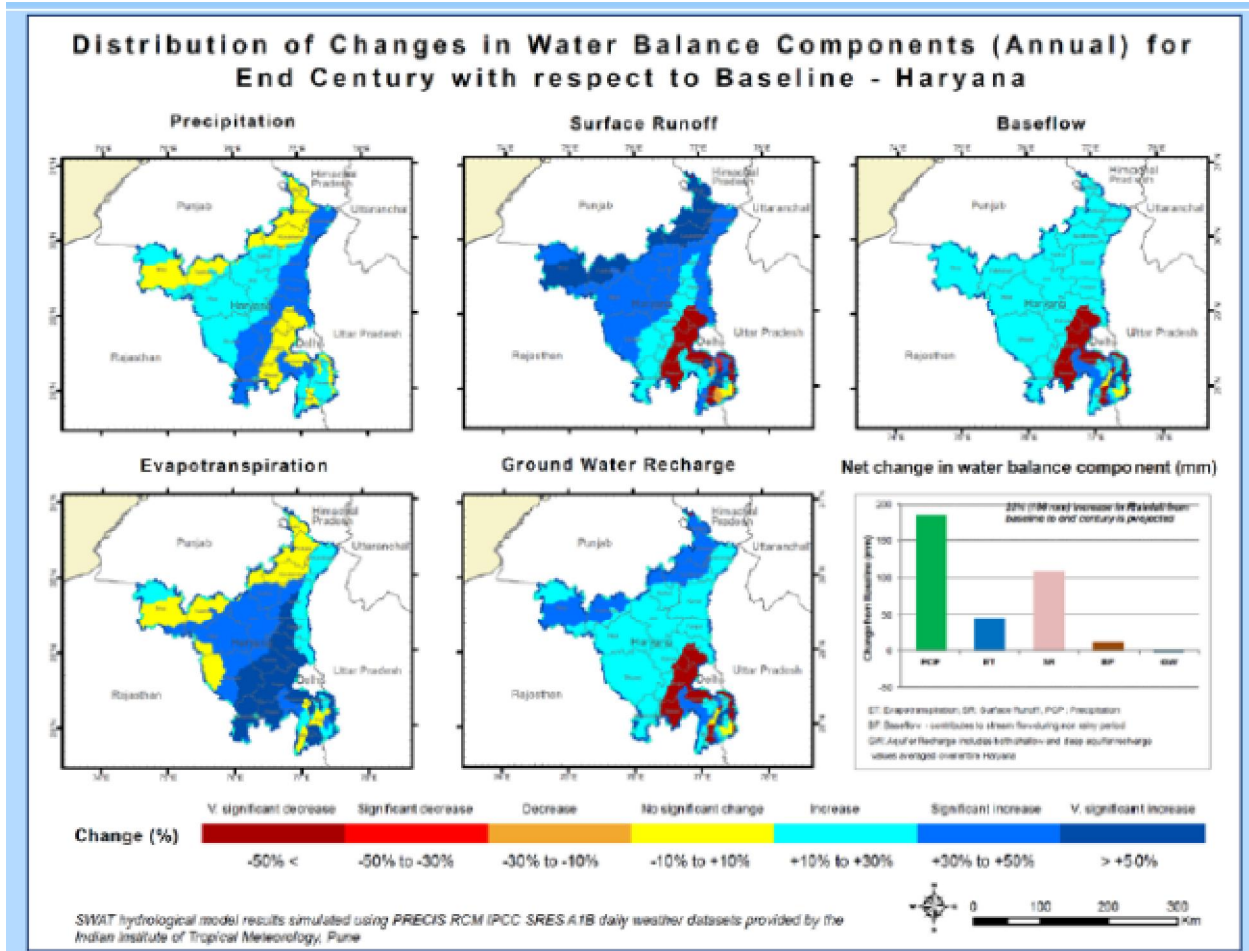


Figure 2: Change in water availability towards 2080s with respect to 1970s (IPCC SRES A1B scenario) in Haryana.

