Nile Basin Initiative

Potential areas for irrigation development

South Sudan

Potential for Irrigation Development
Aweil Area
South Sudan

The Nile Basin Initiative (NBI), under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the project Regional Agricultural Trade and Productivity Project (RATP) has undertaken a study entitled "Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda". The study was categorized as "preparation for a development program" and has a strategic perspective.

During 2011-2012 an overall assessment on the potential to develop irrigation has been undertaken by a consortium headed by FutureWater and WaterWatch (Netherlands). Based on these analyses 35 high potential areas have been selected. This note provides the highlights of one of these areas.

Overview

Aweil focal area (17,876 ha) is located in the northwestern part of South Sudan, within Northern Bahr el Ghazal state. The area descends from the North West (425 m) towards the North East (415 m). One large stream passes the focal area on the northern side, and from the South a minor stream joins in. Both streams join just outside the focal area at the eastern side. An irrigation scheme has already been developed west of the focal area, although this irrigation scheme will need some rehabilitation. It is advised to rehabilitate that part first, before developing this focal area. Slopes in the focal area are largest in the North, reaching 2% on a 250 m resolution map. On a 30 m resolution, slopes are quite significant over the area, reaching over 10% in some small areas.

Land and Water Resources

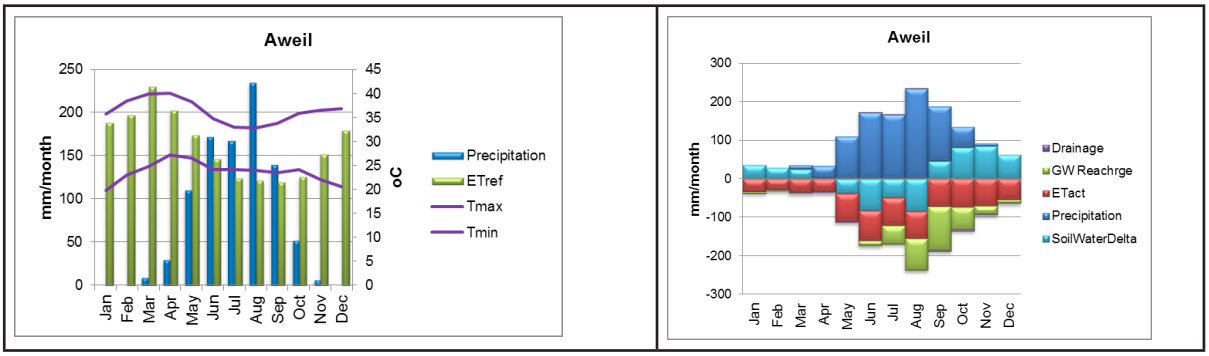
Within the whole area a mixture and combination between Gleysols and Vertisols can be found. The area is well drained, and the soil has a clayey loam texture. Organic carbon in the soil is low (1%) and the available water holding capacity is between 125-150 mm/m. The main obstacle to utilization of Gleysols is the necessity to install a drainage system to lower the groundwater table. Adequately drained Gleysols can be used for arable cropping, dairy farming and horticulture. If too wet soils are cultivated, then the soil structure will be destroyed for a long time. Therefore, Gleysols in depression areas with unsatisfactory possibilities to lower the groundwater table are best kept under a permanent grass cover or swamp forest. Gleysols can be used well for wetland rice cultivation if the climate is appropriate. Vertisols are clayey soils, with a high percentage of swelling clays. These soils form deep wide cracks from the surface downward when they dry out, which happens in most years. Vertisols have considerable agricultural potential, but adapted management is a precondition for sustained production. The comparatively good chemical fertility and their occurrence on extensive level plains, where reclamation and mechanical cultivation can be envisaged, are assets of Vertisols. Compared to the South Sudanese average NDVI of 0.50, the Aweil focal area has a lower than average land productivity (NDVI) of 0.46. The highest land productivity can be found in the swampy area in the east of the focal area (NDVI 0.6). The slight ridges on the north and south of the focal area have significant lower land productivity (NDVI 0.35). Temperature ranges between 24oC and 36oC. Annual average precipitation is 926 mm and reference evapotranspiration 1961 mm per year.

South Sudan at a Glance
(World Development Indicators 2010)

Population	9.9 million
Population below national poverty line	50.6 % (2009)

Socio-economic Factors

The population density is approximately 24 people/km2. Most people in the area live in Aweil town. Around the focal area and the abandoned irrigation scheme west of the focal area, there are quite some houses scattered around. However, within the focal area there are few houses and the abandoned irrigation scheme is not inhabited at all. It seems that population displacement is hardly needed, and especially when started with the rehabilitation of the old irrigation scheme. Considering the population settlement, the rehabilitation seems the best option to start with, as people are living nearby. With the design of any irrigation scheme, it is advised to limit any population displacement. The area is inhabited by Dinka and Jur Chol people, which unfortunately have a very limited knowledge of agriculture, irrigation and farmers cooperatives. The area is not very well accessible, with some earth roads going around the area, and the first proper roads being at Aweil town, which is at about 15 km away. Aweil town is also the primary market, after which other towns can be served.



