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DEVELOPMENT AND EVALUATION OF A REGIONAL WATER POVERTY INDEX FOR BENIN

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ABSTRACT

The paper discusses the application of the Water Poverty Index (WPI) as a monitoring tool for Benin's water sector. Benin is currently in a process of political decentralization shifting responsibility for and administration of rural water supplies from the national to the communal level. Appropriate indicators are needed for monitoring and analyzing the progress of the water sector for each community. The Water Poverty Index allows monitoring of a combination of aspects affecting rural water management, including water sources, access to and use of water, human capacity to manage water, and environmental impacts. The application of this index is tested for Benin at the regional level. A series of variables have been chosen for inclusion into the index following data collection and analysis in Benin under the IMPETUS project. Results show a clear distinction between communes in the north and the south of the country and WPI rankings are similar to those for poverty levels. The paper concludes with a discussion of the strengths and weaknesses of the WPI and suggests improvements for its application at the communal level.

Keywords: Water Poverty Index, Benin, Water, Indicators, Water Stress, Water Supply, decentralization

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Claudia Heidecke[1]

1. INTRODUCTION

During the last few years water has become an increasingly important issue in Benin. In order to achieve its Millennium Development Goals by 2015, Benin is focusing on reducing the number of people without access to potable water. At the same time, the country is undergoing a decentralization process, which shifts responsibilities and administration of water and other resources from the national to the communal level. In line with this new policy focus, rural water supply has been reorganized at the communal level.

In order to monitor the achievement of the potable water target at the local level, appropriate indicators are needed that allow measurement of progress of the water sector for each community. Such indicators should not only provide information on the progress of the target—increasing the number of people with access to drinking water—but also indicate if the progress actually contributes to the Millennium Development Goals of reduced hunger, improved food security, and better health. The Water Poverty Index (WPI) (Sullivan 2000, 2002) was identified as a possible indicator for monitoring progress at the local level, as it puts access to water in a wider water-related context.

The following sections give an overview on Benin, introduce common indicators used to monitor water development, and then describe the methodology and application of the WPI to Benin. The paper concludes with a section on the strengths and weaknesses

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of the index related to data availability, weighting, correlations, and relationships to other indicators.

2. BACKGROUND ON BENIN

NATURAL CONDITIONS

Benin is located in West Africa, between 6°30' and 12°30’ degrees north and 1° and 30°40' degrees east. The country has a surface area of 112,620 km^2, of which 2,000 km^2 are covered by water. Benin shares borders with Togo and Burkina Faso to the west and Niger and Nigeria to the east. Benin’s climate can be divided into three different zones: The southern zone with equatorial climate conditions, the northern zone with tropic continental conditions, and the transition zone in the centre of the country, which faces mixed climate conditions. Rainfall averages 1,039 mm per year, but levels vary considerably among regions and during the course of the year with 70-110 rainy days per year, ranging from 805-1,414 mm. Annual temperature varies between 24.5-33.5ºC. The average potential evapotranspiration rate ranges from 3.7 mm to 4.8 mm per day (FAO 2005).

Several rivers run through the country, of which the most important ones are the Pendjari River in the North (380 km), the Couffo (170 km), and the Oueme (150 km). The Niger forms the northern border of the country. Moreover, several smaller rivers and lagoons are located mainly in the south of the country (FAO-CENATEL 1998). Internal renewable water resources are estimated at 10 km^3 per year, of which groundwater resources account for 1.8 km^3 per year. On a per capita basis, internal renewable water resources stands at 3741 m^3, relatively high compared to Benin’s neighboring countries (see Table 1) (FAO 2005).

Table 1--Water resources

	IRWR				Natural Renewable Water Resources		
	Groundwater Recharge (km^3)	Surface Water (km^3)	Overlap (km^3)	Total (km^3)	Total (km^3)	Per capita (m^3 per person)	Year of data
Benin	1.8	10	1.5	10	25	3,741	1994
Burkina Faso	9.5	8	5	13	13	1,024	1992
Niger	2.5	1	0	3.5	34	2,891	1988
Nigeria	87	214	80	221	286	2,384	1987
Togo	5.7	11	5	12	15	3,076	1987

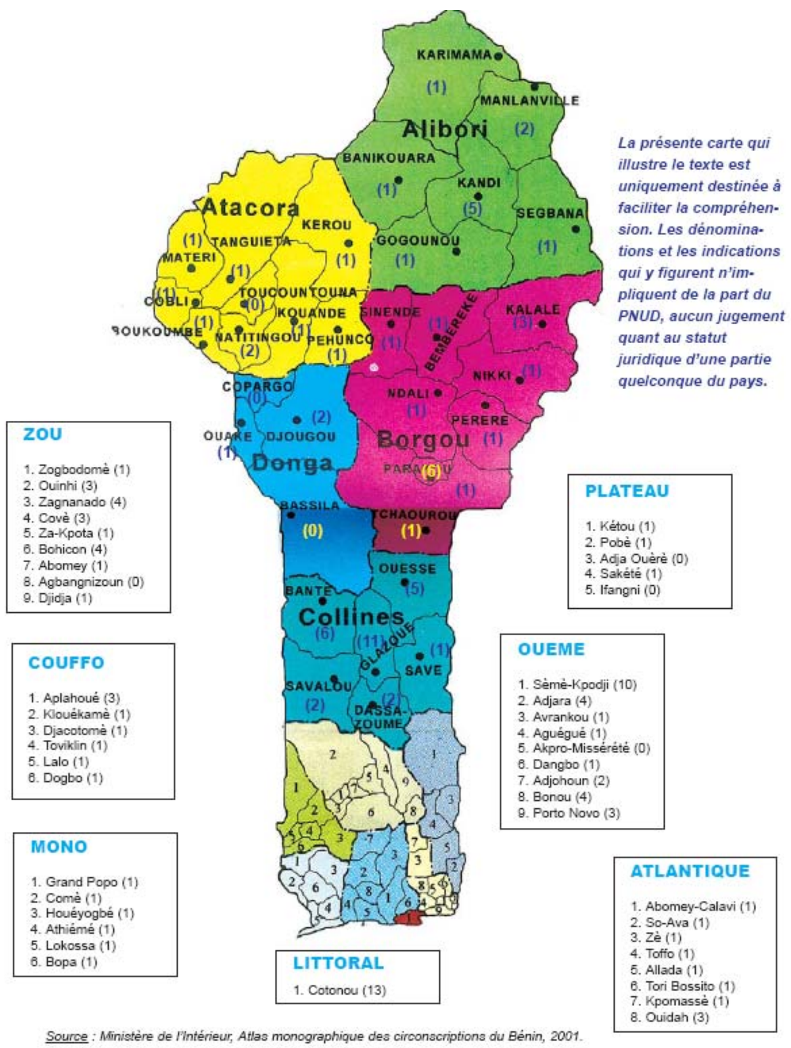
Note: IRWR = Internal Renewable Water Resources, defined as average annual flow of rivers and groundwater recharge generated from endogenous precipitation.
Natural Renewable Water Resources is the sum of IRWR and natural flow originating outside of the country
Overlap is the volume of water resources common to both surface and groundwater.
Source: World Resource Institute (2004).

POLITICAL AND ECONOMIC SITUATION OF THE COUNTRY

Benin has undergone massive political and economic restructuring in its history especially since independence in 1960. A military regime during 1960 to 1972 was followed by a socialist Marxist government from 1971 to 1989. Since 1989 Benin is a democratic republic with multi-party rule (CIA 2005).

In the early 1990s the government introduced the idea of decentralization. However, full decentralization did not gain momentum until 2002, when the first communal elections took place. Since then the country has been divided into 12 administrative zones called ‘departments’ and 77 communes (see Figure 1). Nowadays, the communes have financial autonomy and are run by elected councils (UNDP 2003). Decentralization has greatly affected communal water policies and supplies. The communes are now in charge of providing facilities and managing local water supplies. Water committees have been created to manage these sources, and to charge users. The village head is normally in charge of organizing such a committee. Charges applied are used to develop new water sources and for maintaining existing ones (DANIDA 1998).

