Effects of afforestation and climate warming on evapotranspiration and river discharge in the upper Chao Phraya River basin

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In the Chao Phraya River basin (hereafter as CP), deforestation has been proceeding in the upper mountainous regions; and in the uppermost tributary of the Nan River the increasing trend in low flow was observed, that could potentially be related to deforestation in the basin (Tebakari et al., 2018). Besides, runoff in CP is projected to increase under the global warming particularly in the rainy season (Kotsuki et al., 2014), that would enhance the risks of floods which regularly occur in the late rainy season. Since afforestation has effects to decrease the annual runoff and its peak amount, it is considered as an adaptation measure. However, it also has effects to increase evapotranspiration, that would enhance the water scarcity in the dry season.

In this study, offline experiments were conducted with a land surface model, MATSIRO (Takata et al, 2003; Nitta et al., 2014) that explicitly considered the processes of vegetation canopy to examine the effects of afforestation on river discharge and evapotranspiration in the upper CP under a warmed climate. The meteorological conditions for the 20th century (1981-2004; Kotsuki et al., 2013) and the future (2040-2059 and 2080-2099, Watanabe et al., 2014) with two warming scenarios and three climate models were used. Three experiments were conducted at the horizontal resolution of 5 arc-minutes: the first one is with the vegetation distribution in 2000 (control, CTL), the second one is with that in 1970 (AFR20) in which cropland is 20% less than CTL, and the third one is with that in 1950 (AFR100) in which most of the land is covered with natural vegetation (AFR100).

The annual precipitation, runoff, and evapotranspiration were increased by the warming. About 80% of the precipitation increase turned into the runoff increase, and the remaining 20% into evapotranspiration. The annual increase in runoff was reduced by 3-5% with AFR20 and 10-15% with AFR100 in the mid-21st century. The reduction shrinks with the progress of the warming which agrees with the report by Chacuttrikul et al. (2018), though the simplified simulation for changes in soil properties by afforestation suggested an enhancement of the reduction. The runoff reduction by forest-cover increase was due to the enhancement of evapotranspiration increase. Looking into the seasonal pattern of the changes, the runoff increase corresponds to about 75% of the precipitation increase in the rainy season. The evapotranspiration increase in the rainy season was about 10%, and the remaining 15% turned into the evapotranspiration increase in the dry season. In conclusion, the effect of runoff reduction by forest-cover increase was marked in the rainy season, while the effect of evapotranspiration enhancement was marked in the dry season. It is therefore necessary to take note the both effects of runoff reduction in wet season and evapotranspiration enhancement in dry season, in considering afforestation for an adaptation measure for water management issues.

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References

Chacuttrikul et al. (2018), Hydrol. Res. Lett., 12(2), 7-13.
Kotsuki, S., et al., Hydrol. Res. Lett., 7, 7984, 2013.
Nitta, T., et al., J. Clim., 27(9), pp3318-3330, 2014.
Takata, K., et al., Global and Planetary Change, 38, 209-222, 2003.
Tebakari et al., J. Japan Soc. Hydrol. and Water Resour., 31(1), 17-24.
Watanabe, S., et al., Hydrol. Res. Lett., 8, 33, 2014.

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