Average climate conditions and water balances for the area based on various global and local datasets, satellite information and advanced modeling approaches.

Irrigation and Crop Potential

Very small parts of the irrigation schemes developed around Aweil are still in use. It is advised to rehabilitate them before developing a new one. When rehabilitating the irrigation scheme it is advised to focus partially on staple crops; in this case mainly paddy and vegetables and partially, with an eye on the future, on cash crops such as sugar cane, which could diversify the economy. Within Aweil focal area, the yields are slightly lower than Sudanese average yields. However, the current harvested area can be largely expanded, which will produce tremendously more yield. Besides, there is a real potential to increase crop production, if rice is grown in two growing cycles, and to improve the water management conditions. The use of fertilizer is recommended to push yields even further. It is expected that the yields of rice can reach around 70% of the world's highest, which would mean an increase of over 100%. Currently, sugar cane in not grown in the area, but it can be introduced later on as cash crop. The numbers show that there is a large potential to produce sugar cane, which will enhance poverty reduction and diversify the exports.

Benefit-Costs Analysis

A first-order benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area. The following table shows that based on the benefit-costs analysis for the area investments in irrigation are very positive.

Investment Costs	
Irrigation infrastructure (US$/ha)	3,000
Social infrastructure (US$/farmer)	500
Accessibility infrastructure (million US$)	1.0
Operational Costs	
O&M irrigation (US$/ha/yr)	60
Extension service (US$/farmer)	10
O&M roads (US$/yr)	20,000
Summary	
Initial investments (million US$)	49.0
O&M costs (million US$/yr)	0.980
Net benefits per year (million US$/yr)	19.296
IRR (Internal Rate of Return)	59.7%

The initiative of this study was taken by Regional Agricultural Trade and Productivity Project (RATP) of the Nile Basin Initiative (NBI). Financial support was provided by the Canadian International Development Agency (CIDA). The study was undertaken by a large consortium headed by FutureWater and WaterWatch (Netherlands). More details is available from a series of reports and databases.

Further contact can be obtained from:
Innocent Ntabana (Regional Project Manager RATP)
E: intabana@nilebasin.org; T +257 222756 /02/03
and/or
Peter Droogers (Director FutureWater, Netherlands)
E: p.droogers@futurewater.nl; T: +31 317 460050

Potential for Irrigation Development
Jebel Lado Area
South Sudan

The Nile Basin Initiative (NBI), under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the project Regional Agricultural Trade and Productivity Project (RATP) has undertaken a study entitled "Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda". The study was categorized as "preparation for a development program" and has a strategic perspective.

During 2011-2012 an overall assessment on the potential to develop irrigation has been undertaken by a consortium headed by FutureWater and WaterWatch (Netherlands). Based on these analyses 35 high potential areas have been selected. This note provides the highlights of one of these areas.

Overview

Jebel Lado focal area (3159 ha) is situated in the South of South Sudan within the state of Central Equatoria. The focal area is wrapped around the eastern side of the mountain, and covers a stream valley. The stream valley runs from West to East, and drains in the East into the White Nile. The land descends gradually from 470 m in the West, to 435 m at the junction with the White Nile. The slope of the focal area is very limited and mostly does not exceed 2%. On smaller scales, however, the slopes may reach locally up to 10%. The topography seems to be very suitable for surface irrigation.

