CGIAR RESEARCH PROGRAM ON Water, Land and Ecosystems

LED BY: IWMI International Water Management Institute

Potential for sustainable groundwater irrigation in Africa: A development perspective

Irrigation expansion is seen as a significant leverage to food security, livelihoods, and rural, agricultural and broader economic development in Africa, especially in sub-Saharan Africa. While still playing a secondary and minor role in national and regional plans, groundwater is increasingly developed by smallholder farmers as a viable and suitable supplementary or sole source of water for irrigation along with traditional surface water resources.

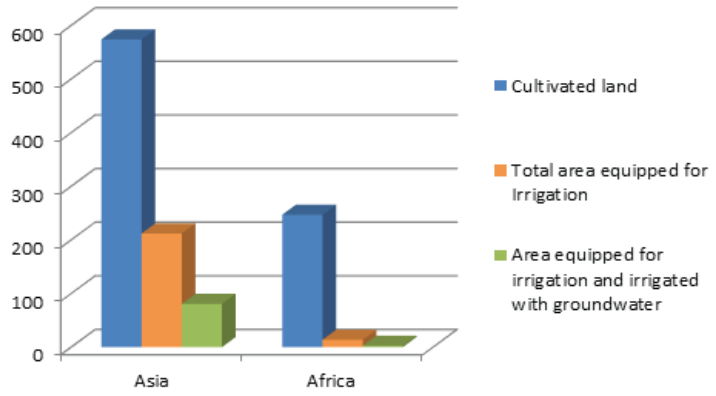
Why use groundwater for irrigation?

Groundwater resources in Africa are generally **plentiful**, but **underutilized**. Moreover, groundwater provides an important **buffer to climate variability** and change.

Fair assumption for further developing groundwater irrigation

In Africa, groundwater irrigation presently covers around 2 × 10^6 ha or 1% of the cropland, while it is 38 × 10^6 ha or 14% of the cropland in Asia, which has a similar climate (Figure 1).

Figure 1. Area irrigated with groundwater compared to the cultivated area in Asia and Africa expressed in 10^6 ha.



Source: Siebert et al. 2010.

What is the groundwater irrigation potential in Africa?

The average annual renewable groundwater availability for irrigation ranges from 692 to 1,644 km^3 depending on three scenarios (where the environmental groundwater requirements represent 70%, 50% and 30% of the recharge). The total area of cropland that is irrigable with groundwater ranges **from 44.6 to 105.3 × 10^6 ha, corresponding to 20.5 to 48.5% of the cropland** over the continent (Figure 2; Table 1). In particular, significant potential exists in the semi-arid Sahel and eastern African regions, which could support poverty alleviation if developed sustainably and equitably. Results show that the groundwater irrigation potential is inconsistently distributed across the continent, even within individual countries, mainly reflecting recharge patterns and presence or absence of cropland.

Where is the untapped part of the groundwater irrigation potential?

The total area of cropland that is irrigable with groundwater is compared with existing data on the present development of groundwater irrigation across Africa (Figure 3), and shows the contrast between the areas with and without further potential for groundwater irrigation development, which are the green areas versus the red areas, respectively).

Photo: Joe Ronzio/IWMI

Figure 2. (I) Total area irrigable with groundwater per cell (0.5° × 0.5°) in 10^3 ha, and (II) proportion of cropland irrigable with groundwater for various levels of environmental groundwater requirements as a fraction of recharge: (a) scenario 1: 70%, (b) scenario 2: 50%, and (c) scenario 3: 30%.

