Water dynamics in the seven African countries of Dutch policy focus: Benin, Ghana, Kenya, Mali, Mozambique, Rwanda, South Sudan: report on Benin

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Report on Benin

Written by the African Studies Centre Leiden and
commissioned by VIA Water, Programme on water innovation in Africa

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Water – Benin

This report has been made by the African Studies Centre in Leiden for VIA Water, Programme on water innovation in Africa, initiated by the Netherlands Ministry of Foreign Affairs. It is accompanied by an ASC web dossier about recent publications on water in Benin (see www.viawater.nl), compiled by Germa Seuren of the ASC Library under the responsibility of Jos Damen. The Benin report is the result of joint work by Ton Dietz, Laurens Nijzink and Fenneken Veldkamp. We acknowledge the support by Joop de Schutter (JdS). Blue texts indicate the impact of the factual (e.g. demographic, economic or agricultural) situation on the water sector in the country. The authors used (among other sources) the ASC web dossier on water in Benin and the Africa Yearbook 2013 chapter about Benin, written by Eric Komlavi Hahonou (see reference list). Also the Country Portal on Benin, organized by the ASC Library, has been a rich source of information (see http://countryportal.ascleiden.nl)[1]*. ©Leiden: African Studies Centre; September 2014*

Political geography of water

The *République du Bénin*, is a country in West Africa. It is bordered by Togo to the west, by Nigeria to the east and by Burkina Faso and Niger to the north. A majority of the population (total: 9.1 million inhabitants in 2011) lives on its small southern coastline on the Bight of Benin. The capital of Benin is Porto-Novo, but the seat of government is in Cotonou, the country's largest city and located between the Ocean and lake Nokoué, and also the country's major port city. Also the city of Ouidah is a coastal town. All coastal towns are vulnerable to the combined effects of sea level rise, increasing river discharges during the rainy season and oceanic storms, occasionally causing floods (e.g. in 2010) and damage to infrastructure.

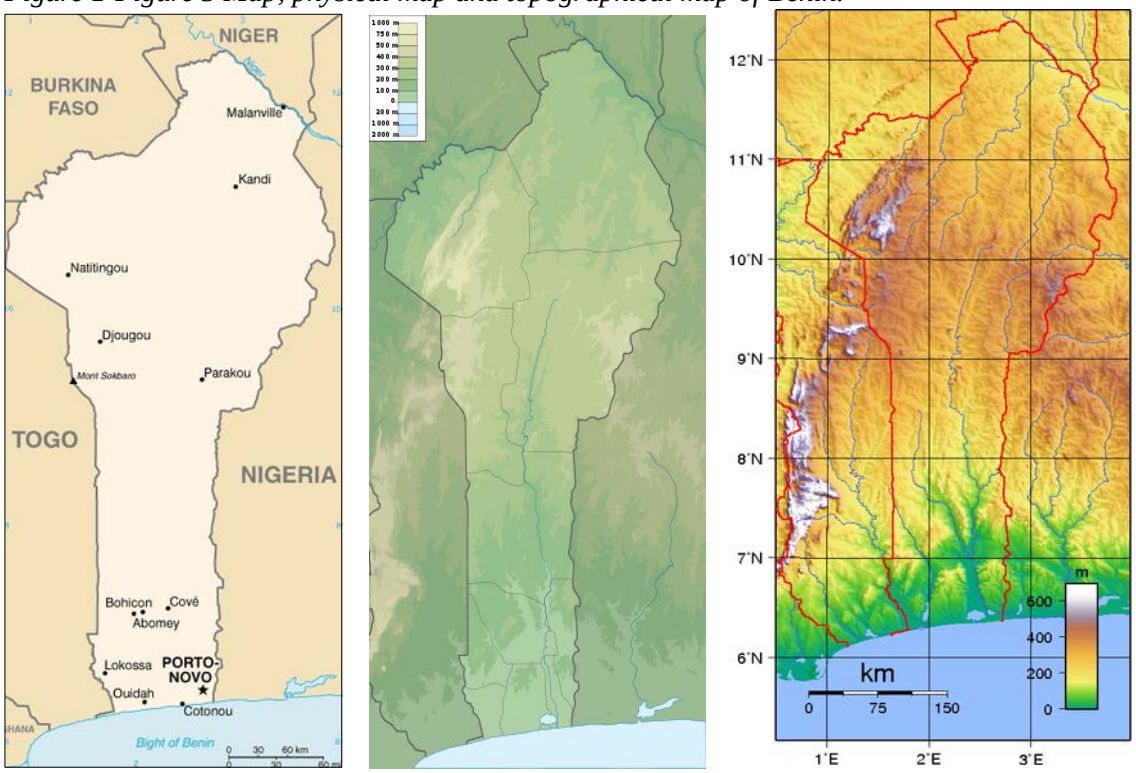
Photo 1 Cotonou Port

http://en.wikipedia.org/wiki/Cotonou

[1] The report has been realized on the basis of short-term desk research and makes no claim of being definitive, complete or scientifically substantiated.