Land and Water Resources

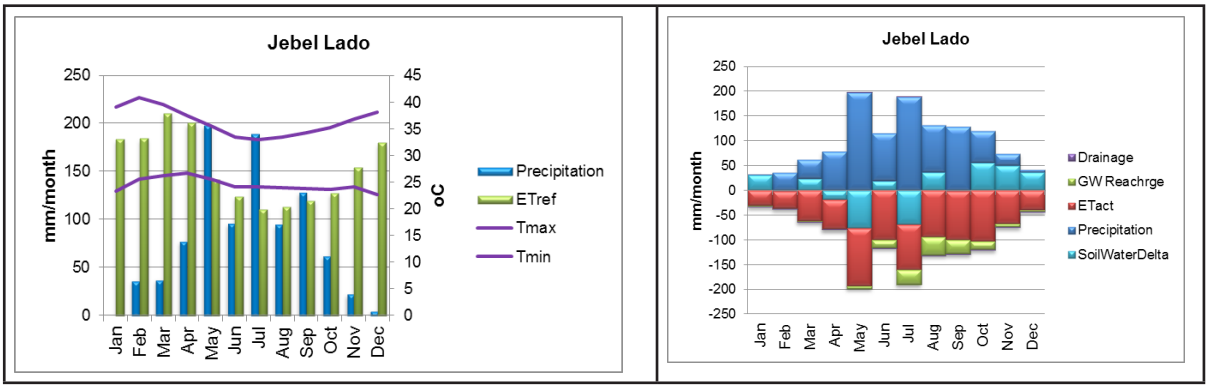
The soils in the focal area are rather uniform. The soil in this river valley is formed under alluvial processes. The largest part of the area is a Fluvisol, with a smaller part having Gleysols. The soil mainly consists of sandy clay, towards loamy on some parts. Therefore, the drainage in the area is quite poor. The top soil is richer in organic carbon than the sub soil, and contains 0.6-1.2% organic carbon. The available water holding capacity is large with over 150 mm/m. Paddy rice cultivation is widespread on many tropical Fluvisols with satisfactory irrigation and drainage. Paddy land should be dry for at least a few weeks every year, in order to prevent the redox potential of the soil from becoming so low that nutritional problems (Fe or H2S) arise. Many dry land crops are grown on Fluvisols as well, normally with a certain form of water control. The main obstacle to utilization of Gleysols, is the necessity to install a drainage system to lower the groundwater table. Adequately drained Gleysols can be used for arable cropping, dairy farming and horticulture. If too wet soils are cultivated, then the soil structure will be destroyed for a long time. Therefore, Gleysols in depression areas with unsatisfactory possibilities to lower the groundwater table are best kept under a permanent grass cover or swamp forest. Compared to the South Sudanese average NDVI of 0.50, the Jebel Lado focal area has an above average land productivity (NDVI) of 0.54. Within the focal area, the NDVI is highest in the stream valley with values over 0.6. Land productivity is decreasing further away from the river to values of 0.45.The climate of the area can be characterized as warm with temperatures during the year ranging from about 24oC to 36oC. Annual average precipitation is 952 mm and reference evapotranspiration 1851 mm per year.

South Sudan at a Glance
(World Development Indicators 2010)

Population	9.9 million
Population below national poverty line	50.6 % (2009)

Socio-economic Factors

The population density is approximately 40 people/km2 compared to the South Sudanese average of 13 people/km2. In the Jebel Lado focal area there are some small communities, which live together. There are not many houses scattered around the area. Especially in the part of the focal area within the river valley the population density is extremely low due to flood risks. Therefore, population displacements are probably not needed when developing irrigation systems. With the design of any irrigation scheme, it is advised to limit any population displacement. In 2008 it is estimated that half of the population is below the age of 18 years. Within South Sudan 51% of the population is living below the national consumption poverty line (SSDP). Concerning agriculture, the agricultural knowledge is average, which means that for irrigation training will be needed. The accessibility is quite good, but should be improved when developing irrigation. Nearby markets include Juba (25 km away). The area is inhabited by the Bari community.



Average climate conditions and water balances for the area based on various global and local datasets, satellite information and advanced modeling approaches.

Irrigation and Crop Potential

Currently, agriculture is practiced in a small part (10%) of the focal area. The remaining land consists mainly of sparse mixed vegetation and scrubland. Crops which are currently grown in the area include maize, sorghum, cassava and millet. They are all grown rain-fed, which incorporates that they are grown in one growing cycle per year within the raining season. When an irrigation scheme is developed, it is advised to focus partially on staple crops, such as paddy, maize, cassava, millet and vegetables and partially, with an eye on the future on cash crops, which could diversify the economy. Within Jebel Lado focal area the yields are slightly higher than Sudanese average yields. For Cassava the yield gap is large as Sudan get yields at 25% of the East African average. With irrigation, the yields for Cassava can at least reach towards this East African average, which would mean a fourfold production. Production of maize and rice can increase under irrigation. Maize can double and reach towards the world's average, and rice is expected to surpass the world's average, and increase towards 60-70% of the world's highest yield.

Benefit-Costs Analysis

A first-order benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area. The following table shows that based on the benefit-costs analysis for the area investments in irrigation are very positive.