Figure 1--Administrative map of Benin



Source: UNDP (2003).

With around seven million inhabitants Benin is a fairly small country by West African standards. However, with annual population growth of 2.8% per year, the population is expected to have doubled by 2045 (World Bank 2004).

The growing population will put significant pressure on available water resources. Water is needed both for drinking purposes and agricultural production, and current and planned industrial water use. Although current water levels satisfy the food and water needs of the country, this may not be the case in the future.

Table 2 summarizes public expenditure, access to water, life expectancy, and mortality indicators for Benin, Sub-Saharan Africa, and low-income countries.

Table 2--Public expenditure, access to water, life expectancy and mortality indicators for Benin

	Benin	Sub-Saharan Africa	Low-income countries
Public expenditure (2001)			
Health (% of GDP)	2.1	2.5	1.1
Education (% of GDP)	3.3	3.4	3.1
Access to water source (%)[2] **(2000)**			
Total	63	58	76
Urban	74	83	90
Rural	55	46	70
Life expectancy (years) (2002)			
Total	53	46	59
Male	51	45	58
Female	55	47	60
Mortality (2000)			
Infant (per 1,000 live births)	93	103	79
Under 5 (per 1,000 live births)	151	174	121
Adult (15-60) 2000-2002			
Male (per 1,000 population)	384	519	310
Female (per 1,000 population)	328	461	259

Source: World Bank (2004).

The health situation of the country is greatly jeopardized by access to water. Diarrheal diseases increased from 105 cases per 1000 children (from 0 to 4 years) in 1995 to 121 cases in 1999 (CNLP 2002). Lack of access to clean water forces many,

[2] **Access to safe water.** Measured by the number of people who have a reasonable means of getting and adequate amount of clean water, expressed as a percentage of the total population. It reflects the health of a country's people and the country's ability to collect, clean, and distribute water. In urban areas "reasonable" access means there is a public fountain or water spigot located within 200 meters of the household. In rural areas, it implies that members of the household do not have to spend excessive time each day fetching water. Water is safe or unsafe depending on the amount of bacteria in it. An adequate amount of water is enough to satisfy metabolic, hygienic, and domestic requirements, usually about 20 liters (about 4 gallons) per person per day.
http://www.worldbank.org/depweb/english/modules/glossary.html#wataccess (accessed 6.10.2005)
Deveopment Education's Programme World Bank

particularly rural dwellers, to drink unsafe water, which aggravates existing health problems by causing and spreading disease. Only three quarters of the urban population and just over half of the rural population had access to safe water sources in 2002 (World Bank 2004).

Table 3 presents selected indicators of Benin's economy. The country relies heavily on imports, especially for food production.

Table 3--Economic indicators for Benin, 2002

Indicator	
GDP in PPP value	$7.742 Billion(PPP)
GDP per capita	$1,100 (PPP)
GDP Growth Rate	5.5% per year
Investments	19.3% of GDP
Inflation Rate (consumer price)	1.5% (estimations for 2003)
Exports	$485 million f.o.b. (2003 est.)
Imports	$726 million f.o.b. (2003 est.)
External Debt	US$1.6 billion (2000)
Foreign Aid	US$342.6 million (2000)

Source: World Bank 2004

The service sector is the largest sector in Benin contributing 50 percent of the country's GDP, followed by agriculture, accounting for 36 percent of Benin's GDP in 2003. In particular, cotton production significantly contributes to the national economy as a major cash crop. Overall, fertilizer use is very high, particularly in central Benin, where cotton production is concentrated.

Food production has a great potential for growth and can be enhanced through increased irrigation. Currently, less than 12,000 ha are being irrigated which is less than 4 percent of the irrigation potential of 320,000 ha. However, irrigation expansion would also put pressure on available supplies (FAO 2005).

INSTITUTIONS AND ORGANIZATIONS IN THE WATER SECTOR

Water Supply

The water sector is divided into urban and rural supply. Until 2002, urban water supplies were administered in conjunction with urban electricity supplies by SBEE (Société Béninoise d'Electricité et d'Eau); however much of the electricity sector has since been privatized. Urban water continues to be delivered by the public sector through the Société Nationale des Eaux du Bénin (SONEP). The highest amount of annual urban water is delivered to the department Atlantique as it includes the Cotonou city supply. Public deliveries are larges in the dry season when other sources, such as wells, do not carry enough water (SBEE 2001).

The Ministry of Hydrology and its Office of Hydrology (DGH) has the primary responsibility for rural water supplies. The process of decentralization has enhanced the scope of regional offices of the DGH for the administration of water supplies at the communal level.

In addition, rural water supply is supported by the PADEAR program (Projets d'Assistance au Développement du secteur de l'alimentation en Eau potable et de l'Assainissement en milieu Rural), a cooperation between different international organizations and donors. Since 1992, the PADEAR program has focused on the development and funding of water-related projects in rural areas, including the construction and maintenance of wells and the supply of hand pumps (MEEH, DGH 2004).

Rural dwellers derive their drinking water from a variety of sources:

- Direct withdrawal from small ponds
- Traditional wells that have a diameter of up to 1.5 m and are constructed locally (water in these well is often not safe for drinking)
- Modern wells that are filled with concrete in order to prevent outside contamination
- Boreholes are drilled wells reaching into deeper aquifers and, hence, provide cleaner, high-quality water (Weisshaupt 2002).

Up to now data on the amount of water consumed from rural water sources is not available for each commune. Hence, only the public water consumption has been introduced in the calculation of the WPI.

CHALLENGES FACING BENIN'S WATER SECTOR

Benin's water sector faces several difficulties in the areas of technical infrastructure, institution building, and water resource conservation. The country has a long way to go to reach the Millennium Development Goal of halving the population without access to drinking water by 2015—it would need to install an additional 28,000 water delivery points (MEEH, DGH 2004).

In the wake of the decentralization process, efficient management and monitoring of local water supplies depend even more than before on the development of leadership and administrative capabilities at the local level. Moreover, water conservation is an issue rarely discussed in the country. Many water sources are threatened by contamination. High levels of groundwater extraction from wells near Cotonou, for example, increase the threat of saltwater intrusion. Furthermore, high amounts of fertilizers and pesticide use for cotton production in the centre of the country contaminate groundwater resources (BMZ 2002).

3. INDICATORS FOR WATER AND DEVELOPMENT

The following section provides a brief description of selected economic development and water indicators, including the Human Development Index (HDI), the Hydrological Water Stress Indicator (HWSI), and the Social Water Scarcity Index (SWSI).

HUMAN DEVELOPMENT INDEX (HDI)

The Human Development Index (HDI) has become one of the most common indicators to reflect the state of a country's development. Prior to the HDI, per capita GDP used to be the most common measure of development. The HDI adds several dimensions to a country's development status:

1. A long and healthy life, as measured by life expectancy at birth
2. Knowledge, as measured by the adult literacy rate (with a two-thirds weight) and the combined primary, secondary and tertiary gross enrolment ratio (with a one-third weight).
3. A decent standard of living, as measured by per capita GDP (US$ PPP) (UNDP 2004).

Each of the indicator components included has minimum and maximum values, which are standardized for the calculation (see Table 4).

Table 4--Goalposts for calculating the HDI

Indicator component	Maximum Value	Minimum Value
1) Life Expectancy at birth (years)	85	25
2a) Adult Literacy (%)	100	0
2b) Combined gross enrolment ratio (%)	100	0
3) GDP per capita (US$ PPP)	40,000	100

Source: UNDP (2004).