Cotonou is located on the coastal strip between Lake Nokoué and the Atlantic Ocean. The city is cut in two by a canal, dug by the French in 1855 and connecting the lagoon of Cotonou with the sea and. Three bridges are located in this area. The Oueme River flows into Lake Nokoué and into the Atlantic Ocean through this canal at Cotonou. The erosion of the coast has been noted for several decades. It worsened in 1961 following the major works undertaken in Benin with the construction of the Nangbéto dam and deep-water port of Cotonou. Similar problems exist in Ghana with the Akosombo Dam and in Togo at the port of Lomé. Houssou Paul, a pilot project funded by the United Nations Environment Program (UNEP) revealed that in 40 years, the coast to the east of Cotonou would have eroded by 400 meters. This erosion has led many people to leave their homes built along the coast. The Beninese state has decided to try and control this coastal erosion process by constructing a number of groynes, but this is expensive and may not really control the erosion process completely. (http://en.wikipedia.org/wiki/Cotonou; JdS).

Figure 1-Figure 3 Map, physical map and topographical map of Benin.



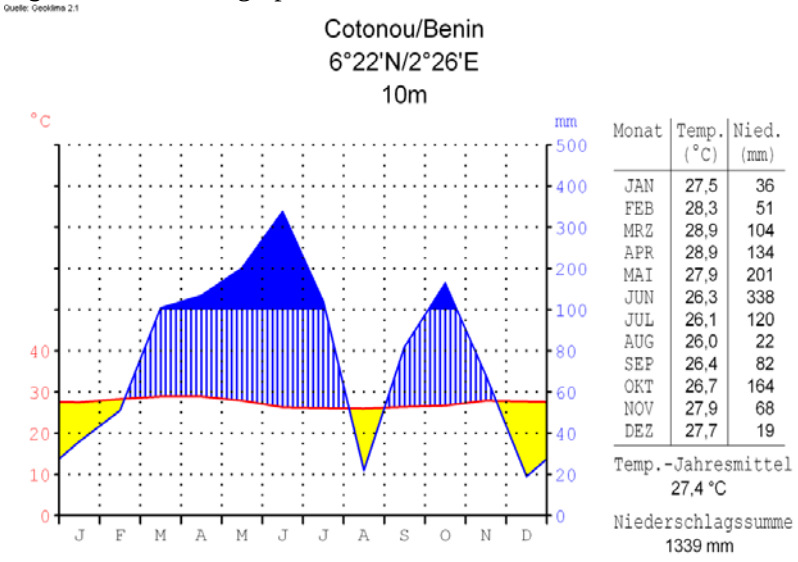
Source figure 1: http://commons.wikimedia.org/wiki/File%3ABenin_map.png
Source figure 2: http://commons.wikimedia.org/wiki/File%3ABenin_physical_map.svg
Source figure 3: http://commons.wikimedia.org/wiki/File%3ABenin_Topography.png

Most of Benin belongs to the humid tropics, with tropical rainforest and dense woodland savannahs as original vegetation, of which a lot has disappeared due to changing land use. The north of the country is more dry, with a sub-humid climate and seasonal rainfall. The far north, near the boundary with Burkina Faso, Niger and Northwest Nigeria can even be regarded as semi-arid, with annual rainfall figures close to 1000 mm, but during drought years (like the ones in the 1970s and 1980s) occasionally below 700 mm. Benin's northern boundary is formed by the Niger River, which originates in Guinea, flows northeast through Mali, then southeast near the boundary between Burkina Faso and Niger and between Niger and Benin, and onwards to Nigeria, where it flows into the Atlantic Ocean at the Niger delta, having joined with another major tributary, the Benue River, which originates in Cameroon.

The northern, dryer, part of Benin forms part of the Niger waterbasin, including the northern cities Malanville (on the Niger River itself), Kandi, Nikki, and Natitingou, and the eastern city Parakou. Most of Benin forms part of the Ouemé River Basin that can only be found in Benin itself and, unlike the Niger River in the north, does not have complicated geo-political relationships with neighboring countries. In the southern part of the country the Ouemé River Basin provides water for the major agricultural areas and for the inland cities of Djougou, Savè City and Cové (both on the Ouemé River), and Abomey until it flows in the Ocean near the big cities Cotonou and Porto Novo.