Investment Costs	
Irrigation infrastructure (US$/ha)	5,000
Social infrastructure (US$/farmer)	500
Accessibility infrastructure (million US$)	2.0
Operational Costs	
O&M irrigation (US$/ha/yr)	60
Extension service (US$/farmer)	10
O&M roads (US$/yr)	40,000
Summary	
Initial investments (million US$)	10.3
O&M costs (million US$/yr)	0.145
Net benefits per year (million US$/yr)	0.921
IRR (Internal Rate of Return)	6.3%

The initiative of this study was taken by Regional Agricultural Trade and Productivity Project (RATP) of the Nile Basin Initiative (NBI). Financial support was provided by the Canadian International Development Agency (CIDA). The study was undertaken by a large consortium headed by FutureWater and WaterWatch (Netherlands). More details is available from a series of reports and databases.

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Innocent Ntabana (Regional Project Manager RATP)
E: intabana@nilebasin.org; T +257 222756 /02/03
and/or
Peter Droogers (Director FutureWater, Netherlands)
E: p.droogers@futurewater.nl; T: +31 317 460050

Potential for Irrigation Development
Pagarau Area
South Sudan

The Nile Basin Initiative (NBI), under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the project Regional Agricultural Trade and Productivity Project (RATP) has undertaken a study entitled "Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda". The study was categorized as "preparation for a development program" and has a strategic perspective.

During 2011-2012 an overall assessment on the potential to develop irrigation has been undertaken by a consortium headed by FutureWater and WaterWatch (Netherlands). Based on these analyses 35 high potential areas have been selected. This note provides the highlights of one of these areas.

Overview

Pagarau focal area (13,832 ha) is located in the Lakes state, in central South Sudan. The area is rather flat and descends slightly from South (420 m) to North (415 m). A large river runs through the area, which can serve as an irrigation water source. The river finally drains into the White Nile, which is approximately 60 km north of the focal area. A small lake borders the focal area on the Southern tip. Based on the 250 m resolution slope map, the slopes do not exceed 1%. On a smaller scale (30 m), slopes are more significant; staying under 3% in most of the area, and reaching towards 10% on some places in the North.

Land and Water Resources

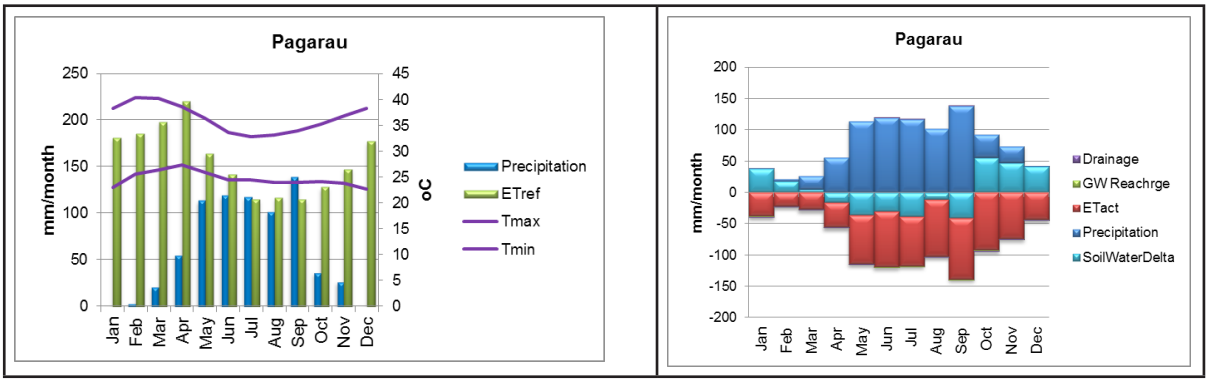
The focal area is located on a transition between soil types. The texture in the western part is loamy, and changes towards a more clayey texture in the largest eastern part. The western part is located in a soil which is formed under strong fluvial processes, and the eastern part, which contains Gleysols and Histosols, is partially formed under fluvial processes. Due to poor drainage and high groundwater levels peat has been developed. Therefore, the available water holding capacity in the whole area is large with over 150 mm/m. Organic carbon in the eastern part is extremely high (15%), compared to 1% in the west. Management of the eastern part with Gleysols and Histosols is characterized by the necessity to install a drainage system to lower the groundwater table. If too wet soils are cultivated, then the soil structure will be destroyed for a long time. Therefore, Gleysols in depression areas with unsatisfactory possibilities to lower the groundwater table are best kept under a permanent grass cover or swamp forest. Concerning Histosols in the tropics, an increasing numbers of landless farmers venture onto the peat lands, where they clear the forest and cause raging peat fires in the process. Many of them abandon their land again after only a few years; the few that succeed are on shallow, topogenous peat. Compared to the South Sudanese average NDVI of 0.50, the Pagarau focal area has an above average land productivity (NDVI) of 0.60. The annual average land productivity is quite uniform over the whole area. The climate of the area can be characterized as warm with temperatures during the year ranging from about 25oC to 36oC. Annual average precipitation is 736 mm and reference evapotranspiration 1892 mm per year.