The actual values of the dataset are standardized using the following equation:

$$(x_i - x_{\min})/(x_{\max} - x_{\min}) = x_i^*, \quad (1)$$

where the x_i^* for all three indicators are averaged to derive the HDI.

HYDROLOGICAL WATER STRESS INDICATOR (HWSI) AND SOCIAL WATER SCARCITY INDEX (SWSI)

Falkenmark, Lundqvist and Widstrand (1989) describe water stress as water available per capita and year, differentiating four categories:

1. Availability > 1,700m³/capita/year => water shortage occurs only irregularly or locally,
2. Availability < 1,700m³/capita/year => water stress appears regularly,
3. Availability < 1,000m³/capita/year => water scarcity is a limitation to economic development and human health and well-being,
4. Availability < 500m³/capita/year => water availability is a major constraint to life. (Falkenmark, Lundqvist and Widstrand 1989)

Ohlsson (1999) further developed the Falkenmark or water stress index into the Social Water Scarcity Index (SWSI) to reflect hydrological water scarcity in relationship to the social conditions of a country by dividing the HWSI (Hydrological Water Stress Index) by the HDI:

$$SWSI = \frac{\frac{HWSI}{HDI}}{2} \qquad (2)$$

The resulting values are then grouped reflecting different stages of water availability:

5 relative sufficiency

6- 10 stress

11-20 scarcity

> 20 "beyond the barrier

(Ohlsson 1999).

Table 5 summarizes these water-related indicators together with the WPI for Benin and neighboring countries. The Human Development Index situates Benin at a level comparable to its neighbors. The SWSI classifies Benin as a country with relative sufficiency regarding water resources, but ranking lowest among the countries presented. The WPI finally ranks Benin worse compared to its neighbors (Lawrence et al 2002).

Table 5--Water indicators for Benin and neighboring countries

Country	HDI, 2004	HWSI, 1995	SWSI, 1995	WPI, 2000
Benin	0.421	2	3	39.3
Burkina Faso	0.302	4	8	41.5
Togo	0.495	3	5	46.0
Nigeria	0.466	4	5	43.9
Niger	0.292	3	7	35.2

Sources: Lawrence et al. (2002), Ohlsson (1999).

4. METHODOLOGY

CONCEPTUAL FRAMEWORK OF THE WATER POVERTY INDEX

The WPI as suggested by Sullivan (2000, 2001, 2002) comprises 5 different components (resources, access, use, capacity, and environment) to capture the complexity of the water situation of a country. Each of these components consists of a several elements. The 'resource' component combines groundwater and surface water resources, and aims to capture the impact of both infrastructure and pollution. 'Access to water' includes domestic use, food production, and sanitation. The 'use' component focuses on the consumption of water in households as well as in different productive sectors, such as industry and agriculture. Lawrence et al. (2002) applied the WPI to national level data reflecting 'wasteful' domestic water use by establishing a cut-off point at 50 liters per capita per day. 'Capacity' is a collection of indicators focusing on the human development of a country, such as GDP, education, health, or investment in the water sector, and where possible aims to capture water institutional capacity. The 'environment' component is very complex, combining variables such as biodiversity, environmental degradation, soil erosion, and water quality. This is designed to represent the degree of maintenance of ecological integrity needed to ensure ecologically sustainable development. For the calculation of the WPI of any region or area, the choice of variables may have to be adjusted according to data availability.

The various components of the WPI are standardized ranging from 0 to 1 similarly to the HDI (Equation 1). However, no upper and lower boundaries have been determined for the WPI. For the Benin calculations 5 percent was added (deducted) to the highest (from the lowest) observed values (Equation 3). This allows the regions with the highest values to achieve further improvement over time. However, the values are still only relative to each other using this approach and cannot really be used for different periods.

$$1. \quad \frac{(x_i - (x_{\min} / 1.05))}{((x_{\max} * 1.05) - (x_{\min} / 1.05))} = x_i^* \qquad (3)$$

The sub-components of the various WPI aspects are then added and multiplied by 100; and their sum is divided by the weight applied to the component (Sullivan et al. 2003):

$$WPI_i = \frac{\sum_{i=1}^{N} w_{x,i} X_i}{\sum_{i=1}^{N} w_{x,i}} \tag{4}$$

where X_i = component (Resource, Access, Use, Capacity or Environment)

w = weight

While the concept of the WPI is similar to that of the HDI, the WPI incorporates a larger number of sub-indicators. On the one hand, the suite of indicators related to the five water-related components make the WPI more comprehensive for the assessment of the water sector. On the other hand, this comprehensiveness might limit its usefulness as it requires a range of consistent data if monitoring is the objective. Understanding the interrelationship between different aspects of water use has long been a scientific challenge. For example, if water access increases dramatically, what would be the implication for water usage or human health? Since these relationships are still fraught with uncertainty, the relationships among the WPI components is also not yet fully defined, but remains work in progress.

DATA SOURCES USED

For the Benin communal-level WPI, the variables of the various indicator components are listed in Table 6. For the calculation of the communal value, 16 indicators have been used.

Table 6--Variables for indicator components of the regional WPI for Benin**

Components / Variable	Level / Disaggregation	Year of Data	Source
Resource			
1) Rainfall	50 km grid level	1961-1999	IMPETUS
2) Rainfall Variability	50 km grid level	1961-1995	IMPETUS
3) Groundwater	Departments	1985	Engalenc and Pipe (1985)
Access			
4) Access to drinking water	Commune	2004	DHG
5) Access to sanitary facilities	Department	2002	INSAE
Use			
6) Domestic water consumption	Communes/Departments	2000	Niemeyer and Thombansen (2000)
7) Animal water consumption	Communes	2000	IMPETUS
8) Irrigation water use	Old Departments	1992	CENATEL
Human Capacity			
9) Household expenditures	Departments	2002	INSAE
10) Child mortality	Communes	2002	INSAE
11) Illiteracy rate	Communes	2002	BenINFO
12) Investments in the water sector	Departments	2002	SBEE
Environment			
13) Forest/ protected areas	Communes	2001	MISD
14) Fertilizer use	Departments	1998	IFPRI
15) Use of pesticides	Departments	1998	IFPRI
16) Soil erosion	Departments	1993	MEHU

Note: Data sources are included in the references.

Rainfall data enters the WPI as average annual rainfall during 1961-1999. Variability in rainfall was calculated as the variation coefficient of the data. Information on groundwater is very sparse and mainly available at the national level. A classification of groundwater availability was derived from a hydro-geological map from 1985, which distinguished four types of potential access to groundwater. These were then transferred to the communal level by overlaying the hydro-geological map with the administrational map (El Fahem 2004). Access to safe drinking water is an indicator calculated separately by the Direction of Hydrology of the Water Ministry (DGH) and the National Statistic

Institute. Results were similar for both data sources, probably because they were derived from similar base data, and DGH data was chosen for the WPI. For the 'use' aspect, water consumption data was included from a study carried out by the urban water supplier (SBEE). Urban water withdrawal was estimated by the SBEE for different levels of population density of a commune. (Niemeyer and Thombansen 2002) These data were transferred to the communal level. Livestock water use was calculated by multiplying the number of animals from each commune with an estimation of livestock water consumption (for example, 25 liters per day for cattle, 5 liters per day for sheep and goats, (Gruber 2004)). All three 'use' variables are assumed to have positive effects on the WPI, in the sense that an increase in water use is likely to have a positive impact on human wellbeing (Lawrence et al. 2002). In the examples included from Benin domestic use does not exceed 50 liters per capita per day. Therefore, increased consumption is considered an improvement (Lawrence et al. 2002). More livestock water use and irrigation are also considered positive as when a commune makes more use of its available water, it is likely to experience better conditions.