Cotonou has a bimodal rainfall regime, with – on average – most rainfall in March-July and again in October, and dry periods in August and in December-January.

Figure 4 Climate graph of Cotonou



Source: http://en.wikipedia.org/wiki/Cotonou

Benin’s river basin areas are vulnerable to flooding. In July 2008 a flood hit central and south Benin, as well as many other West-African countries. The Mono River and Ouémé River flooded, severely threatening and devastating communities alongside both rivers. Weeks after the initial flooding in July 2008, many areas of Cotonou where the Ouémé reaches the sea, were still not drained, posing a serious risk to health given that the flooding affected many densely populated areas. Mid August, the World Health Organization (WHO) estimated that the flooding had displaced at least 150,000 people. Some 500,000 people in total were at risk of additional flooding. Tens of thousands hectares of crop land were inundated and an equal number of animals were drowned by the flood. In 2010 flooding occurred again along the Ouémé river and around Lake Nokoué with even worse effects on population and infrastructure.

In August 2013 the north of the country was hit by severe floods, notably the municipalities of Karimama and Malanville along the river Niger. The flood resulted in the loss of crops and livestock and the destruction of homes. The Red Cross estimated that the flash flood destroyed more than 3000 houses and affected 13,000 hectares of farmland, leaving more than 10,000 people displaced and more than 30,000 affected.

Excluding the Niger river in Benin's far north, the annual supply of fresh water (renewable fresh water resources) is about 13 billion (13.106 bn) cubic meters. If we assume for a moment this quantity being constant, the population increase over the past few decades marks a steep decline of the total availability of fresh water per capita. In 1955 Benin's population reached about 2.1 million people leaving some 6200 m3 of fresh water available per habitant per year. 35 years later, in 1990, Benin's population had increased to some 4.6 million people, leaving about 2835 m3 of fresh water per person available and today with a population of about 9.2 million (2011) the figure has dropped to some 1400 m3 (Republique du Bénin, 2008). However, in reality the quantity of renewable water resources is not constant, due to for example climate change: a decrease of about 15-20% since the 1970s of the quantity of annual renewable water is estimated.

The Food and Agriculture Organization (FAO) of the United Nations indicates that in 2001, 32% of the total water withdrawal was used for domestic purposes, while 45% was used for agriculture and 23% by the industry.

Regarding groundwater, Barthel *et al.* (2009) included roughly 4000 wells all over Benin in their groundwater study. Groundwater, according to reports (IRD) is a major source of water in the country, yet in 2007 only 2% of the available groundwater would be used.

A major distinction to be made in Benin is between the north and the south. In the north the groundwater recharge and groundwater availability are both spatially and temporally correlated. The availability is therefore strongly related to the

amount of precipitation in the wet season. In the dry season, the availability of groundwater is restrained. Main cause for this are the shallow and segmented aquifers: they don't have the capacity to store water from one season to the next. This means that: i) long-term storage capacities do not exist and ii) groundwater recharge is only partially captured by wells. In the south the availability of groundwater is not correlated to regional climate effects. This can be concluded from the depth and the confined state of the aquifers used. However, due to lack of data it is unknown how these deeper-lying aquifers are recharged.

With a growing population and an increasing demand for clean drinking water, Benin faces some difficulties in the field of water conservation. As the number of water delivery points will increase, the quantity of water pumped up from aquifers will increase as well. However, 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 and the north of the country contaminate groundwater resources (Heidecke, 2006). The growing amount of discharged and untreated waste water - especially near urban centres - poses a threat to ground water quality as well.

Waste water treatment and treatment of fecal sludge from urban septic tanks is still largely underdeveloped in Benin. It exists to some extent in the larger urban centres of Cotonou, Porto-Novo and Parakou on a very limited scale. Until recently there is no concrete national policy formulated on waste water treatment or on collection and treatment of urban fecal sludge. Most waste water in Benin – for the larger part domestic in nature - flows through surface drainage systems into rivers, lakes and eventually into the sea. The non-treatment of waste water is a serious factor contributing to the pollution of surface water bodies (Kotey, 2013 and Dodane, 2014) and only very recently through intervention of the World Bank are master plans being developed to attack these problems in the urban environment.

Demographic situation: population, urbanization, water consumption trends

According to the UN Statistics Pocketbook, Benin had 9.1 million citizens in 2011 and will have an average annual population growth of 2.7% between 2010 and 2015. The country has a high urban population: 45.6% of the total population (2012), and it has an expected annual urbanization growth rate of 4.1% (2010-2015). The city of Cotonou had 924,000 citizens in 2011, Porto-Novo had 314,000 citizens in that same year.