South Sudan at a Glance
(World Development Indicators 2010)

Population	9.9 million
Population below national poverty line	50.6 % (2009)

Socio-economic Factors

The population density is approximately 16 people/km2. If an irrigation system is developed, it is not expected that any population displacement is needed. Especially since the population density does not allow for large scale irrigation development. With the design of any irrigation scheme, it is advised to limit any population displacement. The irrigation scheme can be developed around the existing houses. Remarkably, the ratio male to female is 1.11. In 2008 it is estimated that half of the population is below the age of 18 years. Within South Sudan, 51% of the population lives below the national consumption poverty line (SSDP). The area is inhabited by Dinka people, which unfortunately have a very limited knowledge of agriculture, irrigation and farmers cooperatives. When developing an irrigation scheme, additional effort is needed for intensive trainings. The area is not very well accessible, with some earth roads going around the area, and the first proper roads being at Yirol town, which is at about 30 km away. Yirol town is also the primary market, after which other towns can be served.



Average climate conditions and water balances for the area based on various global and local datasets, satellite information and advanced modeling approaches.

Irrigation and Crop Potential

Crops that are currently grown in the area include maize, sorghum, rice and groundnuts. They are all grown rain fed, which incorporates that they are grown in one growing cycle per year during the raining season. When developing an irrigation scheme, it is advised to focus partially on staple crops, such as paddy, maize, sorghum and vegetables and partially, with an eye on the future on cash crops, such as sugar cane, which could diversify the economy. The yields are approximately 20% higher than Sudanese average yields. It is expected that the production of maize can increase threefold towards 20% of the highest obtainable. Rice is already giving yields comparable with the world's average, but with a second growing cycle the yield can double. Sugar cane is currently not much grown in the area, but the graph shows that is will be a very suitable cash crop, which will enhance poverty reduction, and may diversify exports.

Benefit-Costs Analysis

A first-order benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area. The following table shows that based on the benefit-costs analysis for the area investments in irrigation are very positive.

Investment Costs	
Irrigation infrastructure (US$/ha)	5,000
Social infrastructure (US$/farmer)	500
Accessibility infrastructure (million US$)	2.0
Operational Costs	
O&M irrigation (US$/ha/yr)	60
Extension service (US$/farmer)	10
O&M roads (US$/yr)	100,000
Summary	
Initial investments (million US$)	19.2
O&M costs (million US$/yr)	0.285
Net benefits per year (million US$/yr)	2.929
IRR (Internal Rate of Return)	8.5%

The initiative of this study was taken by Regional Agricultural Trade and Productivity Project (RATP) of the Nile Basin Initiative (NBI). Financial support was provided by the Canadian International Development Agency (CIDA). The study was undertaken by a large consortium headed by FutureWater and WaterWatch (Netherlands). More details is available from a series of reports and databases.

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Potential for Irrigation Development
Renk Area
South Sudan

The Nile Basin Initiative (NBI), under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the project Regional Agricultural Trade and Productivity Project (RATP) has undertaken a study entitled "Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda". The study was categorized as "preparation for a development program" and has a strategic perspective.

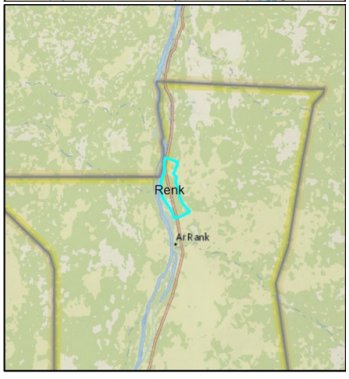
During 2011-2012 an overall assessment on the potential to develop irrigation has been undertaken by a consortium headed by FutureWater and WaterWatch (Netherlands). Based on these analyses 35 high potential areas have been selected. This note provides the highlights of one of these areas.

Overview

The Renk focal area is located completely in the North of South Sudan, within the Upper Nile state, and borders Sudan. The focal area includes some irrigation schemes, which are currently partially operational. The largest irrigation systems are Abu Khadra, Magara and Geigar, which spread from South to North along the Nile. The focal area (10,231 ha) covers the western banks of the White Nile, starting from Renk and going northwards. The area descends from East (390 m) to West (380 m) at Nile level. Two seasonal rivers pass through the area from East to West, but they are not used much for irrigation purposes. Slopes are limited. The steeper slopes can be found at a line following the road going through the area. The majority of slopes stay under 2%.