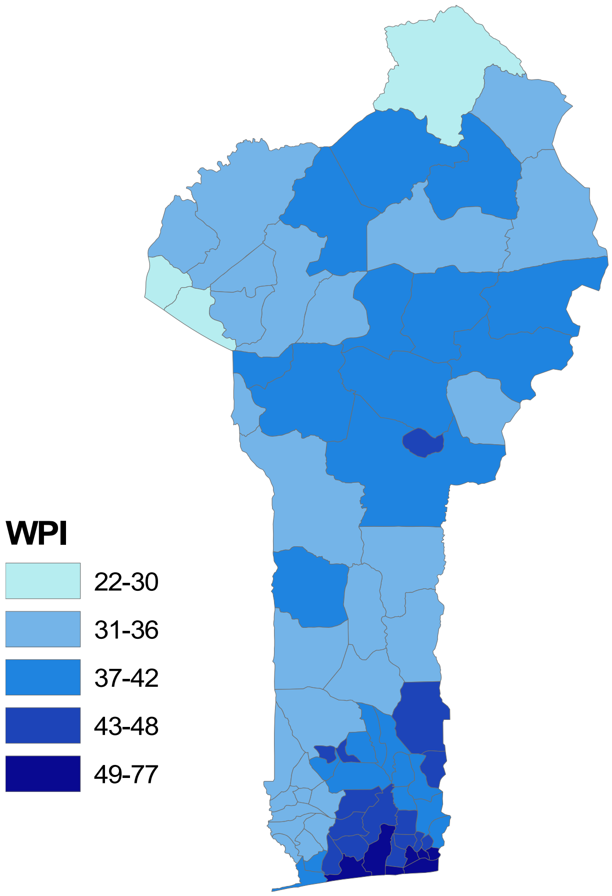
The human capacity indicators are mainly taken from the 2002 census of the National Statistic Institute of Benin. In this study, it was difficult to capture the idea of ecological integrity, as data to adequately represent the environmental situation were not widely available in Benin, as environmental protection is not high on the country's agenda. For this study, data on protected areas, on pesticides and fertilizer use, as well as on soil erosion were incorporated into the WPI. For the last three variables, the reciprocal of the standardized value has been used, as the higher the amount of soil erosion, the worse the environmental impact. In the case of Benin, data availability, especially at the communal scale, is fairly poor. Time-series data, crucial for monitoring purposes, is even harder to assemble. For the calculation of the WPI, as presented in this paper, data sets have been highly aggregated or summarized from different administration levels. Some data, which were only available at the department level, had to be used to approximate the situation at the communal level. Furthermore, the time period for data varied and not all data was available for the target years of 2002-2004.

5. APPLICATION OF THE WPI TO BENIN

RESULTS FOR THE WPI AT THE COMMUNAL LEVEL

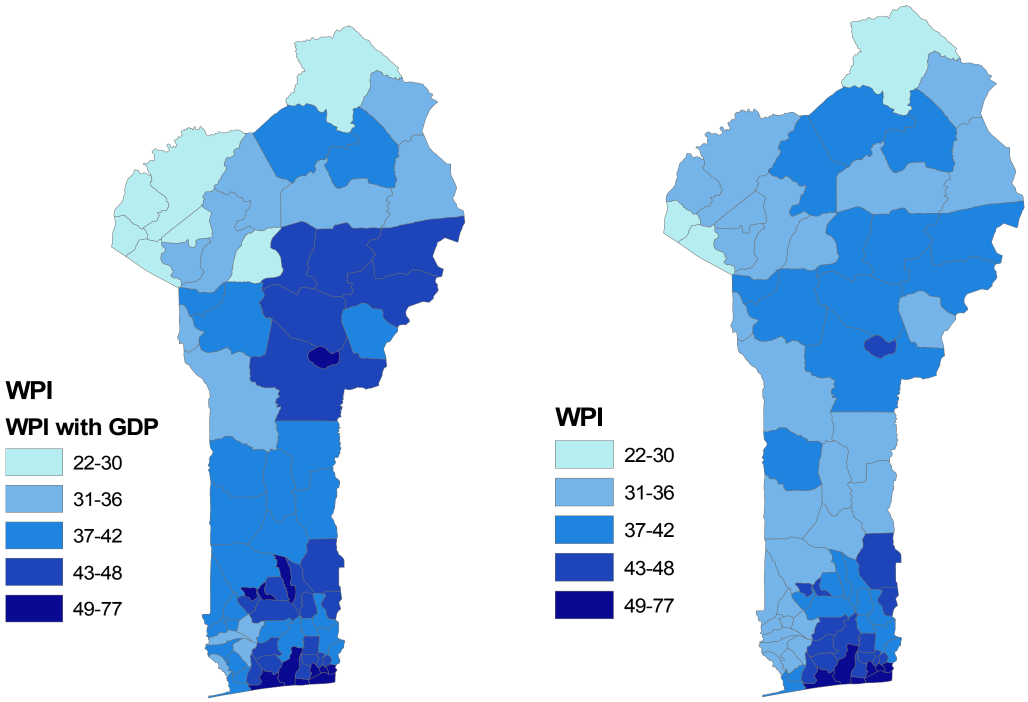
Results for the WPI at the communal level are presented in Figure 2. For better comparison the same range has been applied to all maps with WPI values ranging from 22 to 30 classified as "severe water poverty", and values ranging from 49 to 77 as "relatively good water situation." The average WPI for all communes is similar to the national-level WPI value (Lawrence et al. 2002), even though different data sets, time periods, and spatial units have been used. Annex Table 1 presents the values of the components of the WPI and the ranking for all communes of Benin in alphabetical order.

Figure 2--Results for the WPI at the commune level



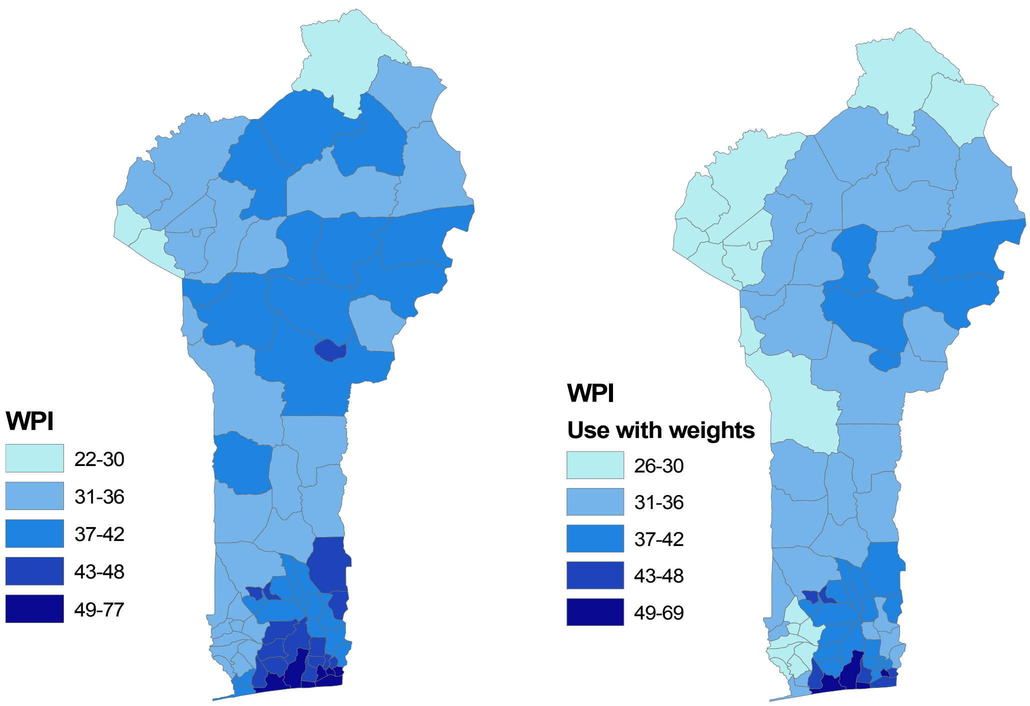
The results show a clear distinction of the water poverty situation between the north and the south of the country. The south includes the urban areas around the cities of Cotonou and Porto Novo. In these areas, public water supply is well established and the economic and social situation is relatively well developed compared to the northern rural areas. The only area in the North with a higher score is the commune that includes the country's second biggest city, Parakou.