According to the WHO/UNICEF Joint Monitoring Programme for Water Supply and Sanitation 2014 update, 85% of the urban population and 69% of the ru-

ral population had access to *improved* drinking water sources (protected sources) in 2012; hence 15% of the urban population and 31% of the rural population had access to *unimproved* drinking water sources (unprotected sources and surface water). With respect to sanitation facilities: 25% of the urban population and 5% of the rural population had access to *improved* sanitation facilities. Hence 75% of the urban population and 95% of the rural population had access to *unimproved* sanitation facilities (WHO/Unicef 2014).

From an interpretation of the WHO/UNICEF 2013 update that looks at a longer period of time (see Table 1), we note the following. The national population grew with 91% between 1990 and 2011, in the cities the population grew with 152%. Between 1990 and 2011 there was 237% growth in access to improved drinking water sources, yet also 41% growth of the number of people that did *not* have access to improved drinking water sources. There was 607% growth in access to improved sanitation (for the rural population this was 1162% growth!); but there was also, nationally, 128% growth in the number of people with *no* access to improved sanitation. For the rural population, this was a growth of 142%.

Thanks to the activities of the national water supply company (SONEB) and an increasingly effective system of rural water supply development in combination with substantive international donor support, Benin has made progress developing its water supply and sanitation sector (having attained the Millennium Development Goal (MDG) target for drinking water access). With respect to sanitation, an estimated 800,000 people have gained access to improved sanitation since 1990; however, the country still lags far behind its MDG target for improved sanitation (WHO/UNICEF, 2013).

As the demographic statistics show, Benin's urban centres grow fast (currently 4.1% annually). This growth results in expanding cities. The former rural areas around these urban centers will see an increase in population density: they are becoming peri-urban. In the near future, these urban fringes may eventually become urban. The number of peri-urban zones has increased with more than 60% between 2002 and 2014. The provision of drinking water in rural areas differs from those in peri-urban areas. To meet a growing demand for drinking water, the supply has to increase as well, which asks for a different water policy. Urban water supply in Benin is the responsibility of SONEB, the national water company. According to new water policies, communities in cooperation with the DG Eau (associated decentralized services) are responsible for water supply in the rural areas. For peri-urban areas, under current conditions also communities are responsible, which is different from the past when no clear policies were in place and which led to a scarcity of drinking water at some places (Livre Bleu Benin, 2009).

Table 1

1990-2011	NATIONAL POPULATION			URBAN POPULATION			RURAL POPULATION		
Water	% growth popu-lation	% growth access to im-proved water source	% growth NO access to im-proved water source	% growth popu-lation	% growth access to im-proved water source	% growth NO access to im-proved water source	% growth popu-lation	% growth access to im-proved water source	% growth NO access to im-proved water source
Benin	91	237	41	152	198	35	59	255	53
Ghana	69	174	-50	144	170	15	27	181	-60
Kenya	78	152	21	151	126	432	63	166	12
Mali	83	324	-11	178	367	-35	54	309	-9
Mozambique	77	144	42	161	179	113	54	112	36
Rwanda	54	71	26	485	414	1200	31	44	12
South Sudan	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sub-Sah. Africa	70	119	24	125	128	112	49	117	12
Northern Africa	41	49	-13	58	60	32	24	38	-32
Africa	65	98	21	106	106	102	45	95	10
1990-2011	NATIONAL POPULATION			URBAN POPULATION			RURAL POPULATION		
Sanitation	% growth popu-lation	% growth access to im-proved sanita-tion facility	% growth NO access to im-proved sanita-tion facility	% growth popu-lation	% growth access to im-proved sanita-tion facility	% growth NO access to im-proved sanita-tion facility	% growth popu-lation	% growth access to im-proved sanita-tion facility	% growth NO access to im-proved sanita-tion facility
Benin	91	607	128	152	351	120	59	1162	142
Ghana	69	266	56	144	286	124	27	238	20
Kenya	78	106	68	151	199	134	63	96	52
Mali	83	168	68	178	195	170	54	116	47
Mozambique	77	273	57	161	206	137	54	594	43
Rwanda	54	193	-12	485	457	534	31	167	-27
South Sudan	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sub-Sah. Africa	70	96	61	125	120	129	49	88	40
Northern Africa	41	76	-50	58	61	18	24	93	-57
Africa	65	88	52	106	93	123	45	90	32

Source: WHO/UNICEF (2013), Progress on sanitation and drinking-water: 2013 update, pp. 14-35
Geneva / New York: World Health Organization / United Nations Children's Fund.