Land and Water Resources

The soil in Renk focal area can be defined as Eutric Vertisol. This area on the shores of the river Nile has been influenced by its regime. The texture is mainly heavy clay, which is well drained. The pH is average with a value of 7. Organic carbon in the soil is rather low (1%) and the water holding capacity is between 125-150 mm/m. The shifting swelling and shrinking of expanding clays results in deep cracks during dry season. Vertisols have considerable agricultural potential, but adapted management is a precondition for sustained production. The comparatively good chemical fertility and their occurrence on extensive level plains, where reclamation and mechanical cultivation can be envisaged, are assets of Vertisols. Their physical soil characteristics and difficult water management cause problems. Buildings and other structures on Vertisols are at risk, and engineers have to take special precautions to avoid damage. The agricultural uses of Vertisols range from very extensive (grazing, collection of fuelwood, and charcoal burning), through smallholder post-rainy season crop production (millet, sorghum, cotton and chickpeas), to small-scale (rice), and large-scale irrigated agriculture (cotton, wheat, barley, sorghum, chickpeas, flax, and sugar cane). Cotton is known to perform well on Vertisols. Management practices for crop production should be directed primarily at water control in combination with conservation or improvement of soil fertility. Compared to the South Sudanese average NDVI of 0.50, Renk focal area has a lower than average land productivity (NDVI) of 0.30. In the focal area, however, the NDVI values range between 0.25 and 0.33. Temperatures range between 22oC and 36oC. Annual average precipitation is 579 mm and reference evapotranspiration 2268 mm per year.

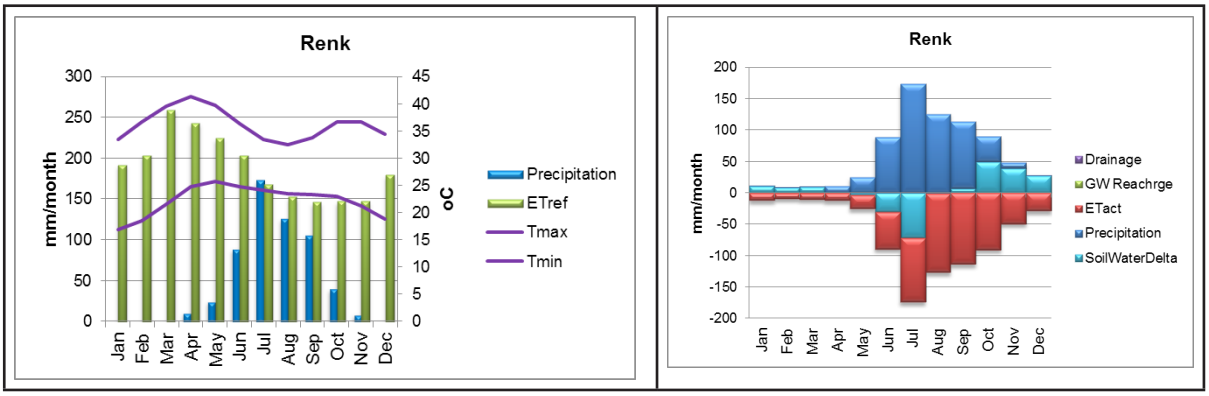


South Sudan at a Glance
(World Development Indicators 2010)

Population	9.9 million
Population below national poverty line	50.6 % (2009)

Socio-economic Factors

The population density is about 12 people/km2. The population in Renk area mainly lives in Renk town, which is quite far from some parts of the irrigated area. Within the abandoned irrigation scheme there are already some places where people live in a community. Since the development of Renk focal area will mainly consist of the rehabilitation of the already existing irrigation scheme, population displacements are not expected. However, on small scale it may be necessary. With the design and rehabilitation of this irrigation scheme, it is advised to limit any population displacement. The people that live in the area do have average knowledge on agriculture and irrigation, as irrigation has been practiced before and is still practiced in small areas. People hardly have any experience on farmer's cooperatives, which could be improved with trainings. The infrastructure is quite good; a tarmac road passes directly by the focal area and Renk town in not far away. Other markets are more difficult, as Renk is situated in a corner of South Sudan. There is a connection to Sudan.



Average climate conditions and water balances for the area based on various global and local datasets, satellite information and advanced modeling approaches.

Irrigation and Crop Potential

When rehabilitating the irrigation scheme it is advised to focus partially on staple crops; in this case mainly paddy, sorghum, maize and vegetables and partially, with an eye on the future, on cash crops, such as sugar cane, which could diversify the economy. Within Renk focal area the yields are much lower than Sudanese average yields, mainly due to low precipitation. With irrigation the water availability is no issue anymore due to abundant water resources. This creates a large potential, and yields are expected to increase significantly with irrigation. Within the irrigated area it is advised to focus on rice, as rice is expected to give the highest yields and economic benefits. Under irrigation the production of rice is expected to increase towards 60% of the world's highest obtainable, which would mean an increase of 200%. Besides the increase in yield, also the harvested area will increase, and a second growing cycle will greatly push the yields and economic development. Later on, some part can be planted with sugarcane, as Sudan keeps good record for sugarcane production.