Figure 3--Results for the WPI at the commune level, the role of GDP per capita



GDP is a standard measure of economic development, and while it is widely used, it does not capture a number of important aspects of the economy, such as household labor, and the consumption of home-produced goods. Since these are both significant in low-income countries, the inclusion of GDP may have a distorting effect on WPI scores. Therefore, a base calculation for the community-level WPI without GDP was compared with a calculation including GDP per capita in the capacity component (Figure 3). The results differ only slightly, reflecting the fact that the WPI includes 16 different sub-components. Furthermore, per capita GDP data were only available at the departmental level and disaggregation to the communal level did not adequately represent differences among communes within the same department.

Figure 4--Results for the WPI at the commune level, different weightings



Discussions with several stakeholders in Benin focused on the concept of increasing water use efficiency. To reflect this, base case results were compared with an alternative WPI giving more weight—here double—to the use component. Figure 4 shows that under the alternative weighting communes in the North have worse WPI values than before. This is likely due to the low levels of domestic water consumption and low amounts of irrigated areas in the north. On the other hand, irrigation is much more widespread in the South. The use variables: consumption, irrigation, and livestock water, have all been introduced as positive variables assuming that the higher usage, the better outcomes for human welfare (see Section 4 on data sources used).

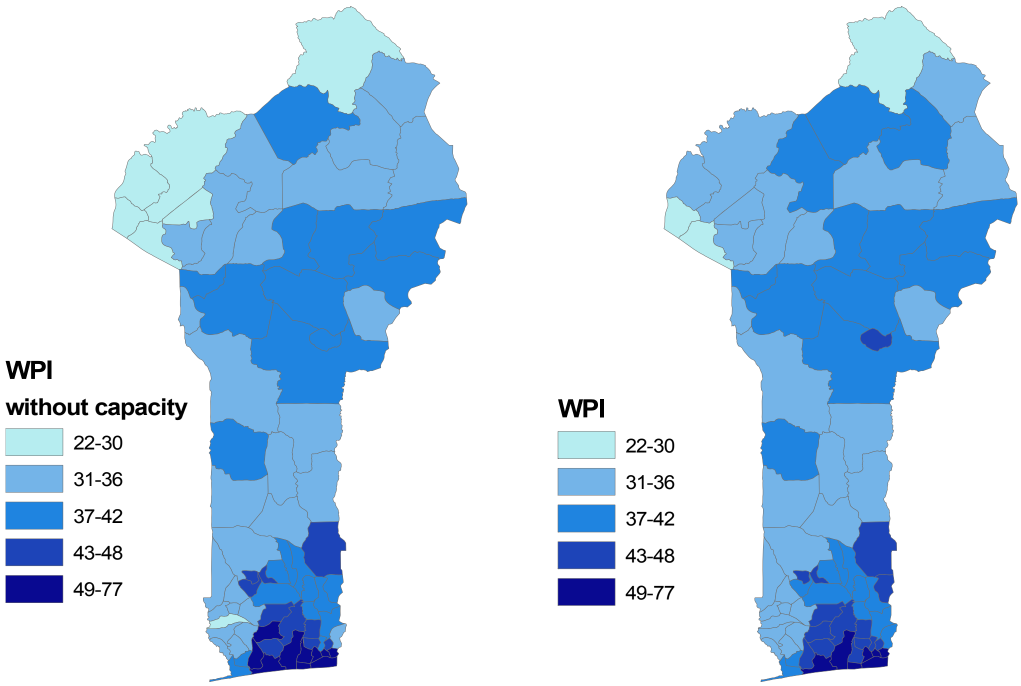
On the basis of the study done by the Centre of Ecology and Hydrology, UK, Table 7 shows results for the correlation among the different components of the national-level WPI values. Of interest is the high correlation coefficient of 0.82 for the factors 'access' and 'capacity'. This might suggest that the 'capacity' component should be left out of the WPI concept, as it may reflect water poverty in general. On the other hand, since capacity is an important element of water management, it is unwise to remove this component. Results for calculations without the 'capacity' component are presented in Figure 5.

Table 7--Correlation Among the Components of the National WPI Data, Benin

	Resources	Access	Capacity	Use	Environ	HDI	WPI
Access	0.05						
Capacity	-0.06	0.82					
Use	-0.01	-0.06	-0.11				
Environment	0.28	0.27	0.28	-0.28			
HDI	0.03	0.87	0.94	-0.12	0.31		
WPI	0.46	0.85	0.77	0.12	0.46	0.81	
Falkenmark	0.58	0.14	0.11	-0.04	0.06	0.11	0.35

Source: Lawrence et al. (2002).

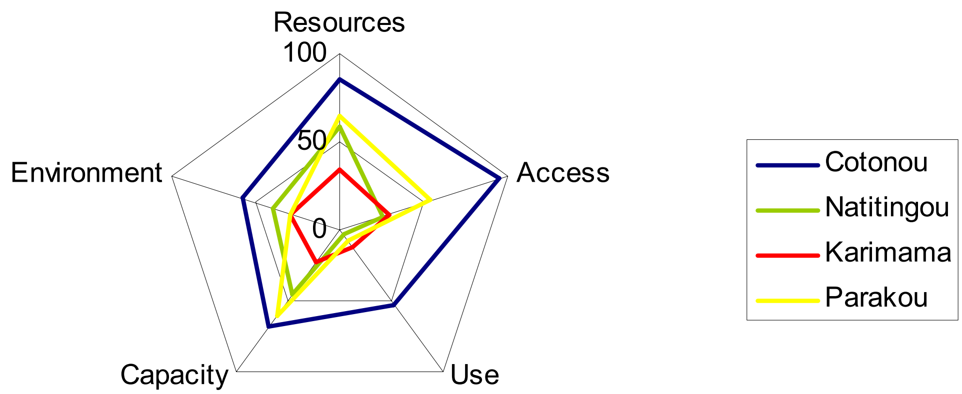
Figure 5--Results for the WPI at the commune level, with and without capacity component



The results for the WPI without the 'capacity' component leaves the urban areas of the country worse off than before; the same occurs for some rural areas in the northern part of the country.

To display the components in a more visible way, a pentagram showing all five components can be used. Although only a few regions are shown, the strengths and weaknesses of these regions can be clearly distinguished. In Figure 6, Cotonou, the largest city in Benin, has the highest WPI value. However, the water situation can still be improved focusing on environmental aspects, particularly wastewater treatment, which is hardly developed in Benin. In contrast, Karimana is the commune with the lowest WPI value. Although all sub-components show low values, special attention should be given to the access and use components. Parakou, the second largest city in Benin, does well in human capacity but is weak on environmental issues.

Figure 6--Results for the WPI for selected communes



They demonstrate the variation found for the different components in different parts of the country. It must also be noted, however, that this research is a preliminary attempt to assess the application of this tool to existing data sources for Benin, and as such, could be make more accurate if appropriate refinements and more representative data were to be found.