Political situation and institutional setting

Political situation

Benin has long been known as one of Africa's most stable democracies. According to the Africa Yearbook (2014), despite economic growth, there was some instability in the country because of President Thomas Boni Yayi's attempts to have the constitution changed to make a third presidential term possible, which led to street protests. Media freedom was suppressed on several occasions. Yayi also conducted several cabinet reshuffles, one of which concerned half the government. The UN urged the government to make child protection a priority after observations of child exploitation. The BBC Country Profile of Benin states that to the north, there have been sporadic clashes along the border with Burkina Faso. The trouble has been blamed on land disputes between rival communities on either side of the border.

Thousands of Togolese refugees fled to Benin in 2005 following political unrest in their homeland. Many of them have yet to return home.

Institutional setting of water

The Ministry of Energy, Mining, Water and Renewable Energies sets general water sector policies and supervises their application.

The General Water Authority (Direction Général de l'Eau, http://eaubenin.bj/site/index.php) under the Ministry of Energy and Water, implements national policies and coordinates water use for different purposes. In order to ensure that the national policies are implemented at the local level, DGEau is represented by 11 Water Service divisions and uses six Department divisions of the Ministry of Energy and Water.

On the basis of the new water law, Benin is in the process of implementing a decentralization policy, under which water supply and sanitation becomes the responsibility of the 77 communities municipalities, which may count between 25,000 and 600,000 inhabitants. Each municipality is headed by an elected council and a mayor. According to Law No. 97-029 of 1999 on the organization of municipalities, they now have full responsibility to provide drinking water and sanitation. The law also provides for the municipalities' right to request technical assistance from the national level or the private sector. Furthermore, the national government is responsible for the transfer of the necessary financial resources for the execution of these tasks to the municipalities.
(http://en.wikipedia.org/wiki/Water_supply_and_sanitation_in_Benin)

Hilhorst *et al.* (2008) state that the water sector in Benin is an example in which a sector-wide approach has worked rather well. A sector-wide approach entails a collaboration under the guidance of national leadership concerning the aims, the execution and evaluation of a sectoral program, in this case water. Working in partnerships is key to this concept. On the one hand, a partnership exists between the government and other actors (NGOs, other civil society groups, private sector) and on the other hand between different governing levels - the central government vis-à-vis decentralized government structures. The basis for Benin's successful sector-wide approach can be traced back to the 1990s, when technical and financial aid assisted newly developed decentralized water policies. Furthermore, the DG-Eau profited from the formulation of the MDGs (Millenium Development Goals) when the Minister of Finance decided to allocate a larger budget for clean drinking water and basic sanitation. Also, institutional reforms have systematically favored deconcentration and decentralization policies. This facilitated a sharp increase of the number of safe drinking water points provided since 2003. The lesson Hilhorst et. al. draw from the sector-wide approach on water is that strengthening the capacity to implement policies at the local level should also be a goal in itself; it doesn't come along automatically when focusing on the services to be delivered only.

In recent years, the coordinated assistance between various donors and donor programs has contributed much to the development of the capacity of the water sector in general and that of water supply and sanitation in particular. Especially the multi-year programme on water supply and sanitation (PPEA) has contributed much to the institutional development, organization and implementation of water supply and sanitation systems around the country. The programme is now foreseen to last through 2020 and includes activities related to IWRM (Integrated Water Resources Management) as well.

In February 2014, Geneva based WaterLex (an initiative started in 2010 claiming a collective effort from field experts, academics, diplomats, private and non-profit actors to provide solutions to current water governance challenges) launched a one-year project in Benin. Aim is to facilitate and promote the implementation of mechanisms of decentralised cooperation for water and sanitation among the country's municipalities. (More info on www.waterlex.org/?p=1191#).

Economic setting: economic growth, transport system, innovation & ICT

Benin is a low-income country and scores high on the corruption ranking (94th rank out of 177 in 2012 and 2013, Transparency International), despite the gov-

ernment's '*Lutte contre la Corruption*' (Africa Yearbook, 2014). Benin's major harbour Cotonou is often mentioned as one of the gateways of considerable smuggling, and of narco-trade, connecting South America, through Benin, with North Africa and Europe. The functioning of the harbour is notoriously problematic and insufficient. Benin is developing plans to expand its port system (also with so-called dry ports inland, which are major storage and transit places where goods are still under customs, such as in Parakou) and to make it more efficient (Africa Yearbook, 2013, 2014).

According to the World Bank, important economic and structural reforms helped Benin sustain its economic growth rates over the last decade. Nevertheless, poverty is still widespread and the economy remains too undiversified and vulnerable to external shocks. In 2013, GDP was $8.307 billion, GDP growth 5.6 %, and inflation 1.0%.

