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Reconciling irrigated food production with environmental flows for Sustainable Development Goals implementation

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Abstract

Safeguarding river ecosystems is a precondition for attaining the UN Sustainable Development Goals (SDGs) related to water and the environment, while rigid implementation of such policies may hamper achievement of food security. River ecosystems provide life-supporting functions that depend on maintaining environmental flow requirements (EFRs). Here we establish gridded process-based estimates of EFRs and their violation through human water withdrawals. Results indicate that 41% of current global irrigation water use (997 $km^3 yr^{-1}$) occurs at the expense of EFRs. If these volumes were to be reallocated to the ecosystems, half of globally irrigated cropland would face production losses of >10%, with ~20-30% of total country production especially in Central and South Asia. However, we explicitly show that improvement of irrigation practices can widely compensate for such losses on a sustainable basis. Integration with rainwater management can even achieve a 10% global net gain. Such management interventions are highlighted to act as a pivotal target in supporting the implementation of the ambitious and seemingly conflicting SDG agenda.

Table 1: Agricultural impacts through water conservation and management. Change in global kcal production and the proportion of affected area (kcal loss >10%) is shown for the total absence of irrigation (**1.**), irrigation constrained by environmental flow requirements (EFRs) (**2.**), upgraded irrigation constrained by EFRs (**3.**) and integrated water management constrained by EFRs (**4.**), all compared to the current situation (1980-2009). Also listed are associated changes in irrigation water withdrawal (IWD) and consumption (IWC).

Scenario	Total kcal production (% change)	Irrigated kcal production (% change)	Total area affected (kcal loss ≥10%) (%)	Irrigated area affected (kcal loss ≥10%) (%)	Irrigation water withdrawal (% change)	Irrigation water consumption (% change)
1. No irrigation	– 14.7	– 44.4	32.5	81.3	– 100.0	– 100.0
2. Respect EFR	– 4.6 (± 0.8)	– 13.9 (± 2.5)	16.1 (± 1.8)	52.2 (± 3.9)	– 41.4 (± 5.8)	– 35.1 (± 5.6)
3. Respect EFR with irrigation upgrade	– 0.1 (± 1.0)	5.6 (± 2.9)	12.0 (± 2.4)	33.6 (± 7.4)	– 54.4 (± 4.3)	– 34.8 (± 5.2)
4. Respect EFR with integrated water management	9.9 (± 1.0)	6.8 (± 2.9)	8.2 (± 2.0)	30.5 (± 7.5)	– 55.7 (± 4.3)	– 36.8 (± 5.2)