Benefit-Costs Analysis

A first-order benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area. The following table shows that based on the benefit-costs analysis for the area investments in irrigation are very positive.

Investment Costs	
Irrigation infrastructure (US$/ha)	3,000
Social infrastructure (US$/farmer)	500
Accessibility infrastructure (million US$)	0.5
Operational Costs	
O&M irrigation (US$/ha/yr)	60
Extension service (US$/farmer)	10
O&M roads (US$/yr)	10,000
Summary	
Initial investments (million US$)	19.3
O&M costs (million US$/yr)	0.387
Net benefits per year (million US$/yr)	10.568
IRR (Internal Rate of Return)	100.0%

The initiative of this study was taken by Regional Agricultural Trade and Productivity Project (RATP) of the Nile Basin Initiative (NBI). Financial support was provided by the Canadian International Development Agency (CIDA). The study was undertaken by a large consortium headed by FutureWater and WaterWatch (Netherlands). More details is available from a series of reports and databases.

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and/or
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Potential for Irrigation Development
Wau Area
South Sudan

The Nile Basin Initiative (NBI), under the Nile Equatorial Lakes Subsidiary Action Program (NELSAP) and the project Regional Agricultural Trade and Productivity Project (RATP) has undertaken a study entitled "Assessment of the Irrigation Potential in Burundi, Eastern DRC, Kenya, Rwanda, Southern Sudan, Tanzania and Uganda". The study was categorized as "preparation for a development program" and has a strategic perspective.

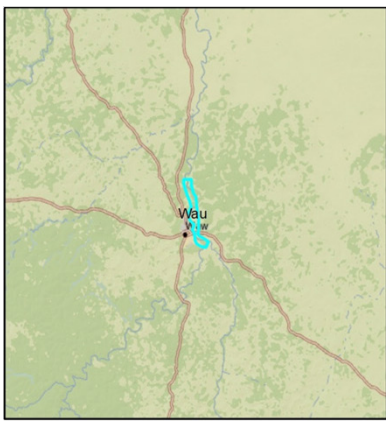
During 2011-2012 an overall assessment on the potential to develop irrigation has been undertaken by a consortium headed by FutureWater and WaterWatch (Netherlands). Based on these analyses 35 high potential areas have been selected. This note provides the highlights of one of these areas.

Overview

The Wau focal area is located in the western part of South Sudan within the Western Bahr El Ghazal State. The area covers the valley of the Nahr al Jur River, which is one of the largest rivers in South Sudan. The area descends from South (440 m) to North (425 m). The topography is very much suitable for surface irrigation. The river meanders through the focal area, and the location of the river within the valley has changed over the years. The cross section of the focal area is rather flat; land may ascend slightly towards the sides with 2-3 meters. The slopes in the focal area are almost 0% on most places, with some exceptions reaching towards 5-15 %

Land and Water Resources

The focal area is located in an alluvial plain, and the soil can be characterized as a Chromic Combisol. The texture of the soil is loamy to sandy clay, and the organic carbon is rather low (<1%). Drainage is somewhat poor, and the available water holding capacity is large with more than 150 mm/m. Cambisols are characterized by slight or moderate weathering of parent material, which proceeds much faster in the tropics than in associated temperate climatic zones. Cambisols generally make good agricultural land and are used intensively. Cambisols in the humid tropics are typically poor in nutrients, but are still richer than associated Acrisols or Ferralsols, and they have a greater CEC. Cambisols with groundwater influence in alluvial plains are highly productive paddy soils. Compared to the South Sudanese average NDVI of 0.50, Wau focal area has a lower than average land productivity (NDVI) with an NDVI of 0.41. The land productivity is lowest around Wau town and close to the river. This can be attributed to the very sandy river banks, with rapidly changing circumstances, such that the system is too unstable to be covered by any vegetation. Therefore, the variation in land productivity on these locations is lowest in these parts too. The areas that currently have the highest land productivity have been in use for agriculture and have been irrigated before. The rehabilitation of these irrigation systems will be difficult, as they have not been used or maintained for a long time. The climate of the area can be characterized as warm with temperatures during the year ranging from about 24oC to 36oC. Annual average precipitation is 1149 mm and reference evapotranspiration 1902 mm per year.