The national economy relies on the agricultural sector, in particular on cotton, and on transit and re-exportion trade. The agricultural sector accounts for about 32% of GDP and is the source of livelihood for nearly 70% of the country's workforce. Cotton is the primary export commodity accounting for about 25 to 40% of official total exports. Re-exportion trade with Nigeria is estimated to represent approximately 20% of GDP and explains the vulnerability of the economy to trade policy changes in its neighboring country and main trading partner.

The global economic and financial crisis contributed to a significant economic slowdown in Benin, and a widening of the fiscal and current account deficits. Growth decelerated in 2009 and 2010 further to weaker global demand for exports, a decrease in re-export trade, primarily to Nigeria, lower cotton production, lower foreign direct investment and also the 2010 floods had a negative impact on the economy. A slowdown in activity at the Port of Cotonou in the second half of 2011, following resistance to and problematic implementation of a new Import Verification Program (PVI), reduced growth from a projected 3.8% to 3.5%. However, growth rebounded in 2012 (5.4%), thanks to significantly higher cotton production and increased port volumes and traffic. Growth projections for 2013 are estimated at 5%. These developments will have a positive impact on Benin's macroeconomic situation, its fiscal position and on poverty alleviation.

Benin aims to become an emerging economy by 2025 through increasing sustainable growth over the medium-term and making progress towards the Millennium Development Goals (MDGs). Increasing economic growth and raising per capita GDP will require that Benin increasingly capitalizes on its comparative advantages in agriculture and its position as a regional trading center. Agricultural diversification and improved agricultural productivity will be key, as will an

improved business environment in order to take greater advantage of Benin's geographic position in serving the Nigerian market and its role as a gateway to land-locked countries to its north.

Since cotton production will be one of the main drivers of Benin's economic growth, the area under cotton production is likely to increase. Since most cotton is not irrigated, it will not directly compete with the existing water consumption. However, artificial fertilizers and pesticides are frequently used for the production of cotton, which may cause pollution problems. Eventually, residues of pesticides and fertilizers may end up - through run off after rain storms or ground water discharge - in surface water (rivers, lakes, reservoirs). Fertilizers can cause eutrophication problems while pesticides may be toxic for living organisms – turning the water useless for other productive (agricultural) activities. The cultivation of organic cotton may be a more environmentally friendly alternative, however it's still in its infancy with a current market share of only 1% (The Guardian, 2014).

Regarding transport: Benin has 6 airports, 438 km of railway, 16,000 km of roads, of which 1,400 are paved, and 150 km of waterways (seasonal navigation on River Niger along the northern border). Its major seaport is Cotonou. In general, Benin's rivers are hardly used to transport goods or people. During the rainy season, rivers flow abundantly, especially in the south of the country. But many small rivers fall dry during the dry season which prohibits navigation for a large part of the year. Vegetation in the rivers, caused mainly by water hyacinth, makes it even harder to navigate Benin's rivers. Only in the very south, around Cotonou (Lake Nokoué) and Porto Novo (Yewa river) people and goods are transported using the waterways.

With respect to ICT: based on a needs assessment held in May 2013, it was agreed that the stakeholders in the water sector in Benin need a spatial data and communication infrastructure (SDI/SNIEAU), which will be used for data sharing, reducing the cost of data generation and improving the products and value-added services based on the data. The new National Water Institute (INE) is managing this project, together with the DG Eau and other government institutions and with international partners from the Netherlands and Denmark. More info: http://eaubenin.bj/site/index.php/snieau-feuille-de-route.html.

In June 2013 the AKVO Foundation undertook a mission presenting new information and communication technologies to be applied to the monitoring of water supply and sanitation infrastructures in rural areas. The AKVO Foundation approach uses mobile phones with internet access as its main communication technology. This technology has already been implemented in five municipalities and should extend to all municipalities in Benin (35 in 2014 and 35 in 2015). (http://eaubenin.bj/site/index.php/inventaire-par-la-methode-akvo.html).

Agricultural dynamics

According to an ASC Community Country report compiled by the ASC's Ton Dietz in 2013 (Agricultural Dynamics in Ghana and Benin, 2013), Benin's agricultural sector has performed well in relation to population growth. In the cases of food staples, increases in total production exceeded the increase in population in all instances. Particularly promising were the increases in yield. In most other Africa cases, the major share of increase in total production was attributed to increases in the cropping area. In the case of Benin, the opposite is true for both cereals and pulses; the major share of increases in total production in food staples is attributable to increases in yields. It may be concluded that people in Benin are on average significantly better fed in 2009, than they were in 1961. With 825,000 Cal/cap/year as WHO target for a healthy life, Benin's population was always beyond that level and considerably beyond that level after 2000.

