



IRRIGATION AND CROP SUITABILITY

Climate smart
High value cash crop
Demeter Pivot Drip Climate change
Design
Crop suitability
Wells^{ET} Irrigation
Reservoir
Make out most of
one single drop

2023

BROCHURE

COUNTRIES

WHERE WE HAVE WORKED IN:

Albania

Romania

Switzerland

China

Brazil

Hungary

Uganda

Nepal

Austria

Lebanon



Bence Fülöp

Chief Executive Officer

TRINITY ENVIRO

Dear Reader,

Among reduced water availability, water quality and siltation are the biggest threads to operation of reservoirs. Our state-of-the-art approach PhosFate has been a proven tool pinpoint area of intervention. We will tell you exactly where to interact, but even more we can calculate you the most cost-effective set of measures to achieve your aims with your reservoir management.

No data, no problem to us our databases are covering the entire globe and based on our previous work your system can be calibrated. Moreover, with our Climate-change downscaling expertise we can.

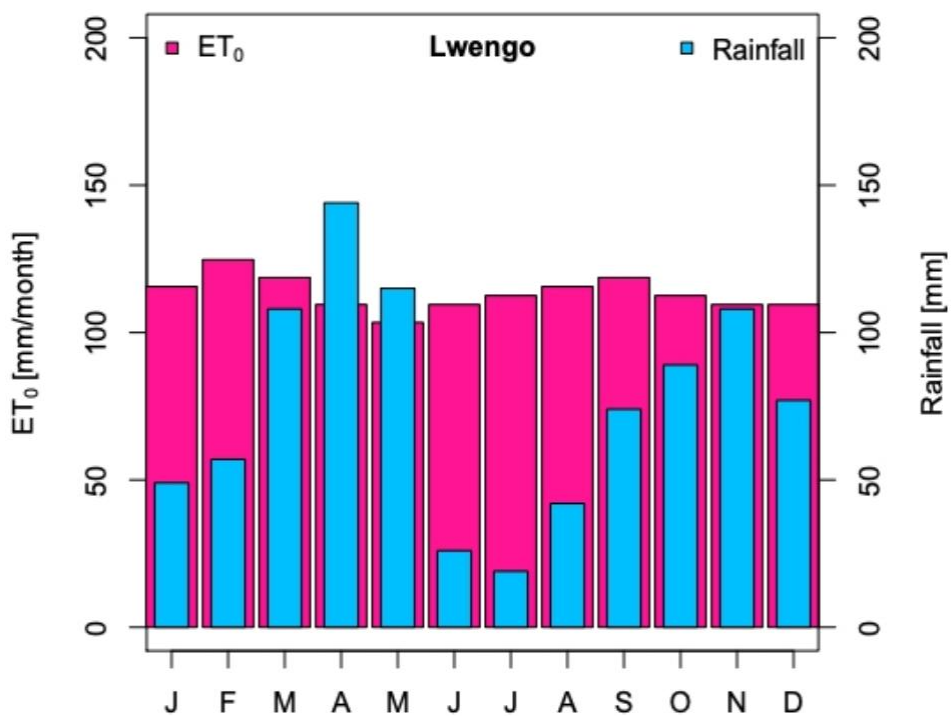
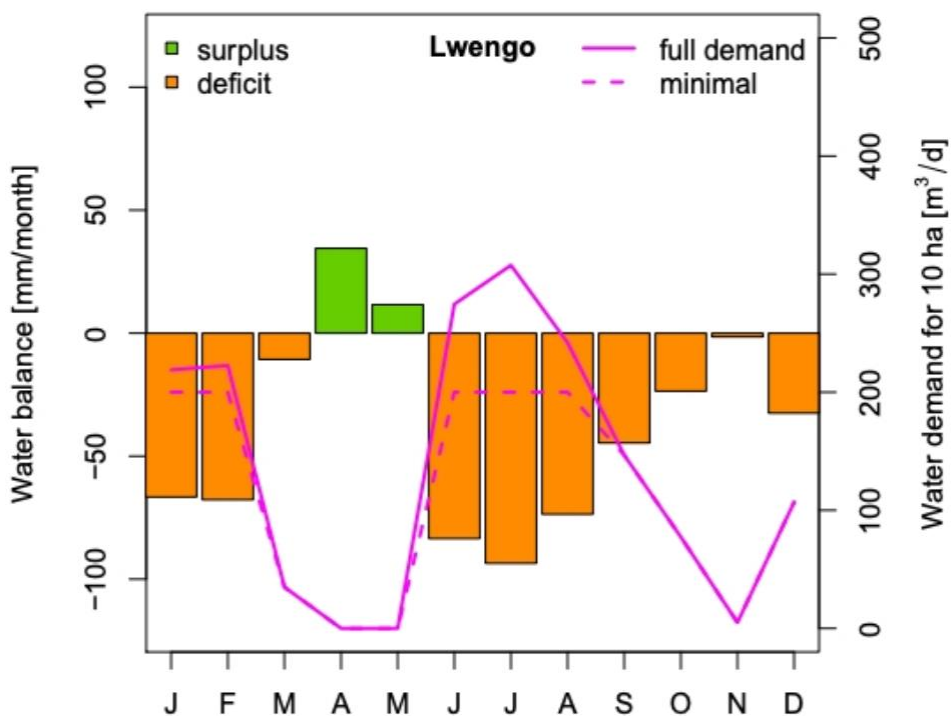