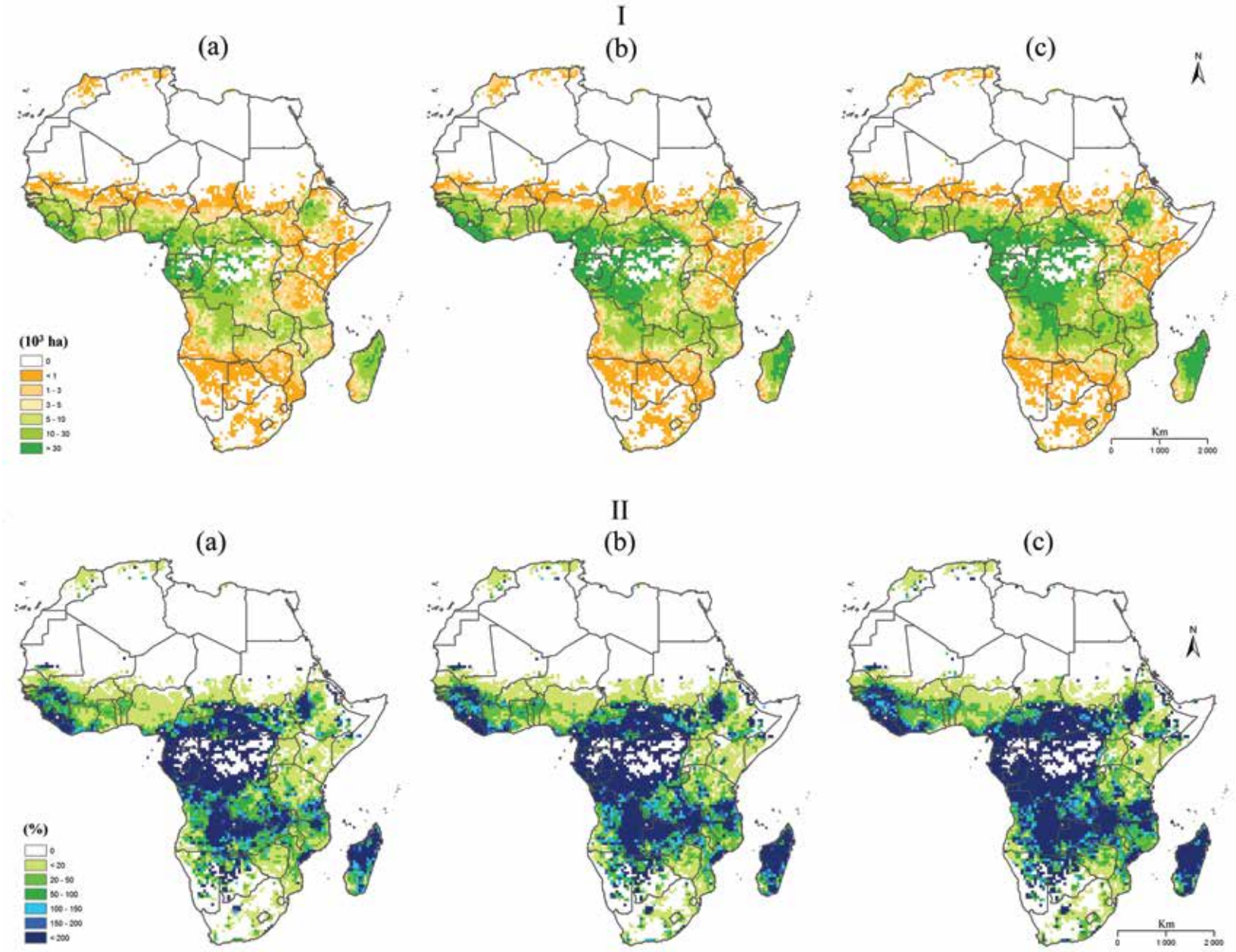