The agricultural dynamics of Benin show that it has been possible to improve the national food availability per capita considerably, and at the same time decrease the relative importance of food crop area as part of total crop area: from a very high 81% in 1961 to 64% in 2009. Cropping areas for cotton, cashew, fruits, vegetables and oil palm increased their share considerably. Cotton and cashew farmers also succeeded to drastically improve the yield levels for these crops. These are mostly crops for the export market.

In 2013, according to the Africa Yearbook, cotton constituted a major cash crop for farmers and an important source of income for the country's economy (CFAfr 110 bn). The sector benefited from a high degree of government attention in terms of monitoring, input, equipment, subsidies and training services. Critics state that that the focus on the industry's income-generating capacity is to the detriment of the sustainability of the sector, as cotton cultivation is marked by intensive use of pesticides and fertilizer, and cultivation into forest zones.

In the north and in the central parts of the country, many farmers still practice a transhumance-based type of livestock raising. However, the modernization of the livestock sector requires an increasing level of settling of these pastoralists. They are most likely to settle near micro dams where there is enough water for their animals to drink from. Currently, Benin counts about 200 places where surface water can be collected – some 40 millions m3 - for the profit of animal husbandry. This quantity allows the current herds to grow with some 35% (République du Benin, 2008).

With respect to irrigation: only some 12,000 ha are currently (2002) being irrigated in Benin. This is just a little less than 4% of the total surface (322,000 ha) that can potentially be irrigated. So, there is still considerable room to improve agricultural yields through irrigation. However, if the area under irrigated culti-

vation increases, water used for irrigation may compete with water needed for drinking and sanitation. This counts especially for areas in the north where water scarcity looms due to small and shallow ground water reserves in relation to diminishing rainfall (FAO, 2012).

Keyzer *et al.* (2007) constructed a model to estimate the possible influence of climate change on cropping patterns and farmers' income in Benin's middle belt – the projections are from 2004 until 2030. Reduced rainfall (dry periods) and increased rainfall variability have different effects on various crops. Some crops will suffer, i.e. maize and yam, while cotton and groundnut yields will improve on average. Farmers may adopt their cropping pattern – expand the area under cotton, sorghum and groundnut at the expense of maize and yam – and thereby compensate for the revenue loss caused by climate change. Furthermore, due to increased scarcities of drought-prone crops, higher prices for these crops may compensate for the yield loss as well.

According to the researchers, there is room for adaptation of the farming system to new climatic circumstances. Less fallow in combination with better fertility management can lead to a profitable kind of agricultural intensification. A stronger orientation on cash crops, intensification of cash crop cultivation and a commercial orientation towards more affluent markets in Nigeria and the expanding urban areas in the South may compensate for initial losses due to climate change (Keyzer *et al.* 2007). However, both Dedehouanou (2011) and Houkannou (2011) show respectively for the north and the south of Benin that once farmers are aware of the changing climate, adaption of their farming practices appears not to be that simple: for the time being they are not (yet) able to compensate for their loss in agricultural revenues.

Energy dynamics

According to the World Bank, as recently as 2000 less than one-fourth of the population in Benin had access to electricity, namely about 53 percent in urban areas and only 2 percent in rural areas. During the past two decades, electricity demand has increased at a rate of about 7 percent per year, with the lion’s share - 95 percent of demand - from households, particularly the coastal area around Cotonou and Porto Novo. As a result, costs have increased, and the country has grown increasingly dependent on electricity imports from neighbouring countries. These imports represented 60 percent of total consumption in 2007. This untenable energy profile has severely constrained Benin’s economic growth and the quality of life of its people.

The International Development Association (IDA) of the World Bank financed the Energy Services Delivery Project, which was launched in 2005 to

improve access to electricity. It aimed to do this by strengthening the government's institutional capacity, and helping it assess how to improve distribution, expansion, and environmental assessments. A follow-up initiative, the Increased Access to Modern Energy Project, was developed and signed in 2009, and aims at improving reliability, efficiency, and access to modern energy services in Benin. One of the next steps was a preparatory study for the Adjarala Hydroelectric Plant on the Mono River, at the border of Togo and Benin. All pre-investment studies for the project have been concluded and complementary studies to update the Economic and Financial Analyses on the project, including the Environmental and Social Management Plan as well as the Resettlement Action Plan have been implemented (involvement of the Dutch national EIA Commission in 2014). The project is expected to be commissioned by 2018 (World Bank special website on IDA projects; West African Power Pool website), with China as most likely candidate to participate in both construction and investment. Another hydroelectric plant has been proposed for the Dyodyonga Dam, on the northern border with Niger, with a capacity of 26 MW. Constraints of this site are that electrical production could not be provided all year long and damage could be done to the natural and cultural heritage of the Mekrou area (Unesco website). Another project led by a UNDP team (2014) is underway to look into the feasibility of these proposals.