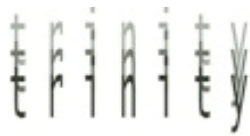
Sustainable Energy-Water Solutions for Medium to Large-Scale Irrigation of Commercial Farming in Uganda – Pre-Feasibility Study

Annex 3 Farm climate analysis

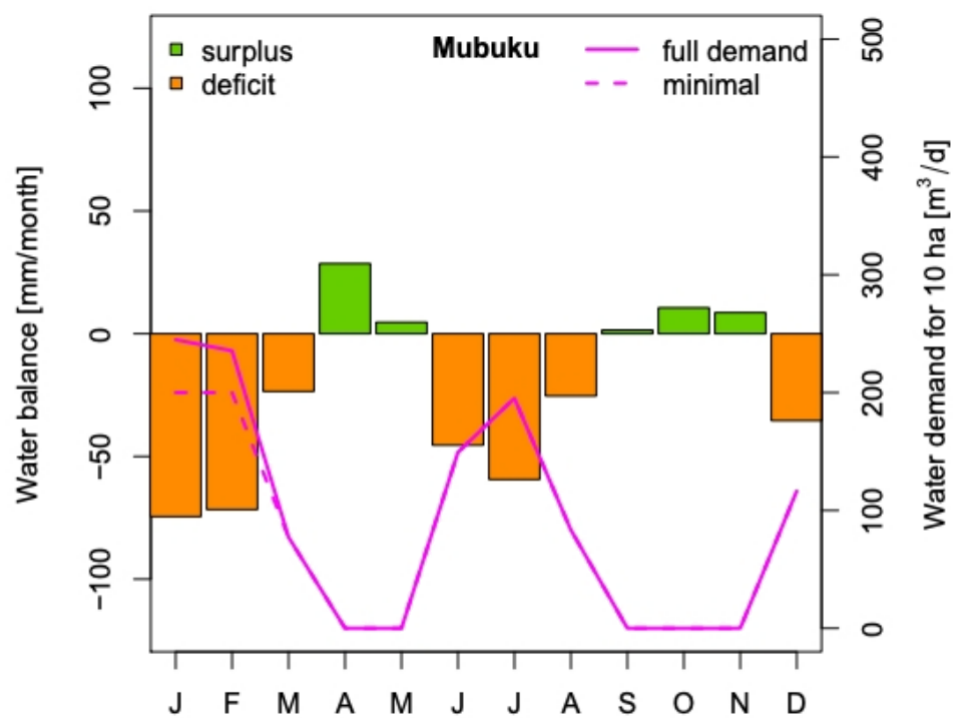
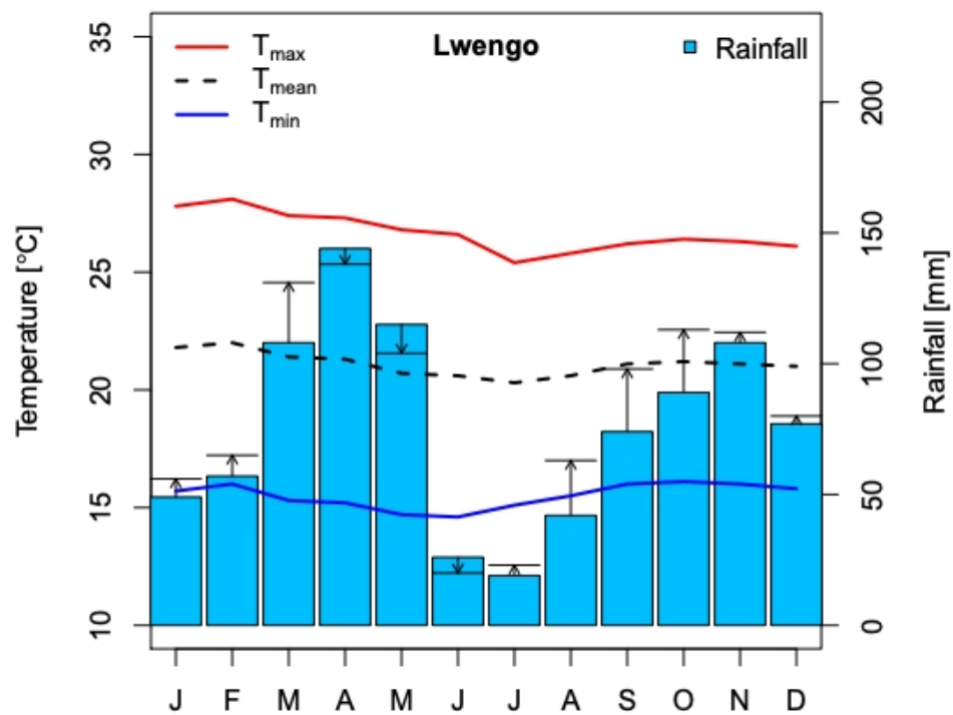


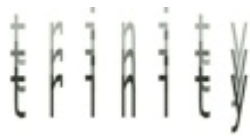
Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study



