Relationship Between Physical Water Availability and Development Indicators in Africa

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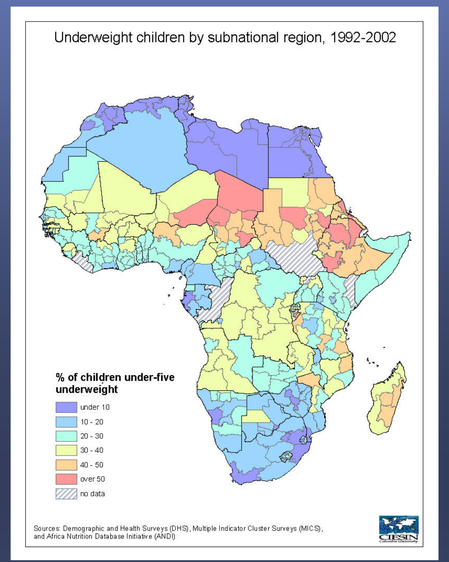
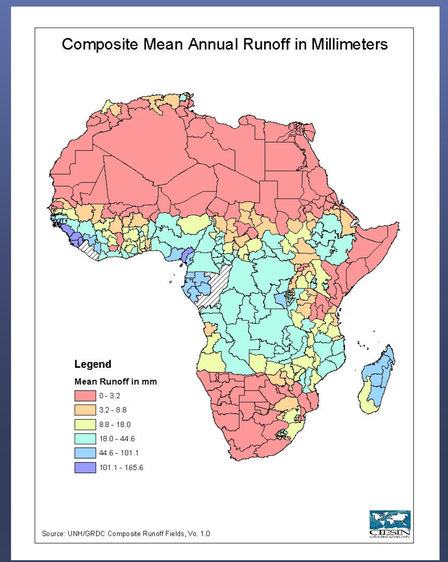
What is runoff? Runoff can be thought of as the proportion of precipitation that is left *after* evapotranspiration and *after* the soil moisture deficit is satisfied. It is typically reported in units of depth (e.g., in millimeters) just like precipitation, and is an areally-averaged quantity (i.e., average runoff depth over a basin).





Abstract: It is widely recognized that water is a crucial ingredient for economic development. But how does physical water availability relate to common health and sanitation indicators such as child malnutrition, access to improved sources of water supply, and diarrhea prevalence? And how is population distributed in relation to available water? This exploratory analysis utilizes data from the UNH/GRDC Composite Runoff Fields (v.1); the Demographic and Health Surveys (DHS); the Multiple Indicator Cluster Surveys (MICS); and the Gridded Population of the World (GPW v.2).

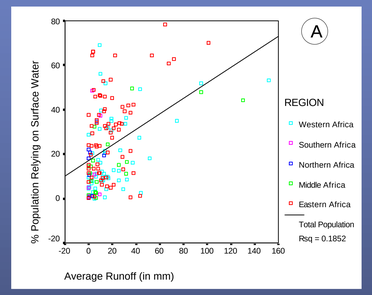
Findings: Preliminary analyses show:

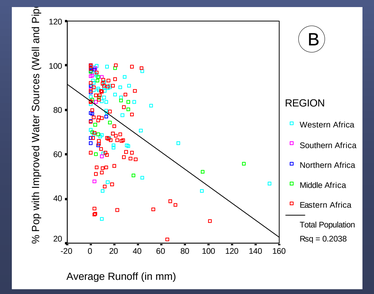
(1) A significant proportion of the continent is characterized by water scarcity (below right).

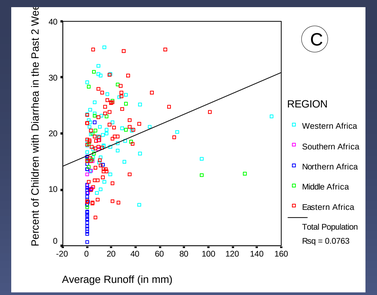
(2) In Sub-Saharan Africa there appears to be a negative relationship between annual water availability and child malnutrition (left). Because per capita income also reduces child malnutrition, in North Africa where development levels are higher per capita income strongly mediates the negative effect of low water availability.

(3) An abundance of water, rather than being associated with higher levels of health and sanitation, is generally associated with poorer access to improved water sources and higher levels of diarrheal disease (upper right).

Further analyses will combine these countervailing impacts of water availability on child wellbeing.