WPI WITH ALTERNATIVE WEIGHTINGS

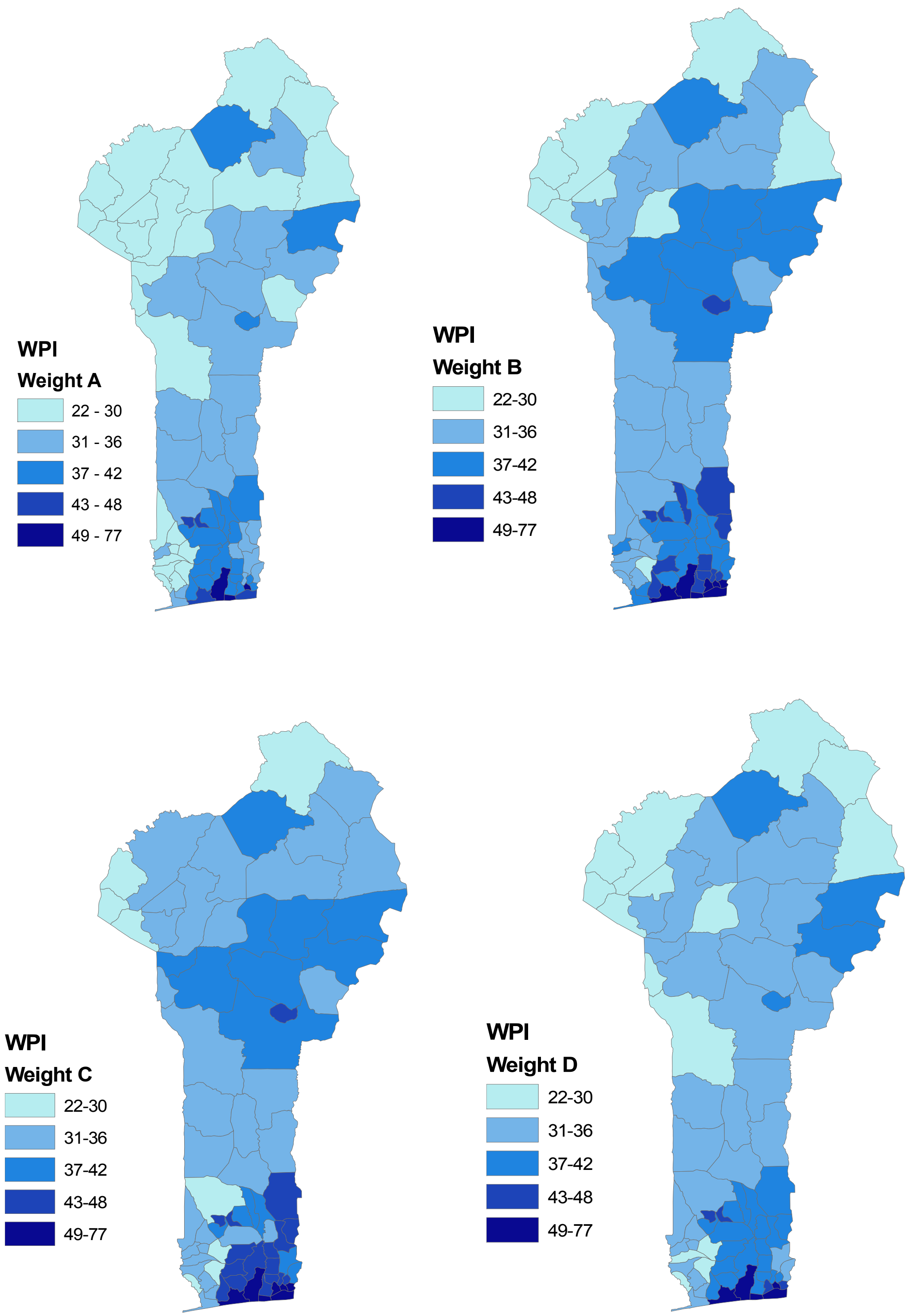
The WPI design allows placing emphasis on different components of the index to enable policymakers to examine potential impacts of different management options. For example, attributing more importance or weighting to the ‘access’ component could provide an indication of the possible impacts of increasing investments to improve access to water resources. More work needs to be done to refine this by clarifying more explicitly the interactions between components, but even at this preliminary phase, it is possible to demonstrate how WPI calculations can be altered by applying weights to different components in order to emphasize their relative importance. Weightings can be chosen by policy makers to put an emphasis on national priorities in the water sector. In the following four examples alternative weightings are presented to evaluate the transparency of the WPI and its weighting capabilities.

Table 8 and Figure 7 present four alternative scenarios for government priorities reflected by different weightings. The 'resource' category has not been altered as it appears less amenable to change through policy choices. Table 9 shows that an emphasis on the 'use' component (Scenario A) reduces the overall WPI value, as this value is generally low in Benin highlighting the fact that water is currently not used to the most efficient degree possible. On the other hand, the factors 'capacity' and 'access' have overall positive effects on the results showing how investment in those aspects are likely to have a direct effect on human well-being. It is evident, however, that if weightings are used, they must be transparently displayed, to avoid misinterpretation or manipulation of data and results.

Table 8-- Results from Different Weightings for Selected WPI Components

	Local Conditions	**Different weightings**					**WPI**
Scenario	**National Priorities**	**Resources**	**Access**	**Capacity**	**Use**	**Environment**	**Average Value for the WPI**
A	Agriculture Industry Society	1	2	2	3	1	34.05
B	Society	1	2	2	1	1	39.16
C	Environment Society	1	2	2	1	2	38.73
D	Industry Agriculture	1	2	2	2	1	36.28

Figure 7--Results for the WPI, Alternative Weightings



COMPARISON WITH THE HDI

In recent years, the Human Development Index has become one of the most widely used indicators to measure the state of a country's development. A comparison of the WPI with the HDI allows for some conclusions for the application of the WPI. Table 9 presents the HDI values for the years 2001 and 2002 and the WPI calculated in this study, and their respective rankings for Benin's 12 departments. Based on this table, Littoral (with the largest city Cotonou) ranks highest and Atacora ranks lowest for both indicators.

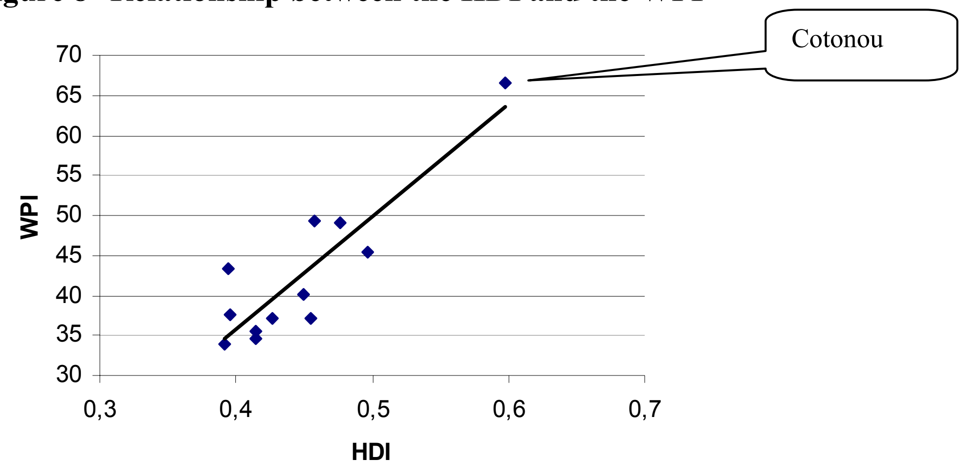
Table 9--Ranking of Benin's 12 departments based on the HDI and WPI

Departments	HDI 2001	HDI 2002	Ranking 2002	WPI	Ranking WPI
Atacora	0.39	0.39	12	34.00	12
Donga	0.39	0.40	10	37.66	7
Atlantique	0.46	0.49	4	49.27	2
Littoral	0.59	0.60	1	66.47	1
Borgou	0.44	0.45	6	40.01	6
Alibori	0.43	0.46	5	37.16	8
Mono	0.41	0.41	8	34.50	11
Couffo	0.41	0.41	8	35.45	10
Ouémé	0.47	0.48	3	49.03	3
Plateau	0.49	0.50	2	45.47	4
Zou	0.39	0.39	11	43.26	5
Collines	0.42	0.43	7	37.13	9

Source: UNDP (2003) and author's calculations.