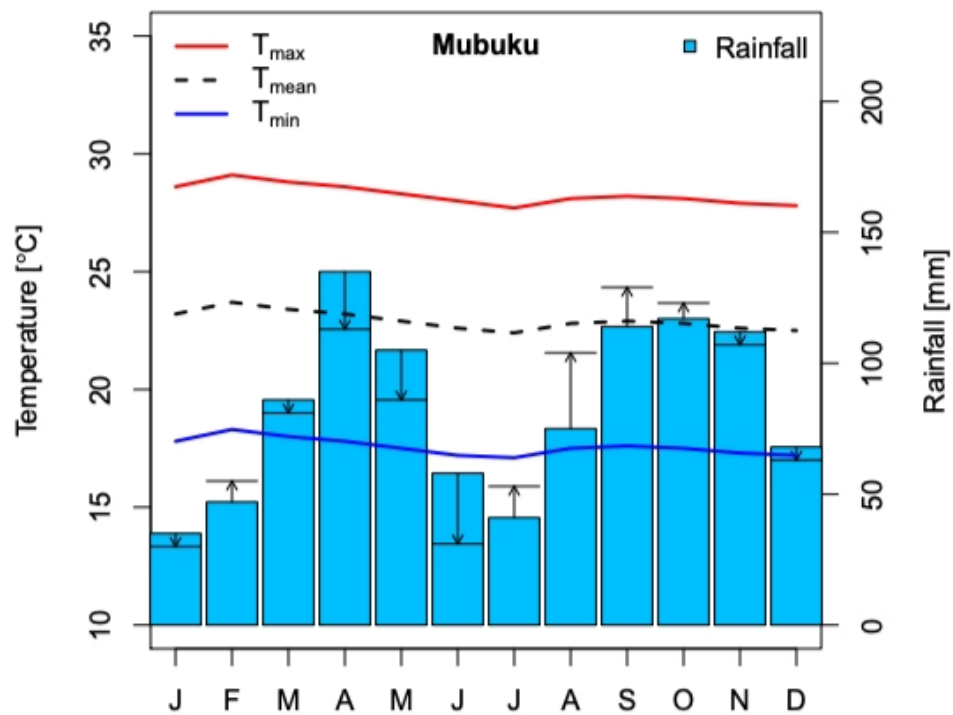
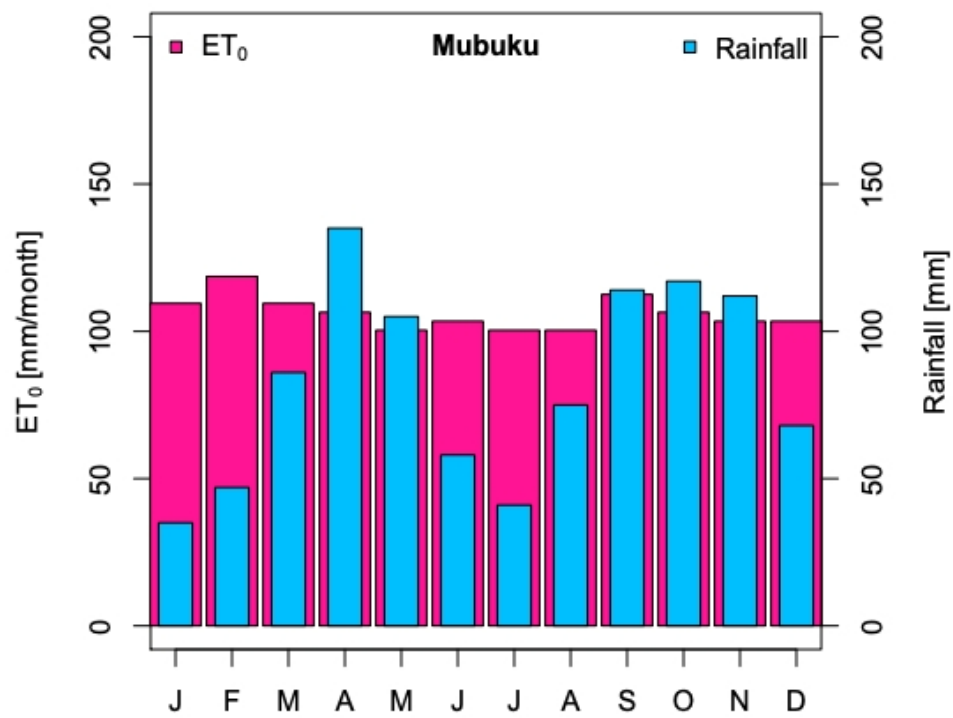


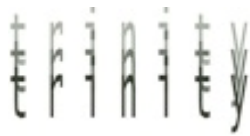
Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study