- Chart A shows that as water runoff increases, the proportion of the population that relies on surface water as their sole water source also increases.
- Chart B shows that as runoff increases, the proportion of the population relying on improved water sources (piped water and wells) decreases.
- Paradoxically, those countries with the greatest physical water availability are more likely to have unimproved water sources. This suggests that these countries do not invest in water supply infrastructure because of an abundance of water resources.
- Chart C shows that there is a positive association between runoff and incidence of diarrhea. This potentially reflects greater reliance on less sanitary surface water supplies, and a tendency of water-rich places to have less water delivery infrastructure.

Model Predicting Malnutrition Accounting for Water Availability and Per Capita Income

	Unstandardized Coefficients
(Constant)	34.179
Average Runoff (in mm)	-0.045 *
GDP per Capita (PPP, 1998)	-0.003 ***
North Africa Dummy Variable	-8.220 ***

Dependent Variable: Percent of Children Underweight
Adjusted R^2 = 0.386 ***
N = 340, * P > .0001, ** P > .01, * P > .05
Note: The North Africa region includes Algeria, Egypt, Libya, Morocco, and Tunisia

- In Africa, a high proportion of agricultural households are dependent on rainfed lands. I hypothesized that drier areas with low runoff would have high proportions of underweight children.This relationship is confirmed in Sub-Saharan Africa.
- North Africa, although very dry, does not experience equally high levels of child malnutrition due to much higher per capita income. This suggests that levels of development are an important factor in mediating the expected relationship between water scarcity and child malnutrition.

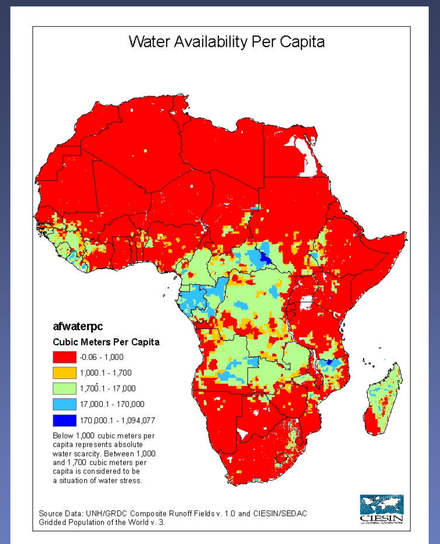
Water and Development Hotspots

		% Underweight				Runoff (mm)		
	GNI PPP	High	Low	Mean	Nat'l Avg.	High	Low	Mean
Ethiopia	$800	52.5	13.9	40.2	47.1	35.2	0.0	16.5
Eritrea	$1030	51.2	23.4	41.1	43.7	5.5	0.0	1.6
Sudan	$1750	51.3	34.2	43.0	-	6.9	0.0	2.1
Madagascar	$820	44.1	31.8	38.1	40.0	101.1	9.3	61.3
Mali	$770	40.7	25.8	34.2	40.0	13.8	0.0	5.1
Niger	$880	51.0	33.2	39.5	39.6	1.4	0.0	0.6
Burkina Faso	$1120	36.8	32.9	34.8	37.6	6.2	1.2	4.0
Tanzania	$520	48.2	14.2	30.8	30.9	26.2	0.0	9.3
Chad	$1060	70.6	24.6	43.2	27.6	31.8	0.0	8.8
Mozambique	$1050	49.8	5.7	27.2	26.1	38.0	0.0	13.8
Mauritania	$1940	37.1	21.4	30.5	23.0	0.4	0.0	0.1

Note: High, Low and Mean for % Underweight and Runoff relate to the figures for the subnational units in each country. GNI PPP per capita, 2001 (US$) is the gross national income in purchasing power parity (PPP) divided by midyear population, from the World Bank, *World Development Indicators 2002*.

- Water and Development Hotspots (left) are countries with low per capita income, high malnutrition, and low levels of runoff. In these countries a high proportion of GDP is derived from agriculture. Therefore, water scarcity is likely to be a brake to development.

- The map at right depicts the extent of water scarcity in Africa. It represents available runoff divided by population for 2.5 minute grid cells.[1] The red areas suffer absolute water scarcity, whereas the brown areas suffer from water stress. Green and blue areas are relatively water abundant.



[1] This map does not take into account water that flows between grid cells in the form of river corridor discharge. This is why major river basins such as the Nile and Niger show up as being water scarce.

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