Title

Defining New Global Land-use Map in 2050 by Including Environmental Flow Requirements

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Abstract

Allocation of agricultural commodities and water resources is subject to changes in climate, demographics and dietary patterns. The use of integrated assessment modeling frameworks that combine climate, hydrological, crop and economic models anticipate those future changes. Results from previous integrated assessments have almost always neglected water resources or included them only in a broad way. The focus of this study is on how the inclusion of water resources affects future land use and, in particular, how global change will influence repartition of irrigated and rainfed lands at global scale. We used two general circulation model (GCM) simulations of climate change scenario including a radiative forcing of 8.5 W/m2 (RCP8.5), the socio-economic scenario (SSP2: middle-of-road), and the Variable Monthly Flow (VMF) method to calculate environmental flow requirements (EFRs). Irrigation withdrawals were adjusted to a monthly time-step to account for biophysical water limitations at finer time resolution. Re-allocation of rainfed and irrigated land might be useful information for land-use planners and water managers at an international level. For example, some countries are likely to adopt measures to increase their water use efficiencies (irrigation system, soil and water conservation practices) to face water shortages, while others might consider improving their trade policy to avoid food shortage and to protect freshwater ecosystems.

Future land use maps including water restrictions and socio-economic opportunities

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Introduction

- irrigated area has doubled since 1960
- Water use has tripled and outpaced human population growth rate
- Irrigated production supply 40% of our food
- Some rivers do not reach the sea anymore (Colorado, Nile, Indus)
- 35 % loss of river species worldwide (Loh et al., 2010)

Environmental flow requirements (EFRs) and water availability were almost always neglected in land-use scenarios (Alcamo, 2003 ; Gerten, 2013) or defined in a very simplistic way: fixed threshold of annual flow (Vorosmarty, 2010; Smakhtin, 2004).

A New environmental flow method was developed in 2014, the Variable Monthly Flow (VMF) and was implemented in the Global Biosphere Management model (GLOBIOM, Havlik et al., 2014) to design new sustainable land-use repartition of agriculture land including rainfed and irrigated areas (Figs. 1, 2 and 3; Table 1).