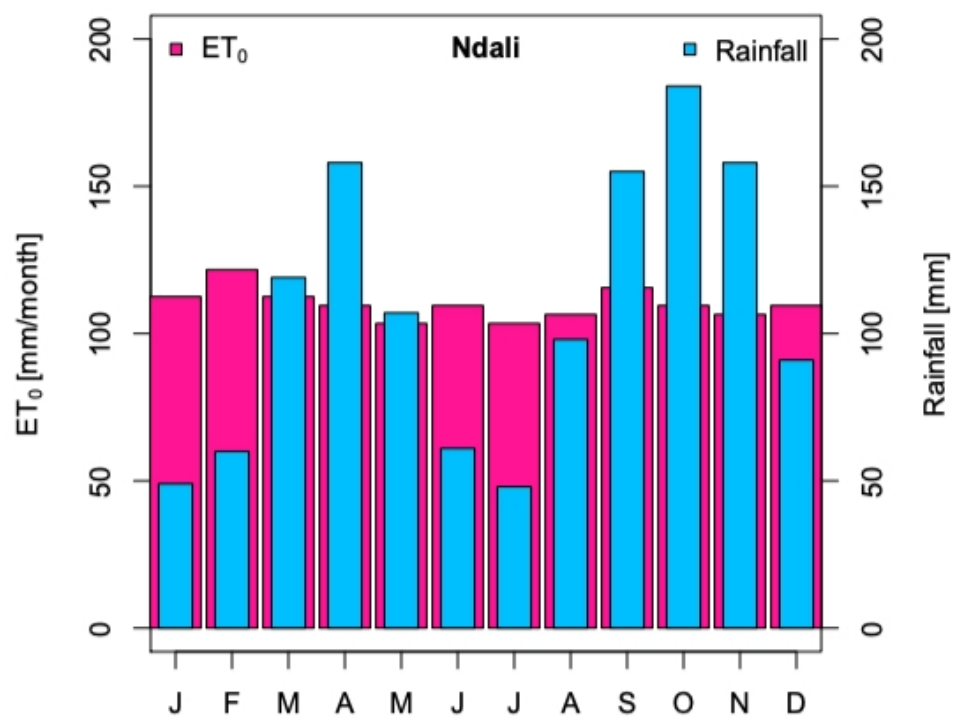
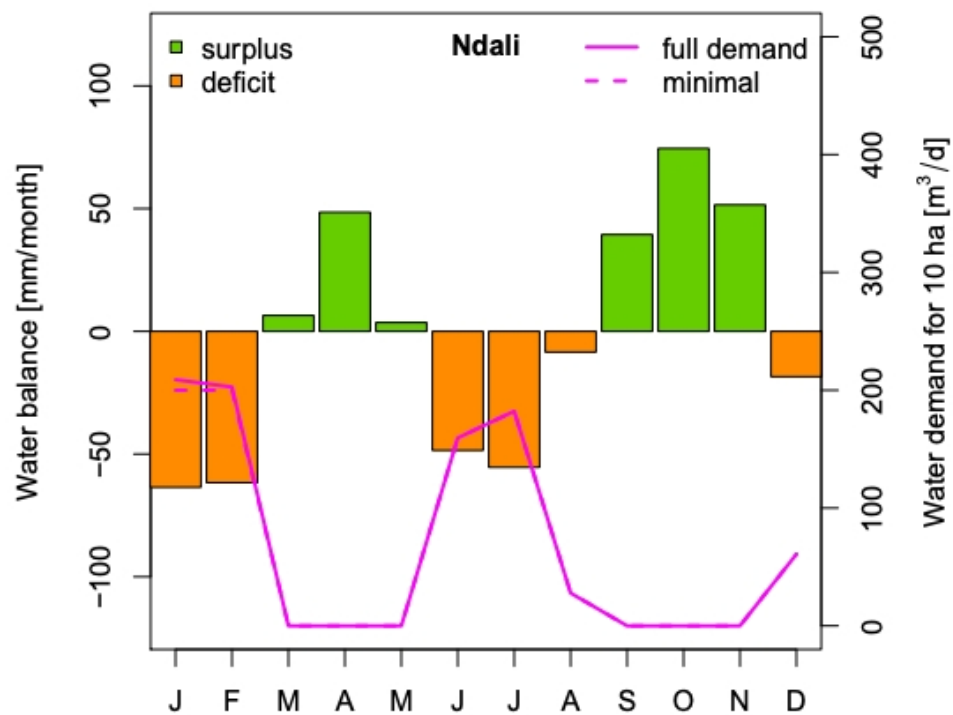


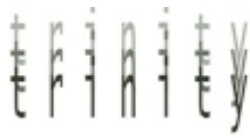
Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study