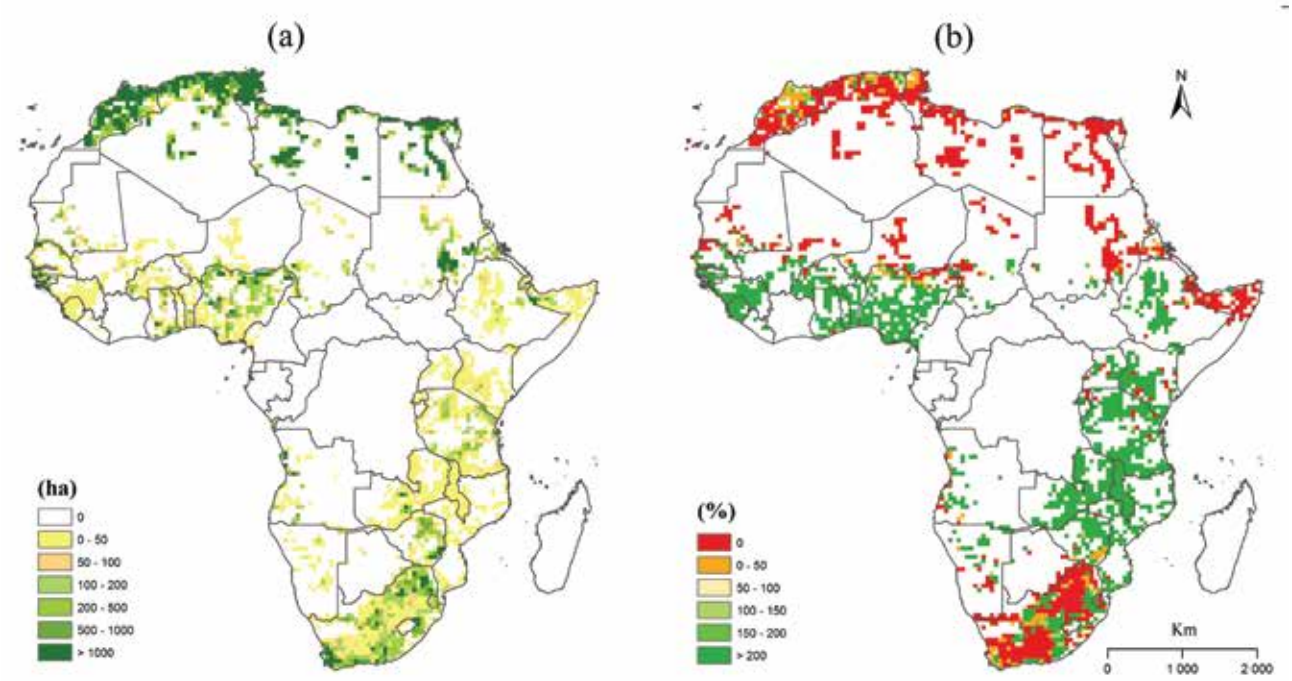