As Figure 12 indicates, there is a fairly strong relationship between the HDI, reflecting general economic development, and WPI values, focusing more on water-related development. Thus, the state of the water situation, at least for the case of Benin, also reflects the general economic development situation.

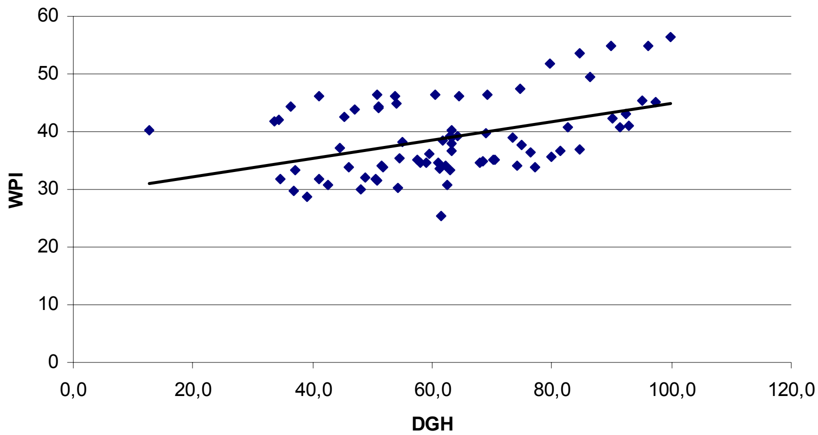
Figure 8--Relationship between the HDI and the WPI



As explained in Section 3 the HDI consist of three components relating to poverty; the WPI, on the other hand, consists of 5 components including poverty as well as water-related issues. The capacity component of the WPI is similar to the HDI variables of education, health, and financial capability, which explains part of the similar outcomes. However, the WPI goes one step further by relating poverty issues with descriptive variables of the water situation (access as well as resources) and environmental issues.

Figure 9 presents the relationship between the WPI and the access rate to safe water calculated by the Direction of Hydrology (DGH). This relationship is weaker compared to the correlation between the WPI and the HDI. As the DGH data only refers to people's possibility to access water, it leaves out other important aspects related to the water situation. This suggests that the WPI can be seen as an instrument to display more than just an area's water supply situation by focusing on other aspects, such as the overall development needs of a region.

Figure 9--Relationship between the rate of access to safe drinking water and the WPI



6. EVALUATION OF THE WPI

The WPI is a fairly new concept, which was first developed in 2000 (Sullivan, 2000, 2002, Sullivan et al. 2003). As the paper has shown, the WPI does allow for regional differentiation among the various communes and departments in Benin and WPI results compare well with HDI outcomes, while allowing for a better representation of water issues. Despite these positive results, there is scope for further development of the WPI. When and before using the WPI, the purpose of its application should be clearly specified. The following section evaluates the WPI in terms of accuracy, replicability, versatility and usability. Furthermore, recommendations for future applications are given provided.

ACCURACY OF THE WPI

Data used in the WPI are often drawn from different scales. For example, for this study some of the data needed for the communal analysis were only available at the departmental level. Furthermore, as has been mentioned before, data is often taken from different years. Moreover, it is not possible to evaluate the accuracy of public data sets included in the calculation in this research. Taken theses constraints into account, one needs to be careful with interpretations of the derived results. Results can only be as good as the data included. With better data quality in the future, the accuracy and the informational value of the WPI can be improved.

REPLICABILITY

The WPI concept has been developed to assure replicability for different scales and countries. The way the WPI is calculated in this research would be replicable if the same data choices are made for other years, scales or countries. However, the data choices in this paper have been made based on the data available in Benin. It would be difficult to find data that is derived in the same way in other countries. For example, it would be hard to identify standardized ways on the measurement of access to safe water in public data sets of countries and at regional levels.

VERSATILITY

The results of the WPI can be used by different stakeholders. The scenario analysis particularly lends itself to decision and discussion support. Moreover, the pentagram tool helps visibility of the WPI outcomes. The WPI thus can be used as an instrument to start a discussion, as an overview of the water situation in a country, as well as for classifications of the water situation. The variety of uses can also be seen in the interdisciplinary concept of the WPI. Several sectors and aspects are included making it an interesting monitoring tool not only for the water sector.

USABILITY AND UTILITY

Classifying and monitoring the water poverty situation has increased in importance following the commitment of countries towards achieving the Millennium Development Goals. However, for this the WPI data categories would need to be uniform across countries. This has only been done so far at the national scale, which cannot capture regional and country-level peculiarities.

Moreover, quantitative data, such as water use, for example, might say little about the relative benefit of that data. For example, the domestic water consumption included typically only refers to urban water use, whereas the rural population uses mainly sources other than tap water. In the values for the use component this water use is seldom incorporated. Even if these data were available, the water quality of the rural source might be lower, while the benefit derived from less water of lower quality in rural areas might be higher. Such differences could only be reflected with difficulty in the indicator.

7. RECOMMENDATIONS

METHODOLOGICAL IMPROVEMENTS

By introducing upper and lower boundaries in the calculation of the WPI as is done in the HDI concept, values can be standardized and comparable across years and different scales. Upper and lower boundaries can be determined based on a percentage increase or decrease over maximum and minimum observed values for all the variables. This was done for the calculation of the communal WPI in Benin. However, the upper and lower boundaries derived need to be applied in the same manner in other calculations to make it comparable (see Section 4).

Theoretically, the WPI can be used for scenario analysis. One can assume that in the coming years the "use" factor will increase due to increasing industrialization or population growth. However, changing the contribution of the 'use' component will likely also result in changes in the other components. Still, components are not directly linked with each other. For example, if the 'use' or 'access' component is increased, changes in the health indicators are probably necessary as well. Moreover, as the data is calculated in relative terms, improvements achieved in one region might lead to worse results for other regions. This could also be avoided by standardizing upper and lower boundaries for each variable.

INTERPRETATION OF THE RESULTS

When and before using the WPI, the purpose of its application would need to be clarified. Several indicators have been used in the past to describe water availability or access and composite approaches focused on water stress, water productivity, or crop productivity. The development of composite indexes combining these elements needs to be done in a transparent manner. If not, the indicator will neither be of use for stakeholders nor for comparison within regions. To establish an appropriate and transparent indicator, standardized data set are needed. Until these are available, however, useful information can still be gained from its calculation, especially at the local level where appropriate scale information (often from existing other studies) can be applied to generate more meaningful results. The question of scale in the application of the WPI has been discussed by Sullivan et al. 2005. It is important to recognize that the reliability of any indicator (including the WPI) will inevitably be influenced by the quality and coverage of the data on which it is based.

To display the results to the public or as a tool for policy-making, the pentagram can be used as it reflects the values for the various WPI components. The use of the pentagram allows simultaneous display of the scores on the five key WPI components, allowing for easy comparison of the strengths and weaknesses the particular water situation examined. It is also useful to include a table with types of data incorporated, the scales and the values for each community to ensure that summary values are not misinterpreted.

Thus, the WPI calculation only provides a complete picture of the water development situation if the data background is taken into account when interpreting the results.

Furthermore, additional research is needed on which variables to include in each component. As the water sector is currently focusing more on aspects of water quality, such data should be reflected in the indicator as well, as has been suggested in the original WPI development study. It is important to identify which type of water quality data at which resolution is most appropriate. Moreover, agricultural water use, which takes up the largest share of total water use, needs to be reflected better. In this calculation, only irrigation and livestock water use have been included. More distinctive data about crop and water productivity would improve the WPI concept immensely.

Assuming that in the future difficulties with data availability can be resolved and a set of standardized variables with globally accepted minimum and maximum boundaries is decided on, then the WPI applied to the sub-national level can be a useful tool for policymakers as it:

- Allows comparisons between different regions;
- Helps to identify those regions and communes that would need extra support to meet targets, such as those under the Millennium Development Goals;
- Facilitates and promotes discussion with people involved in the water sector, stakeholders as well as local people (Sullivan and Meigh 2003);
- Analyses improvements over a period of time if calculated in different years and thus could be used as a monitoring tool; and
- Can be used as a tool to track changes over time and display results for scenario analysis.