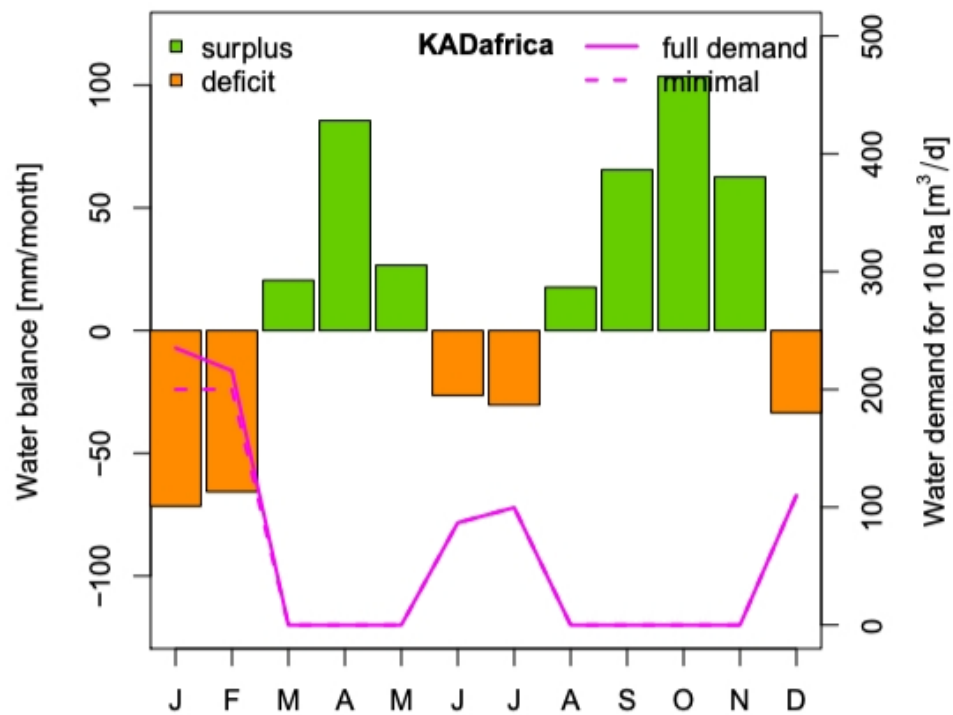
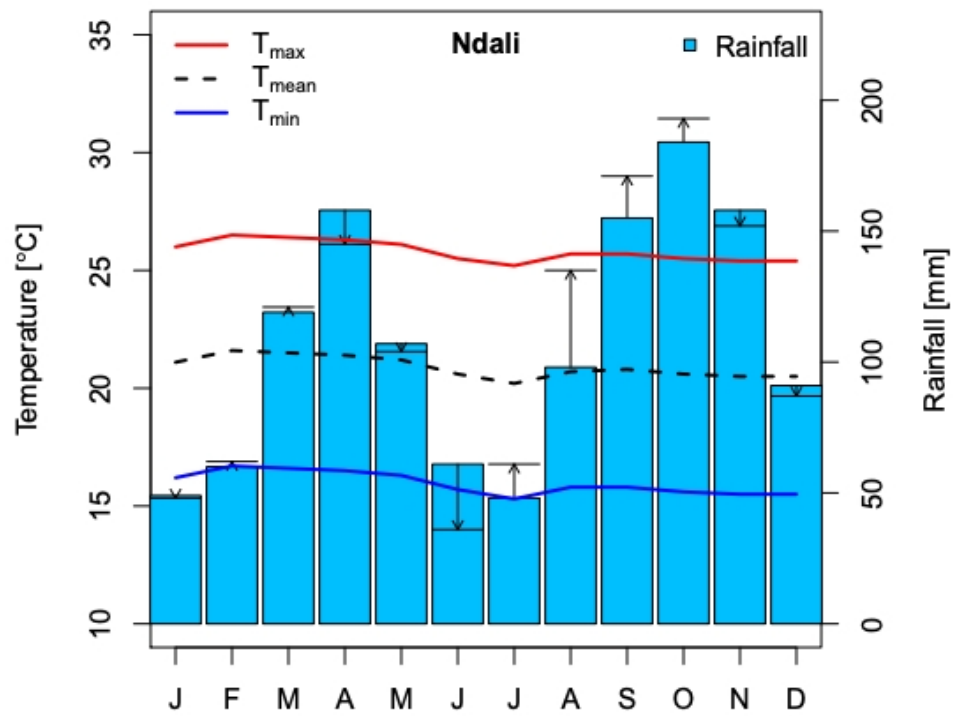


Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study



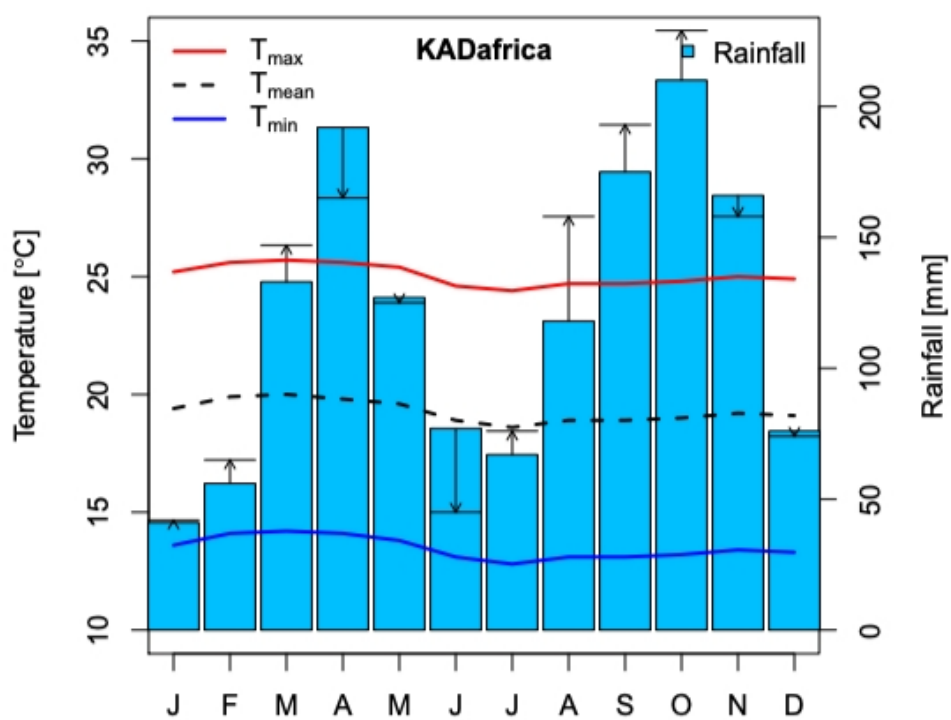
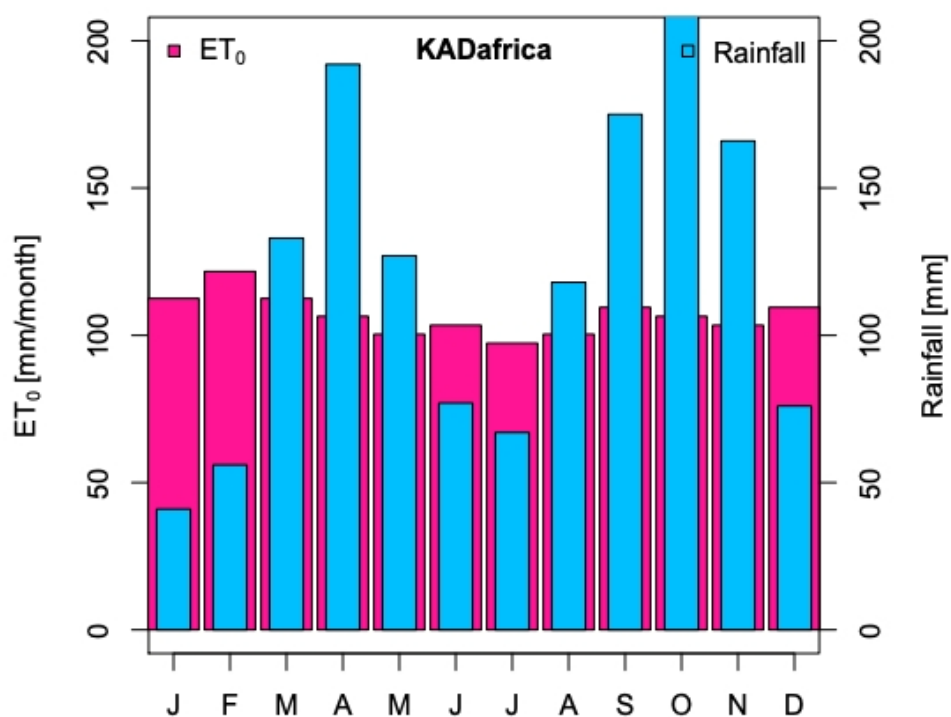