Agricultural water stress indicator

Agriculture faces water stress if the water requirements of crops are not met. To detect the severity and spatial occurrence of water stress in the basin, the relative evapotranspiration (ETrel) expressed as the ratio of actual evapotranspiration (ETa) over potential evapotranspiration (ETp) has been used. For relative evapotranspiration, it is generally recommended that this ratio does not drop below 0.70 throughout the year (Bos et al., 2005). Bastiaanssen et al., (2001) used an ‘operational range’ and an ‘acceptable range’ for this indicator. If the indicator remains within the operational range, crop yield will deviate less than 10% from the target

value. If the indicator moves out of the acceptable range yield reductions of over 20% occur. For ETrel, the operation range was set at 0.8-1, and the acceptable range at 0.7-1. The relative evapotranspiration (ETrel) is calculated for the basins of Yamuna and Indus lying within Haryana on seasonal basis. The results of seasonal agricultural water stress are presented in Figure 36. The figure shows that water stress is higher in winter and season. It is higher in the western part of Haryana with less average annual precipitation (maroon tones) when compared to the eastern part (orange to yellow tones). The agriculture water stress is going to exacerbate towards end century.

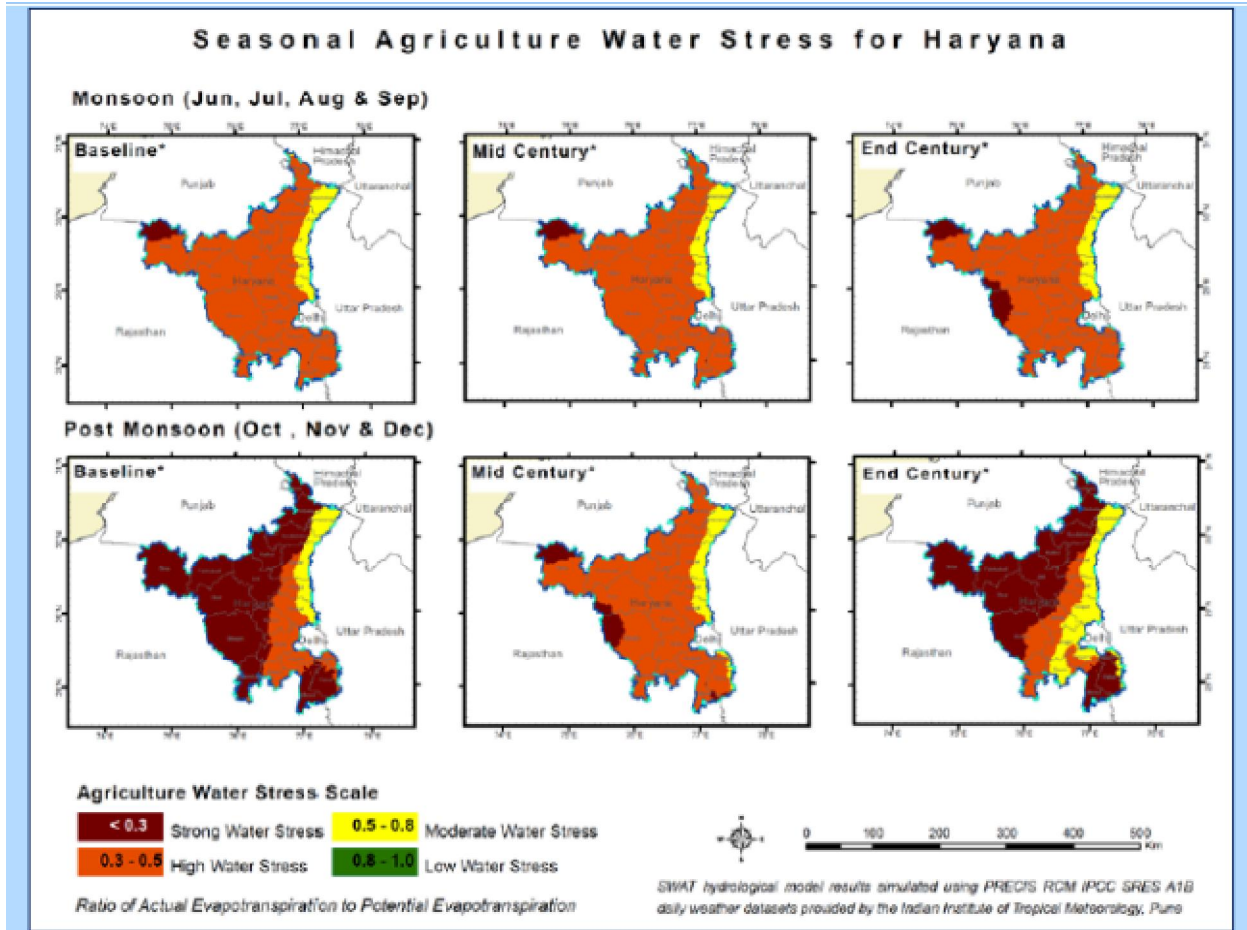


Figure 3 : Change in Agriculture Water Stress for baseline, mid century and end century scenarios (IPCC SRES A1B scenario) in Haryana.