8. CONCLUSION

> "*Indicator development is a complex and slow process, requiring widespread consultation. New indicators have to be tested and modified in the light of experience." (UNESCO-WWAP 2003, p.7).*

As has been discussed at the beginning of the paper, a number of different variables significantly influence the water sector, such as natural, political, and demographic conditions. Adequately reflecting all these variables in indicators is crucial for providing a comprehensive overview of the water sector. The idea of combining five dimensions in the Water Poverty Index is an appropriate step toward accurately reflecting the water sector situation of a specific region. As Benin has decentralized many policymaking and administrative responsibilities to the communal level, it is extremely important for the government to develop a tool for analysis and comparison among these communes. This study examined the applicability of the Water Poverty Index as a decentralized monitoring tool for water resources development and related outcomes in Benin's communes. Since the decentralization process in Benin is relatively recent, more disaggregated data sets will likely become available over time, allowing for more decentralized monitoring of water outcomes through the WPI in the future. The quotation at the beginning of this section is also valid for the WPI: time and open dialogue to further develop this instrument, including standardized data sets, time series data and standard boundaries, and more stakeholder inputs will improve its use as a comprehensive, policy-support tool that is needed not only in Benin, but throughout the world.

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Annex Table 1--Values of the components of the WPI and ranking for all communes of Benin in alphabetical order

Commune	Resources	Access	Use	Capacity	Environment	WPI	Ranking
Abomey	15.53	12.07	7.24	10.44	2.41	47.69	14
Abomey-Calavi	13.12	11.88	6.46	10.80	12.29	54.55	3
Adja-Ouere	14.85	5.97	1.10	10.34	11.53	43.80	25
Adjara	11.39	11.22	1.05	11.95	11.53	47.15	17
Adjohoun	14.46	9.01	1.20	11.14	11.53	47.34	16
Agbangnizoun	17.16	11.56	6.77	7.16	2.41	45.07	22
Aguegue	14.73	11.98	1.01	8.32	11.53	47.58	15
Allada	15.28	8.99	5.07	7.10	12.28	48.71	13
Apkro_Missirete	15.64	6.25	1.15	11.59	11.53	46.16	20
Aplahoue	15.09	7.93	2.26	8.26	3.75	37.29	49
Athieme	13.56	6.30	1.69	6.32	3.75	31.62	75
Avrankou	18.67	6.79	1.25	11.25	11.53	49.49	9
Banikoara	10.51	7.61	6.91	9.15	11.38	45.56	21
Bante	13.39	6.82	7.22	7.36	4.13	38.92	42
Bassila	13.12	4.90	0.67	8.58	8.93	36.19	55
Bembereke	12.13	7.09	4.46	9.61	7.05	40.34	38
Bohicon	18.49	11.83	7.43	11.10	2.41	51.27	7
Bonou	15.40	6.01	1.01	9.58	11.58	43.58	27
Bopa	15.06	7.66	1.72	3.67	3.75	31.85	74
Boukoumbe	11.26	3.83	1.06	5.52	8.79	30.46	76
Come	15.28	9.84	1.78	7.29	3.75	37.93	44
Cotonou	10.29	17.84	11.07	15.00	12.28	66.47	1
Cove	14.78	11.26	6.72	9.02	2.41	44.19	24
Dangbo	18.52	10.01	1.18	10.05	11.53	51.30	5
Dassa-Zoume	12.01	5.82	7.39	9.18	2.54	36.94	50
Djakotomey	14.60	9.05	1.67	8.65	3.75	37.72	46
Djidja	12.63	5.19	7.15	7.66	2.41	35.05	64
Djougou	13.67	6.87	2.04	8.37	9.63	40.58	36
Dogbo-Tota	14.56	5.48	1.72	8.36	3.75	33.87	66
Glazoue	11.47	6.16	7.37	9.46	2.41	36.87	52
Gogounou	12.50	5.62	3.94	8.47	6.40	36.93	51
Grand-Popo	11.17	10.21	1.77	7.35	3.75	34.25	65
Houeyogbe	15.21	9.00	1.61	6.13	3.75	35.71	60
Ifangni	15.91	2.25	1.26	11.74	11.53	42.68	29
Kalale	12.50	8.03	5.46	9.45	6.44	41.88	32
Kandi	11.53	4.80	5.76	9.47	7.83	39.40	41
Karimama	9.18	6.74	2.56	4.22	6.38	29.08	77
Kerou	11.28	7.42	3.33	6.53	9.02	37.58	48
Ketou	17.35	6.96	1.87	11.85	12.50	50.54	8
Klouekanme	14.33	7.02	1.78	8.45	3.75	35.33	63
Kobli	13.52	3.57	0.71	5.97	8.79	32.56	71
Kopargo	12.99	8.38	0.67	7.22	8.81	38.07	43
Kouande	13.40	6.00	2.68	7.01	8.81	37.90	45
Kpomasse	14.85	7.40	4.90	7.63	12.28	47.06	18
Lalo	14.47	5.72	1.67	7.05	3.75	32.66	70

Lokossa	14.93	7.53	1.92	7.51	3.75	35.64	61
Malanville	12.65	6.91	2.81	6.08	8.06	36.51	54
Materi	11.43	4.23	1.22	6.58	8.79	32.25	73
Natitingou	10.94	6.12	0.81	9.50	8.79	36.16	56
N'Dali	11.77	8.04	2.00	9.15	10.41	41.38	34
Nikki	10.72	8.17	4.46	9.88	6.38	39.61	39
Ouake	13.78	5.55	0.56	7.13	8.79	35.80	59
Ouesse	11.12	7.43	7.14	8.32	2.50	36.52	53
Ouidah	13.03	11.29	5.25	9.88	12.29	51.74	4
Ouinhi	15.03	9.36	6.71	7.12	2.41	40.64	35
Parakou	9.67	11.39	1.57	13.06	6.39	42.08	31
Pehonko	12.54	4.05	2.00	5.56	9.26	33.42	68
Perere	10.76	7.80	0.88	7.98	6.38	33.79	67
Pobe	15.42	6.64	1.50	11.52	11.53	46.61	19
Porto-Novo	15.55	13.51	2.36	14.50	11.53	57.45	2
Sakete	15.64	4.65	1.22	10.66	11.53	43.70	26
Savalou	12.63	6.41	7.71	8.42	2.44	37.62	47
Save	9.52	7.38	7.20	8.98	2.88	35.96	57
Segbana	14.08	3.67	2.60	7.54	7.58	35.47	62
Seme-Kpodji	12.25	13.09	1.20	13.12	11.63	51.28	6
Sinende	12.56	9.38	2.72	7.42	7.54	39.61	40
So-Ava	11.43	10.16	4.57	6.36	12.28	44.80	23
Tanguieta	10.64	4.87	0.70	7.39	8.79	32.39	72
Tchaourou	13.56	8.04	1.66	10.33	7.81	41.40	33
Toffo	18.03	7.00	4.44	7.00	12.65	49.12	11
Tori-Bossito	16.64	7.78	4.65	7.47	12.28	48.81	12
Toukountouna	11.28	5.56	0.29	7.14	8.79	33.06	69
Toviklin	14.56	8.73	1.58	7.22	3.75	35.84	58
Za-Kpota	14.92	11.39	6.91	7.07	2.41	42.70	28
Zangnanado	14.71	10.41	6.82	7.95	2.41	42.30	30
Ze	18.03	7.45	4.55	6.95	12.35	49.34	10
Zogbodomey	15.38	8.00	6.81	7.78	2.50	40.48	37

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