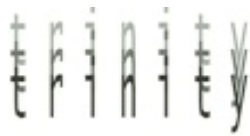
Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study



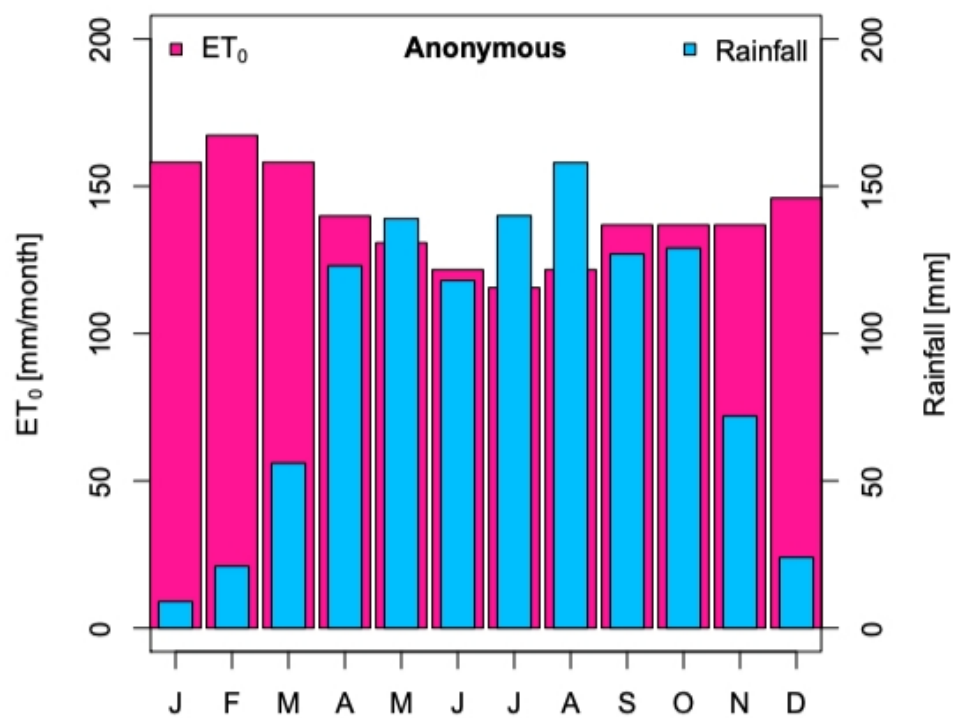
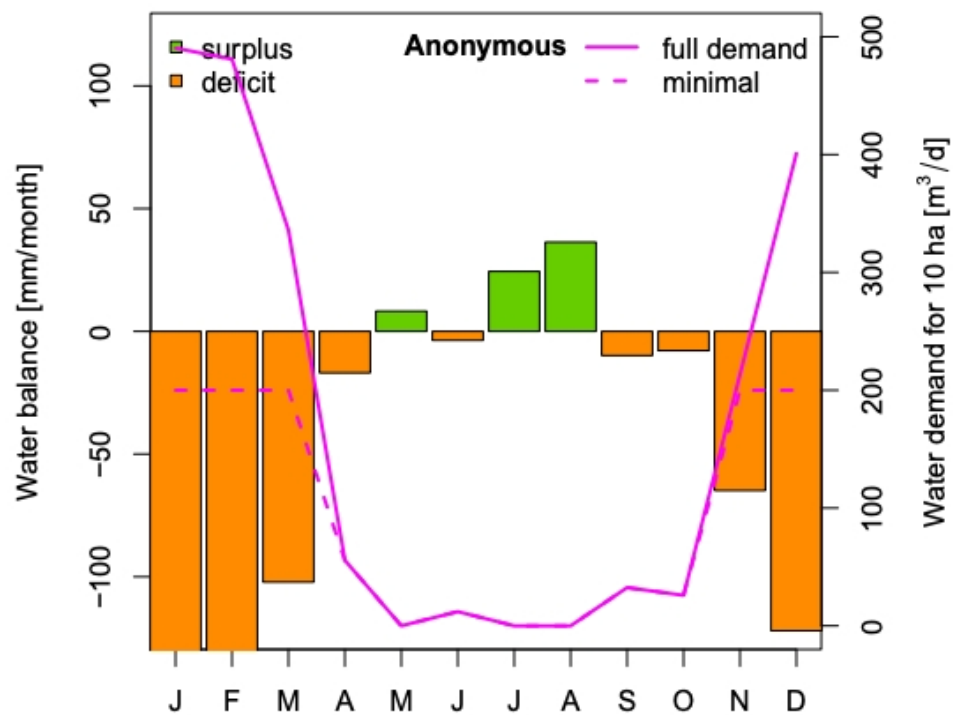


Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study



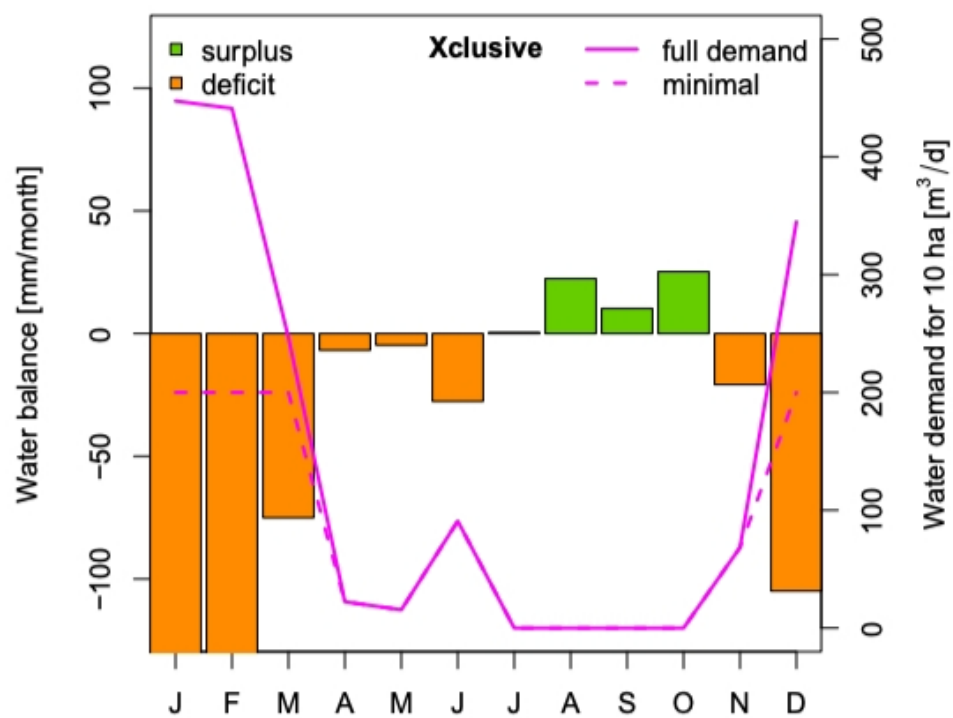
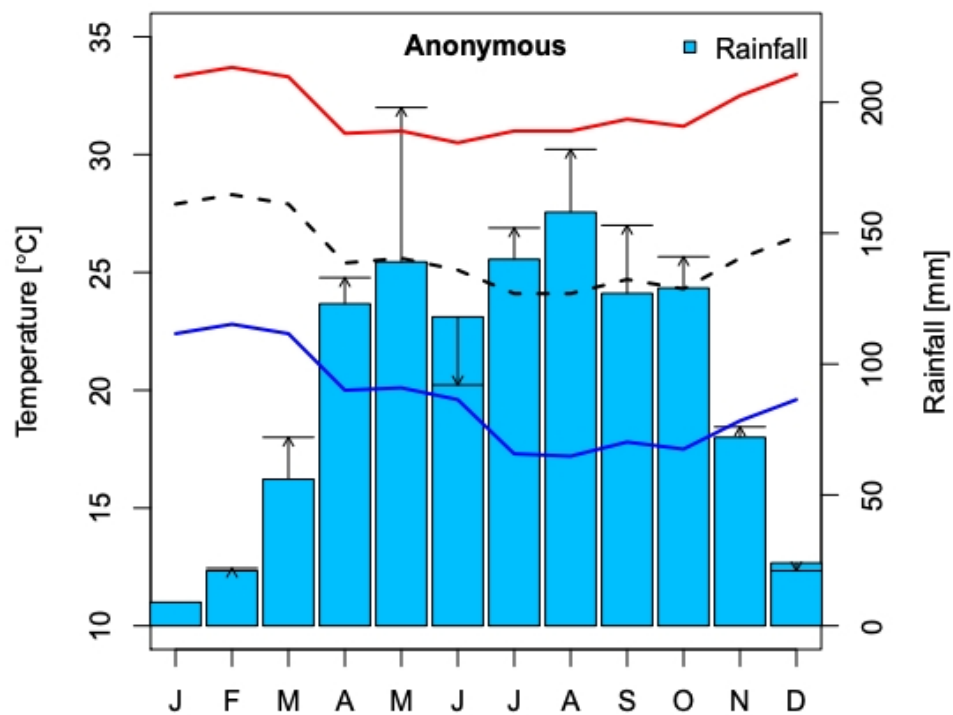