Impact of climate change on forests of Haryana

Observed climate change and implications for forestry: The forest resource in Haryana is vulnerable not only to climate change resulting in increased mean annual temperature but also due to lower and irregular rainfall in the whole of Haryana. The south-western region receives very less and irregular rain fall resulting in the reduced survival of plantation and change in vegetation type. The scanty rainfall has also led to less ground water recharge. This lowering of water table may lead to change in species and growth of trees and biomass production. The fodder production from trees is a very important source of food for the cattle in south and west part of the state. The new variety of species need to be identified zone wise suitable for the new soil and moisture conditions to increase the tree cover to achieve the National and Haryana State Forest policy of 20% tree cover at the earliest in a phased manner.

- Higher mean annual temperatures

- Erratic and reduced rainfall and other precipitations
- Extreme events such as floods, droughts and cyclones.

These observed adverse conditions could potentially affect the native vegetation and also the afforestation efforts of the Forest Department and associated livelihoods of the people in the state. The productivity of forests (biomass/ha/year) and trees can reduce due to change in optimum condition. The rising mean temperature and reduced precipitation and reduced rainy day has forced the farmers to draw more and more ground water resulting in the lowering of water table. This has significant impact on the growth of trees on adjoining forest strip land and farm lands. The number of dead trees has increased many folds in last 10 years forcing the Haryana Forest Department to restrict the extraction of dead trees only which surpasses the working plan prescription for annual harvesting of trees from forests. The felling of green trees has virtually

stopped except for emergency felling for development projects such as widening of roads. The long spell of dry season has caused delay in start of plantation activities which usually coincided with monsoon in June end during 1980s. The plantations are normally raised during August – September, which results in reduction of the growing period before the onset of winter in November. The extreme winter frost takes heavy toll of the frost sensitive species and large scale casualty occurs and the survival of young saplings drops considerably.

The reduced productivity of crop has led to increase in sown area on the common land, which were hitherto were under tree plantations and preserved as ‘Village Forests’ have been diverted for cultivation to meet the food grain requirement. The plantations raised by HFD have decreased in last 15 years due to non availability of community land for plantation due to competing land use in favor of food crop. However, schemes have been revised to associate other stakeholders to plant trees and HFD provides around 3.0 crore seedlings free every year. The reduced growing period has led to change in species choice and drought and frost resistant species are preferred. This has led to changes in the composition of species in the state. Shisham and kikar trees are drying in the state. This is indicated by the fact that the proportion of dead trees harvested by Production Circle in total wood harvested has increased in last ten years.

Likely Impacts of Climate Change on Agriculture

- short periods of exposure of wheat crops to temperatures of 28 °C to 32°C result in significant decrease in yield by 20% or more. North-Western parts of India where sowing of wheat is often delayed due to late harvest of rice and cotton in wheat-rice-cotton cropping system and range of 28 °C to 32°C temperatures are commonly encountered in the later part of the growing season. As a result, significant losses in yield occur due to heat stress during grain filling period. In view of global warming and increased total demand for wheat in India during next 12 years, development of heat-tolerant cultivars is of major concern in wheat breeding programs.

- In traditional way of irrigated rice production, rice consumes more than 50% of the water used for irrigation in Asia. Rice requires 2-3 times more water per unit grain produced than crops such as wheat and maize. Traditional rice irrigation faces threat with projected less water availability in future.

- Indian mustard cultivation is adversely affected by drought and salinity stress causing production losses as seedlings and mature plants show stress related symptoms including delayed

germination, poor growth and poor flowering. With projected increase in drought frequency, erratic rainfall in future mustard yield may be severely affected.

- unpredictable moisture deficits during crop growth are a major constraint to productivity, adaptation and stability of chick pea performance throughout the world. Due to this single factor the annual yield losses are globally very high, ranging from 30-40 %. Deficit soil moisture conditions are projected to increase in future.

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