Climate change

Of concern are the still inadequate supplies of potable water, but also continuing processes of deforestation and desertification (although with a lot of recent doubts about the latter).

The different climate change models for the region predict further reducing rainfall, higher temperatures and a more erratic rainfall pattern. Keyzer *et al.* (2007) relate these climatic changes to possible future developments in the agricultural sector.

For the south, well yields will most likely not be affected by a dryer climate in the near future since aquifers hold generally large volumes and are at a greater depth. But storage capacity and hydraulic properties of the deeper-situated aquifers may limit the capacity of individual wells to capture groundwater storage when more water is needed. Furthermore, climate change scenarios forecasting less precipitation (generated from global climate change models based on IPCC scenarios) indicate that the situation in water-scarce regions (the north) will worsen, as recharge volumes lessen and occur over a shorter period of time. Drilling more wells may be a limited option to capture larger portions of

groundwater recharge since the capture zone and therefore the regional influence of existing wells is rather small (Barthel *et al.* 2008).

Especially in the rural north diminishing rainfall will result in a worsening of the health condition of many rural dwellers. Diminishing rainfall may increase water scarcity due to the drying out of wells. Research has shown (Barthel *et al.* 2008, Heidecke 2006, Keyzer *et al.* 2007) that a high prevalence of diarrhoea is closely correlated to a diminished access to clean drinking water. However, overcoming institutional constraints may entirely compensate for the increasing groundwater scarcity. Improving institutions managing pumps, wells and sanitation will be of more relevance than ever before (Keyzer *et al.* 2007).

Benin is party to the following agreements: Biodiversity, Climate Change, Climate Change-Kyoto Protocol, Desertification, Endangered Species, Environmental Modification, Hazardous Wastes, Law of the Sea, Ozone Layer Protection, Ship Pollution, Wetlands, Whaling.

Pressing needs

** Fairer distribution of access to clean drinking water and sanitation*
Access to clean drinking water and sanitation should be more fairly distributed over Benin's population. There has been a massive investment into augmenting the level of coverage of clean drinking water with traditionally a strong emphasis on the rural areas and in recent years more attention for urban areas. For a fairer distribution of access to these services not only the number of new water sources count but also more qualitative elements should be taken into account like: who profits from this service? Where are these sources located? What exactly is being provided: piped water, wells, pump? (Adjinacou & Yadouleton, 2009).

** Promotion of a culture of, and mechanisms for good governance*
This has two dimensions: i) between the national (central) government and the local level (municipalities) and ii) between the state and non-state actors in the water sector. The first dimension aims at the discrepancy between on the one hand the tasks and the responsibility handed over in the decentralization process from the national to the local level, and on the other hand the lack of skills and knowledge at the local level to deliver the services effectively and efficiently. The second dimension corresponds with the necessity to include (representatives of) civil society in the coordination and monitoring of water services (Hilhorst *et al.* 2006, Adjinacou & Yadouleton, 2009).

**Strengthening of authority and capacity of local communities and municipalities*
On paper nothing withholds municipalities to plan, initiate and coordinate local water-related projects; however in reality project finance and management often remains at a national (central) level. Local authorities lack budgets, but also the skills and knowledge to start projects themselves. However, within Benin's political landscape of decentralization policies, the future of effective and efficient water-management lies at the local level.(Hilhorst *et al.* 2006, Adjinacou & Yadouleton, 2009)

** Maintaining and improving datebases*
The BDI (Banque de Données Intégrées) and the SNIEAU (Systeme National d'Information sur l'Eau), under the joint responsibility of the DG Eau and the new National Water Institute, should be upgraded and extended. This is essential to monitor the socio-economic and environmental effect of water policies on a local, regional and national scale. Furthermore, an extended database and information system allows for an analysis – and subsequently the formulation of policies – on the basis of IWRM principles in Benin (Barthel *et al.* 2009).

** Measures to deal with surface water pollution & waste water*
The pollution of bodies of surface water mainly by the non-treatment of an increasing quantity of waste water poses problems now and in the future. The growing urbanization is a substantial contributing factor in this context. To avoid environmental catastrophes, waste water policies should be formulated and measures should be taken.

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