Material and method

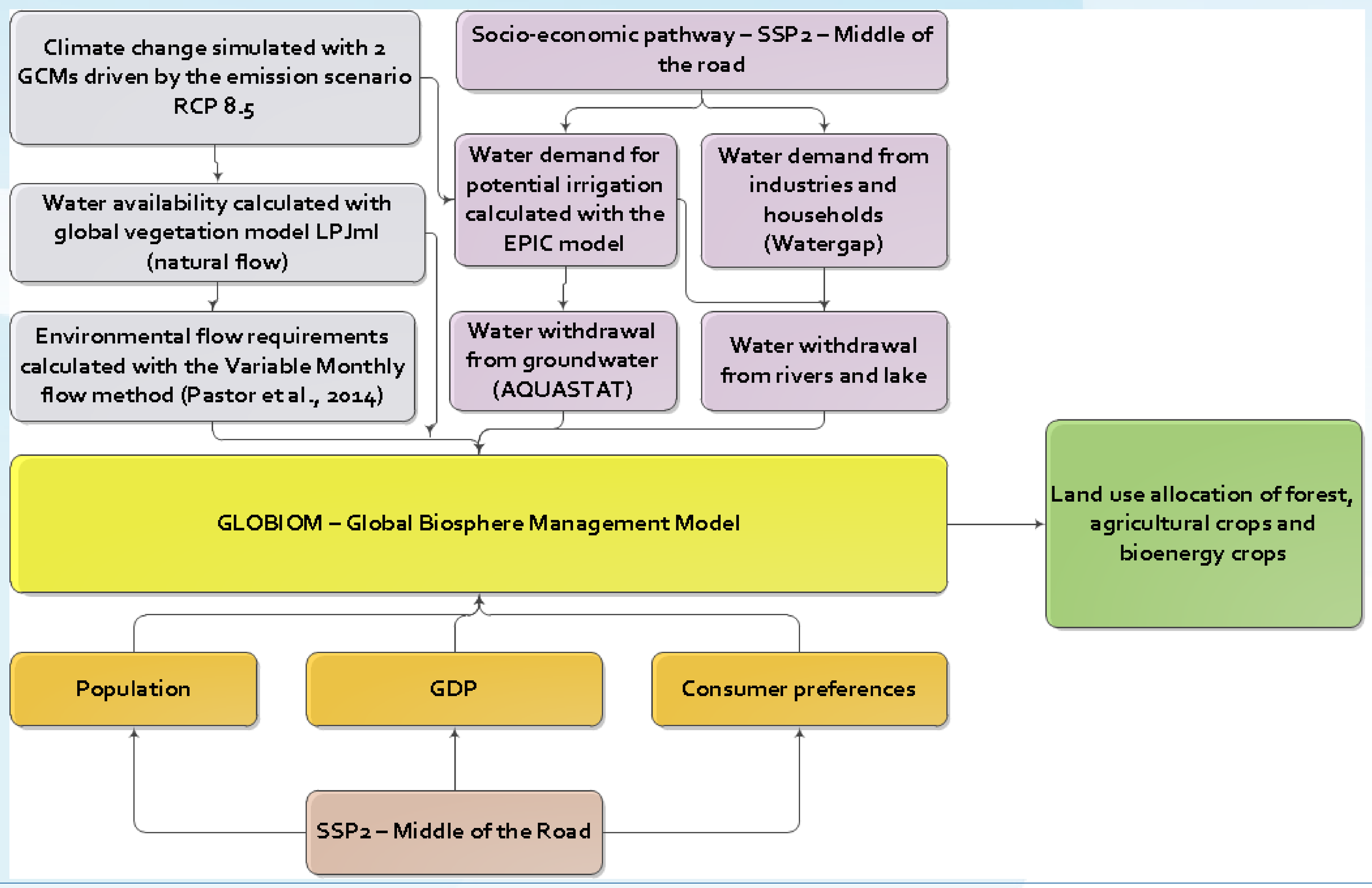

Fig. 1: Conceptual framework of designing new land-use maps with GLOBIOM

Scenarios

	Climate change 2050 (2GCM2 – RCP8.5)	Water demand 2050 (EPIC – watergap)	Water restrictions at LU level	Environmental Flow Requirement level (VMF method)
Baseline 2000	2000	2000	-	-
BAU_2050	x	x	-	-
BIO_2050	*x*	*x*	*x*	-
VMF_2050	X	X	X	X
VMFhigh_2050	X	X	X	X (+50%)

Table 1: scenarios selected to design new land-use map

Results and discussion

- Strong signal from both GCMs that water availability will decrease in Brazil, China, South-east Asia and in Mediterranean and middle-east regions.
- Without EFR implementation, irrigation expansion is likely to decrease by more than 20% (+50Mha) and with EFR implementation, irrigated area is likely to decrease by up to 32% (-70Mha; Fig. 4).
- The increase in food demand would require more than 150Mha.
- Depending on EFR implementation, the ratio of irrigated/rainfed area is likely to change from 0.35 (in both scenarios Baseline and BAU_2050) towards 0.17 with VMFhigh_2050 scenario (Fig. 5).
- Global impact of implementation is not substantial however, local impacts and shift of agriculture land and crops are substantial (maize, sugarcane area increase vs. wheat production; data not shown).

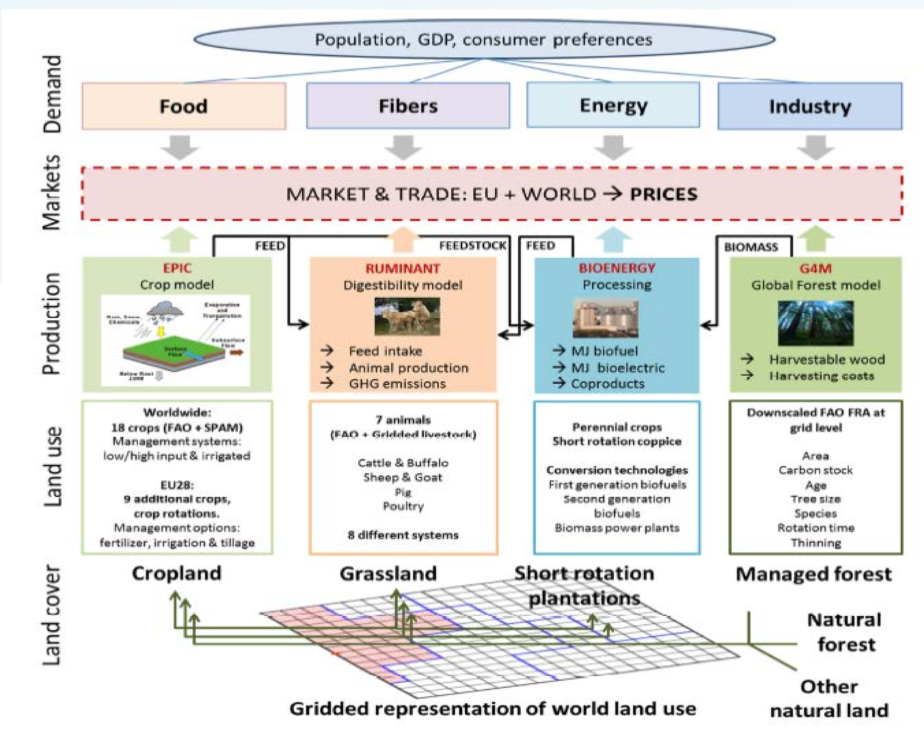

Fig. 2: Conceptual diagram of the Global Biosphere Management Model (GLOBIOM)