Table 1. Gross groundwater irrigation potential and cultivated area per country in Africa.

Country	Area of cropland irrigable with groundwater[a] (10^3 ha)			Siebert et al. (2010)	FAO AQUASTAT database[b]
	Scenario (percentage of groundwater for environmental requirements)			Area equipped for irrigation irrigated with groundwater (10^3 ha)	Cultivated land (10^3 ha)
	1 (30%)	2 (50%)	3 (70%)		
Algeria	140	94	49	362.1	8,465
Angola	7,032	5,016	3,001	16	5,190
Benin	518	368	218	2.2	3,150
Botswana	66	46	27	0.7	287
Burkina Faso	268	188	108	3	6,070
Burundi	214	149	84	0	1,450
Cameroon	7,019	5,005	2,990	1	7,750
Central African Republic	6,961	4,969	2,978	0	1,880
Chad	566	401	237	6	4,932
Côte d'Ivoire	2,920	2,078	1,236	0	7,400
Democratic Republic of Congo	23,060	16,450	9,840	0	7,810
Djibouti	5	3	2	1	2
Egypt	2	2	1	331.9	3,612
Equatorial Guinea	634	453	271	0	180
Eritrea	10	7	4	16.2	692
Ethiopia	4,336	3,064	1,793	2.6	16,488
Gabon	5,884	4,202	2,520	0	495
Gambia	24	17	10	0	445
Ghana	1,426	1,010	594	12	7,400
Guinea	2,751	1,962	1,172	0.5	3,700
Guinea-Bissau	176	125	75	4.9	550
Kenya	512	355	199	1	6,130
Lesotho	21	15	8	0.1	285
Liberia	2,238	1,597	956	0	710
Libya	26	18	10	464	2,055
Madagascar	6,753	4,814	2,875	0	4,110
Malawi	640	454	268	0	3,885
Mali	787	559	331	1	7,011
Mauritania	52	37	22	4.8	411
Morocco	145	97	49	677.2	9,403
Mozambique	2,171	1,546	921	0.6	5,950
Namibia	98	70	41	1.6	809
Niger	19	12	6	1.4	16,000
Nigeria	6,287	4,446	2,606	66.8	41,700
Republic of Congo	7,420	5,295	3,170	0	600
Rwanda	148	102	56	0.1	1,432
Senegal	382	271	160	10.2	3,415
Sierra Leone	1,551	1,107	662	0.2	1,897
Somalia	51	35	20	10	1,129
South Africa	270	181	95	127.3	12,413
South Sudan	3,042	2,164	1,286	0.2	2,760[c]
Sudan	429	299	169	69	13,893[c]
Swaziland	21	15	8	1	190
Tanzania	3,007	2,135	1,263	17.5	16,650
Togo	300	213	126	0.1	2,850
Tunisia	26	17	9	257	5,249
Uganda	571	399	228	0.1	9,150
Western Sahara	0	0	0	0	4[c]
Zambia	3,952	2,818	1,684	6.7	3,836
Zimbabwe	370	259	148	20	4,100

[a] Errors up to 35% for small countries (due to the cell size, projection used in GIS and shape of the countries, i.e., Gambia)
[b] http://www.fao.org/nr/water/aquastat/countries_regions/index.stm
[c] estimated

Figure 3. (a) Area irrigated with groundwater in 2005 expressed in hectares per cell (0.5° × 0.5°) (*Source:* adapted from Siebert et al. 2010), and (b) groundwater irrigation potential for scenario 2 (environmental groundwater requirements represent 50% of the recharge) expressed as a percentage of the area irrigated with groundwater.



Methodology and limits of the approach

The maps (Figure 2) are derived from a monthly water balance assessment over the period 1960-2000 based on a geographic information system (GIS) analysis, model data (van Beek et al. 2011; Wada et al. 2011) and mapping with a final resolution of 0.5˚ (about 50 km x 50 km). The groundwater irrigation potential is the cropland area that can be irrigated with the available groundwater resources (as the excess of groundwater recharge after satisfying other demands from humans and the environment), and crop irrigation requirement based on crop distribution and cropping calendar. The methodology assumes that groundwater is the sole source of irrigation water and provides an estimate of the area that could potentially be irrigated using groundwater disregarding any existing irrigation, whether it is from groundwater or surface water. The water balance approach considers locally renewable groundwater availability as the major controlling parameter for groundwater irrigation potential (i.e., non-renewable or fossil groundwater is not considered), and assumes non-limiting conditions in terms of other fundamental physical properties. Possible constraints related to hydrogeology as well as water quality and socioeconomic conditions, such as infrastructure (roads, markets, energy/electricity) or institutional/farmer capacities, may reduce the potential or hamper its realization. Furthermore, climate trends and progressive water demands from growing human and livestock populations have not been considered.

References

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Further Information: This leaflet has been produced by the International Water Management Institute (IWMI).

For more information, contact:
Yvan Altchenko, Senior Researcher – Hydrogeologist, IWMI, Pretoria, South Africa (y.altchenko@cgiar.org)
Karen Villholth, Principal Researcher – Groundwater Management, IWMI, Pretoria, South Africa (k.villholth@cgiar.org)

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