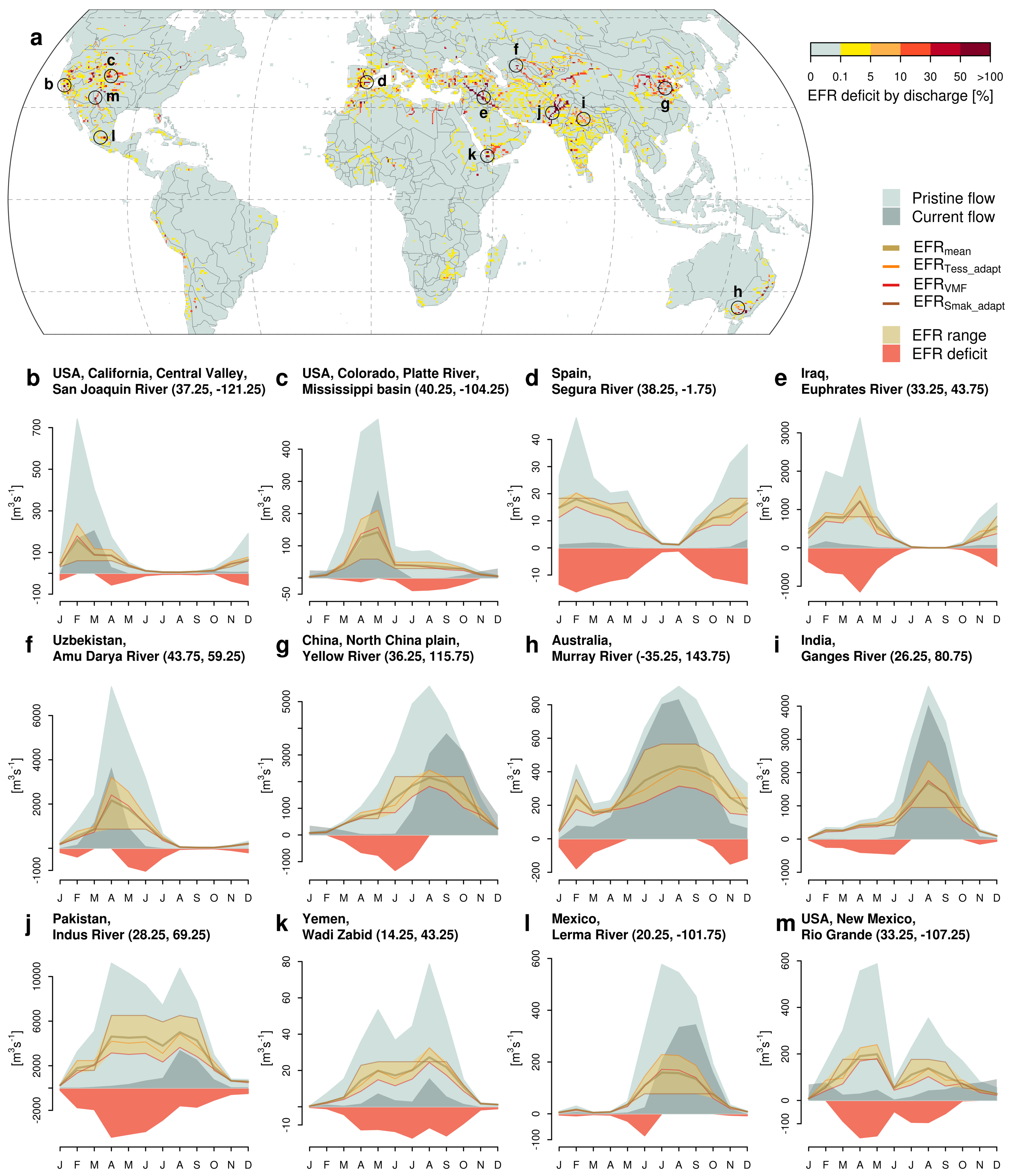

Figure 1: Discharge and environmental flows of selected river stretches. The map (a) illustrates the mean annual EFR deficit relative to mean annual discharge. Hydrographs (b.—m.) highlight seasonal flow alterations (pristine versus current discharge) together with EFR estimates and deficit. All estimates are in $m^3 s^{-1}$ and for the time period 1980-2009.