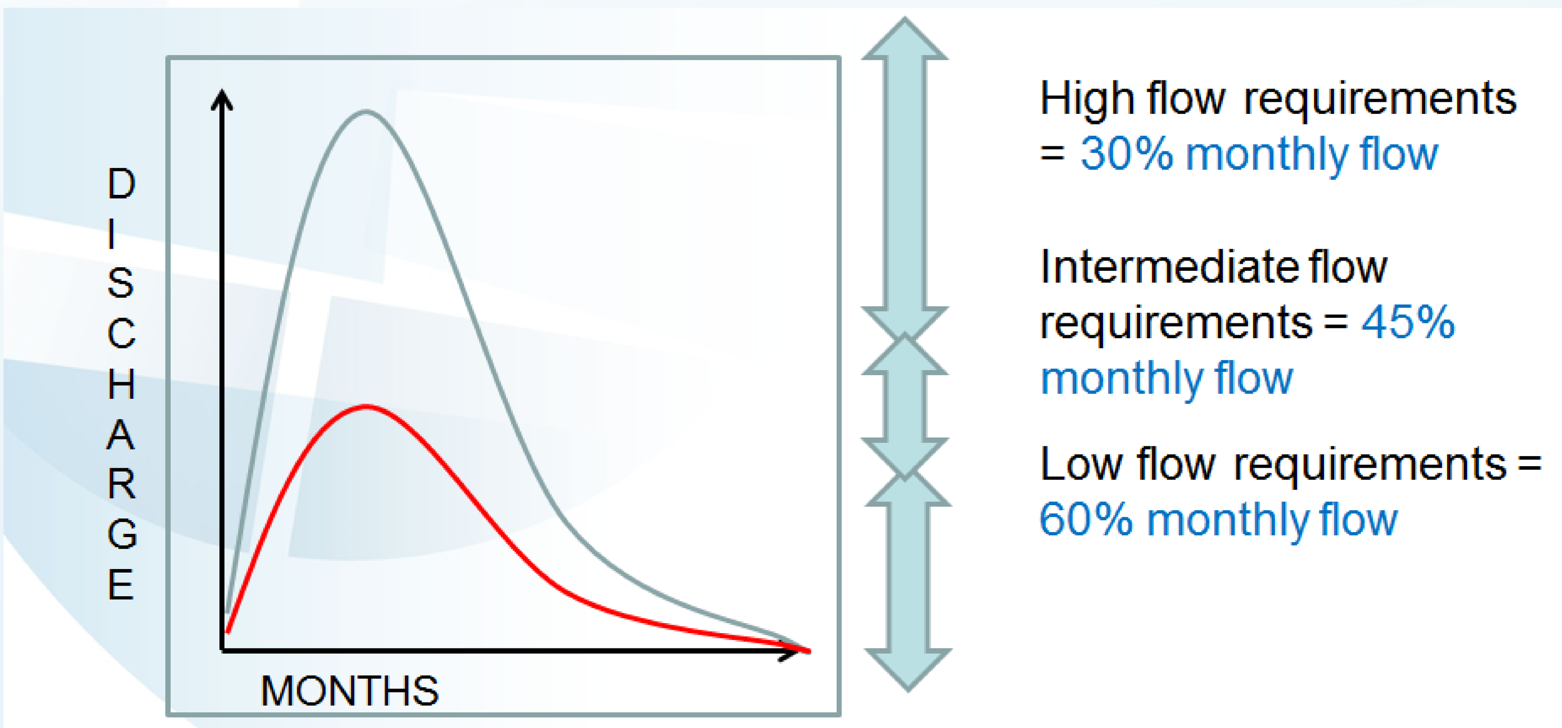

Fig. 3: Environmental flow requirement method: the Variable Monthly Flow (VMF) method (Pastor et al. 2014)