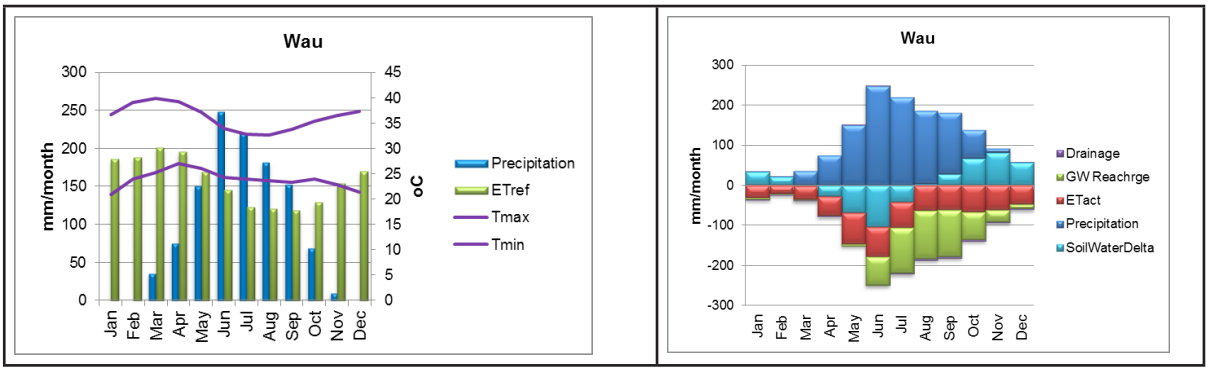


South Sudan at a Glance
(World Development Indicators 2010)

Population	9.9 million
Population below national poverty line	50.6 % (2009)

Socio-economic Factors

The population density is about 4 people/km2. Most people live in Wau town, which is bordering the focal area on the southwest. However, on the eastern banks of the river, on the opposite of Wau town, there are quite some settlements too. Along the eastern shores of the river there is a long line of houses, buildings and industries going north along the river. On the western banks of the river, a build-up area continues some kilometers north of Wau, after which houses become more scattered. When developing irrigation schemes, it is advised to avoid population displacements and design the scheme around the already build up area. However, in this focal area the irrigation scheme may become very much fragmented. With the design or rehabilitation of any irrigation scheme, it is advised to limit any population displacement. . The area is inhabited by Dinka, Fartit and Jur Chol people, which have an average experience with agriculture and farmers cooperatives. This can largely contribute to a successful introduction of an irrigation scheme. The accessibility of the focal area is very good, as Wau is a transport hub within South Sudan.



Average climate conditions and water balances for the area based on various global and local datasets, satellite information and advanced modeling approaches.

Irrigation and Crop Potential

When rehabilitating the irrigation scheme it is advised to focus partially on staple crops; in this case mainly paddy and vegetables, and partially with an eye on the future, on cash crops, such as sugar cane, which could diversify the economy. Within the Wau focal area the yields are about 10-20% lower than Sudanese average yields. It is expected that the production of rice and later sugarcane have a high potential to increase yield. The exact yield increase depends largely on river flow regulation. Under good water management circumstances it is expected that the yields of rice can increase much, surpassing the world's average towards 60% of the highest obtainable. Vegetables will definitely increase largely under irrigation and production will probably reach the threefold. Sugarcane is a good cash crop, which can be introduced after a few years of good practice. Sudan keeps good record with sugar cane, and yields are expected to reach towards the worlds' highest. Irrigation will not only increase yields due to proper water management, but also enable for a second growing cycle per year, which enhances productivity.

Investment Costs	
Irrigation infrastructure (US$/ha)	6,000
Social infrastructure (US$/farmer)	500
Accessibility infrastructure (million US$)	0.5
Operational Costs	
O&M irrigation (US$/ha/yr)	60
Extension service (US$/farmer)	10
O&M roads (US$/yr)	10,000
Summary	
Initial investments (million US$)	13.8
O&M costs (million US$/yr)	0.155
Net benefits per year (million US$/yr)	3.738
IRR (Internal Rate of Return)	35.2%

Benefit-Costs Analysis

A first-order benefit-cost analysis is undertaken for the area. Information for this is based on various sources such as FAO publications, IFPRI publications, local expertise and data. A full benefit-costs analysis has to be undertaken in a sub-sequent feasibility study for the area. The following table shows that based on the benefit-costs analysis for the area investments in irrigation are very positive.

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Further contact can be obtained from:
Innocent Ntabana (Regional Project Manager RATP)
E: intabana@nilebasin.org; T +257 222756 /02/03
and/or
Peter Droogers (Director FutureWater, Netherlands)
E: p.droogers@futurewater.nl; T: +31 317 460050

Nile Equatorial Lakes Subsidiary Action Program
Regional Agricultural Trade and Productivity Project
5th Floor Kigali City Tower, Avenue Du Commerce, Kigali-Rwanda
P.O Box 6759; Tel: +250788307334
Fax: +250252580100; Url: www.nilebasin.org/nelsap