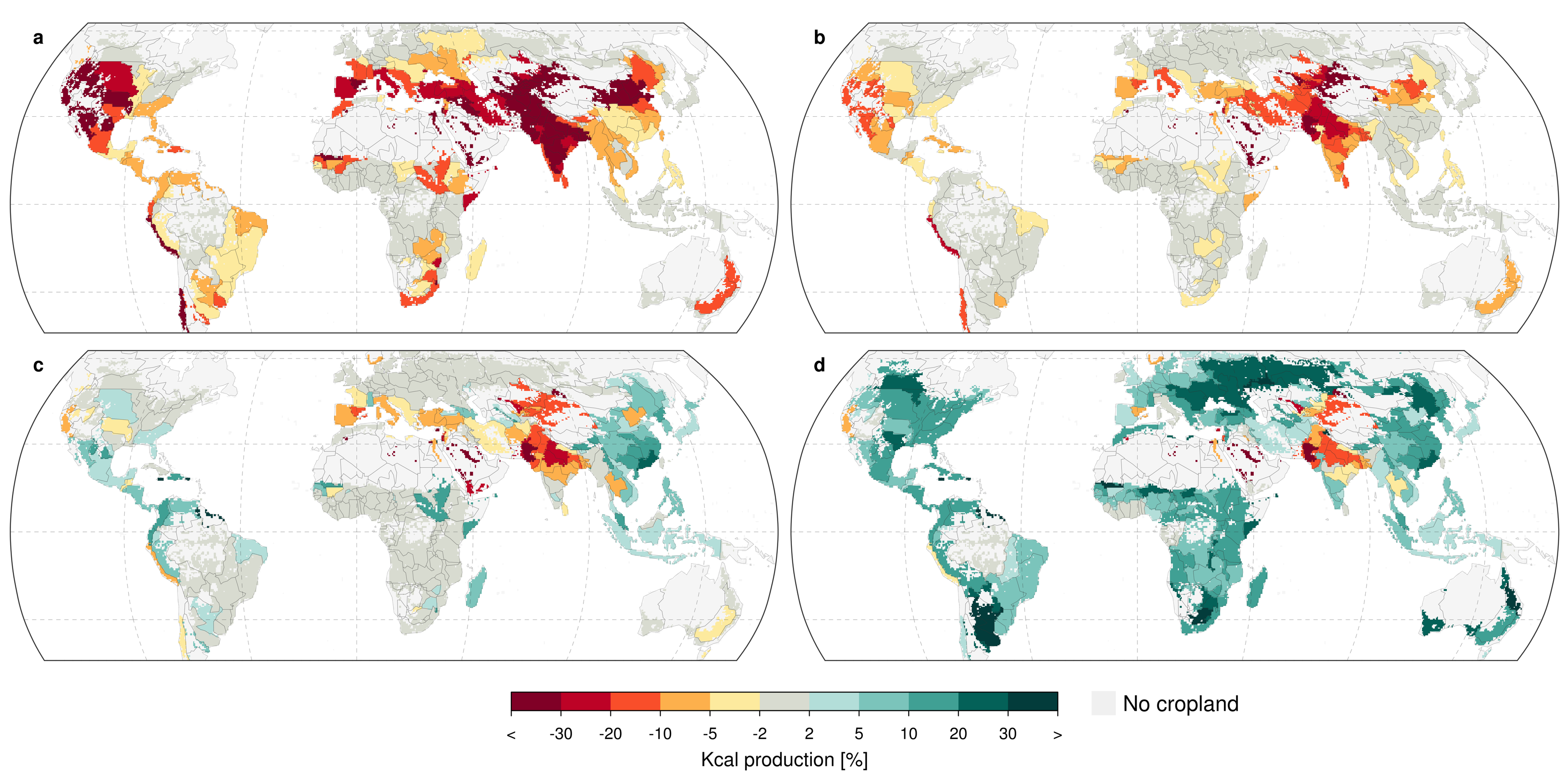

Figure 2: Governing environmental flows constrains food production. The maps illustrate the change in total (i.e. rainfed and irrigated) kcal production in the absence of irrigation (**a**), with irrigation constrained by EFRs (**b**), with upgraded irrigation constrained by EFRs (**c**) and with integrated water management constrained by EFRs (**d**), with respect to the current situation and aggregated to Food Production Units (1980-2009).