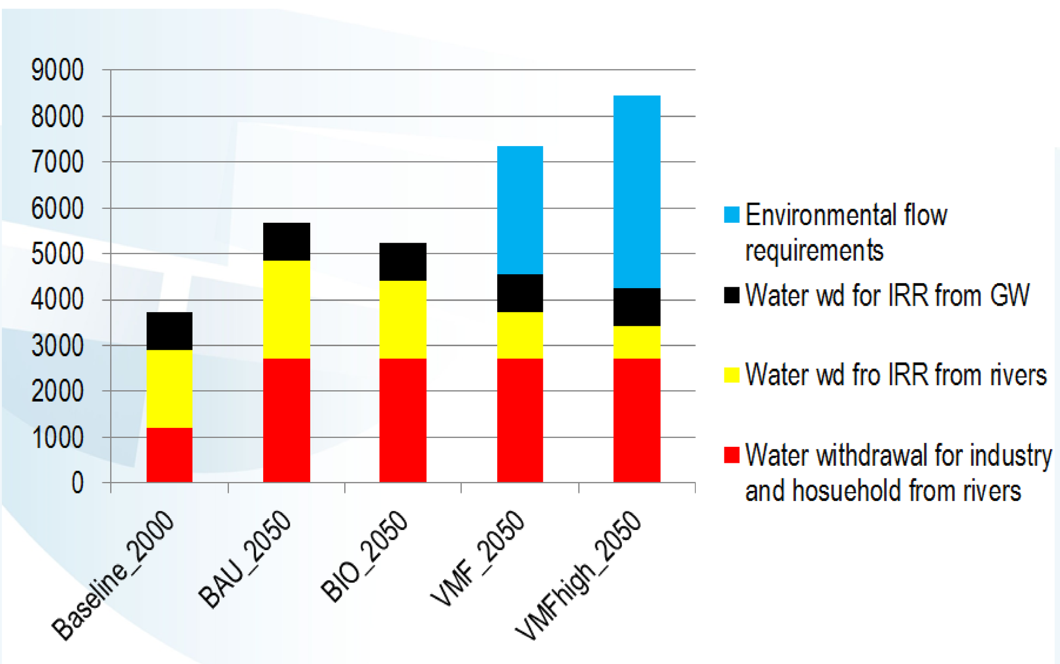

Fig. 4: Global water use prediction with EFR implementation by 2050 ($km^3\ year^{-1}$)

Source: http://allianceforwatereducation.org/why-its-urgent/6-reasons-why-you-need-to-know-about-water-right-now/

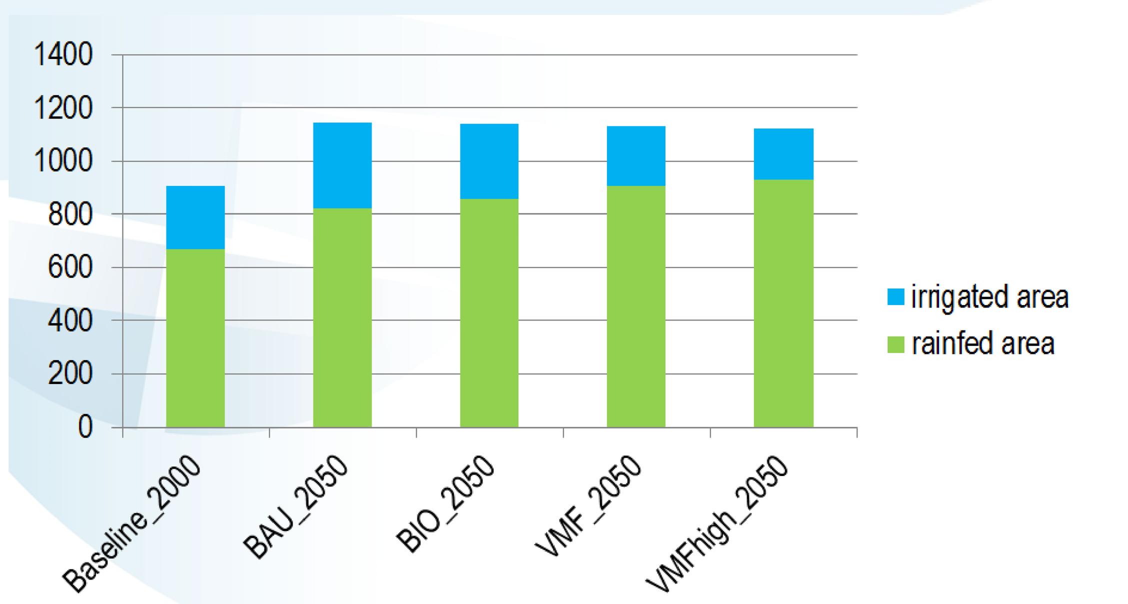

Fig. 5: Global agriculture land expansion with EFR implementation by 2050 (Mha)

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