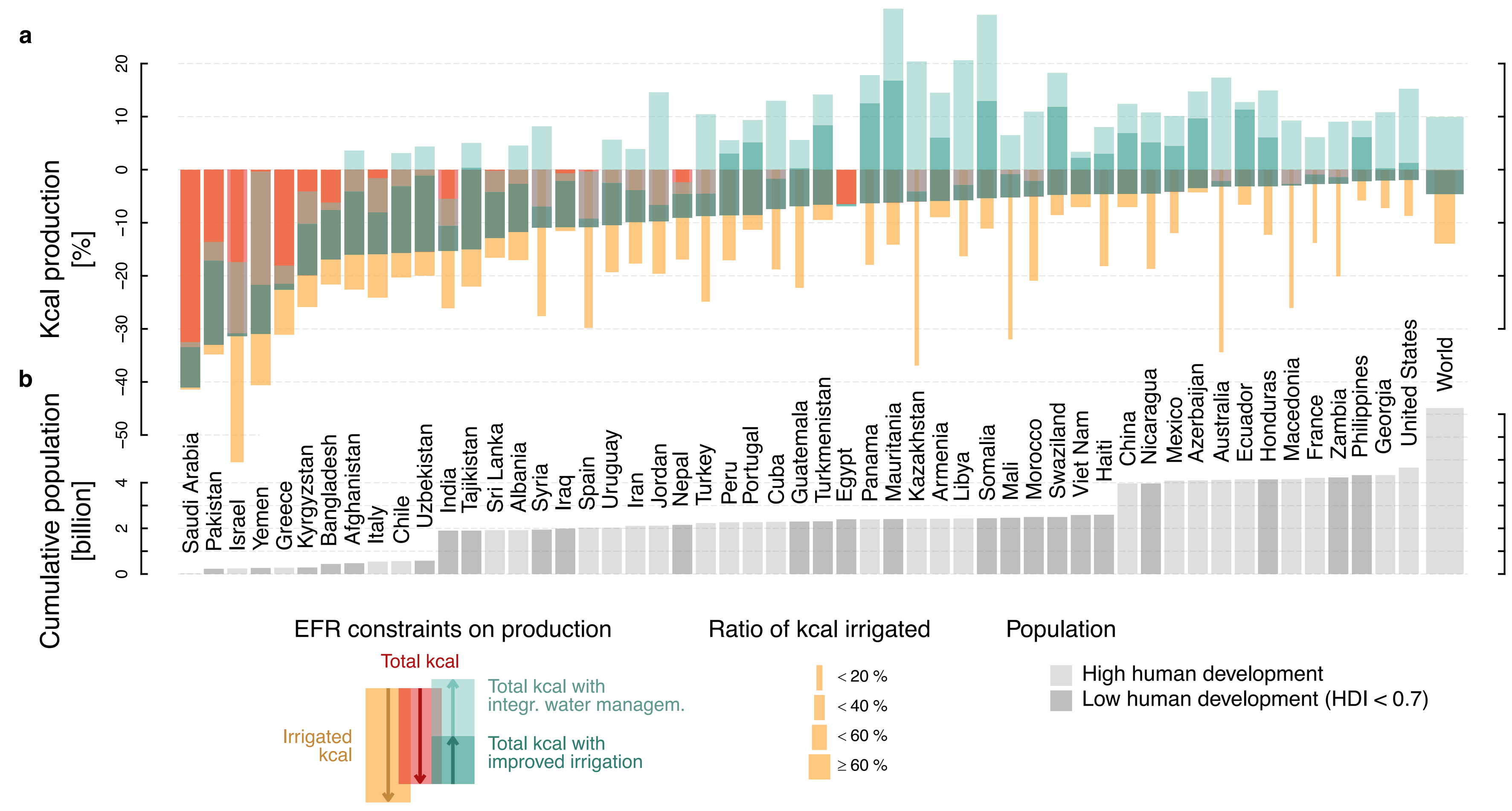

Figure 3: Reconciling EFRs and food production across countries. Countries are ordered by the dependence of kcal production on EFRs (red) (**a**). Beige bars highlight production declines on irrigated cropland only. Compensating effects of two different water management scenarios ('Scenario 3 irrigation upgrade' and 'scenario 4 integrated water management') on total production are indicated in mint green. Cumulative country population is shown in the bottom panel (**b**).

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