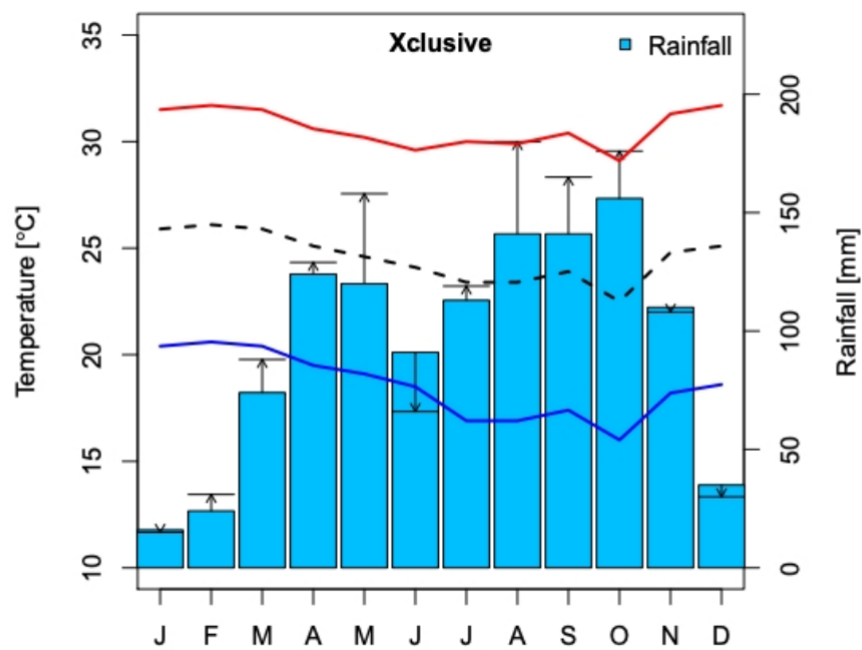
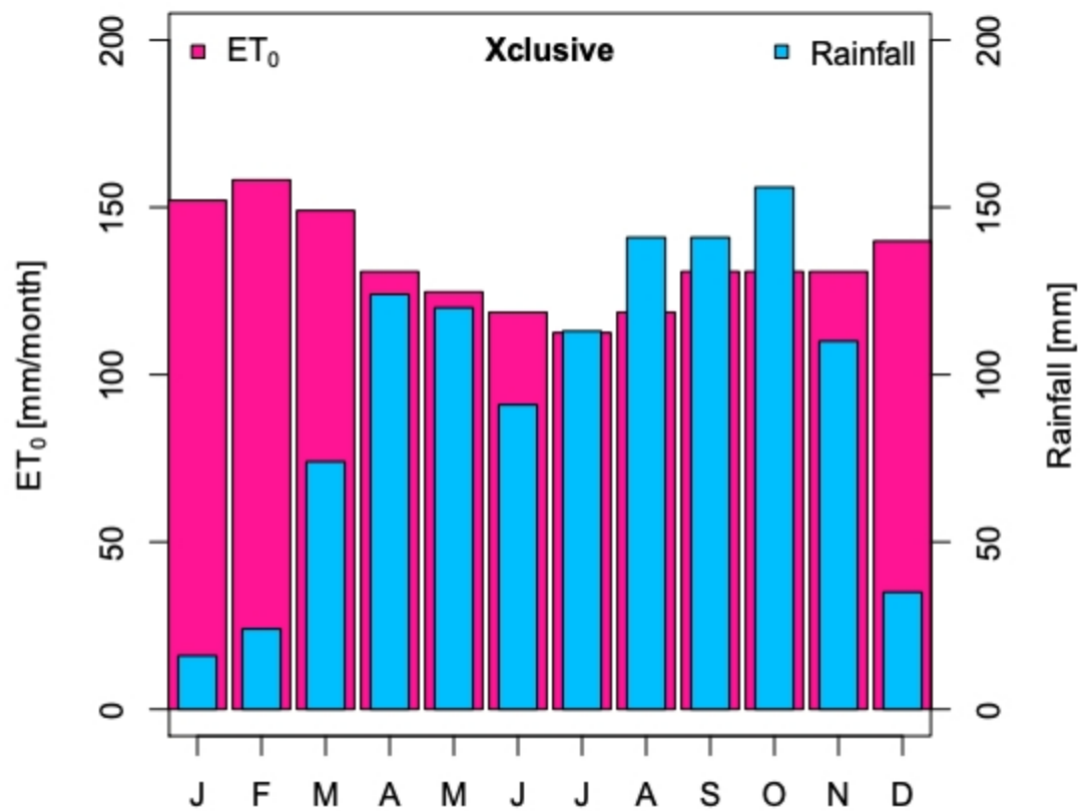
Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study

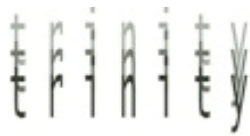




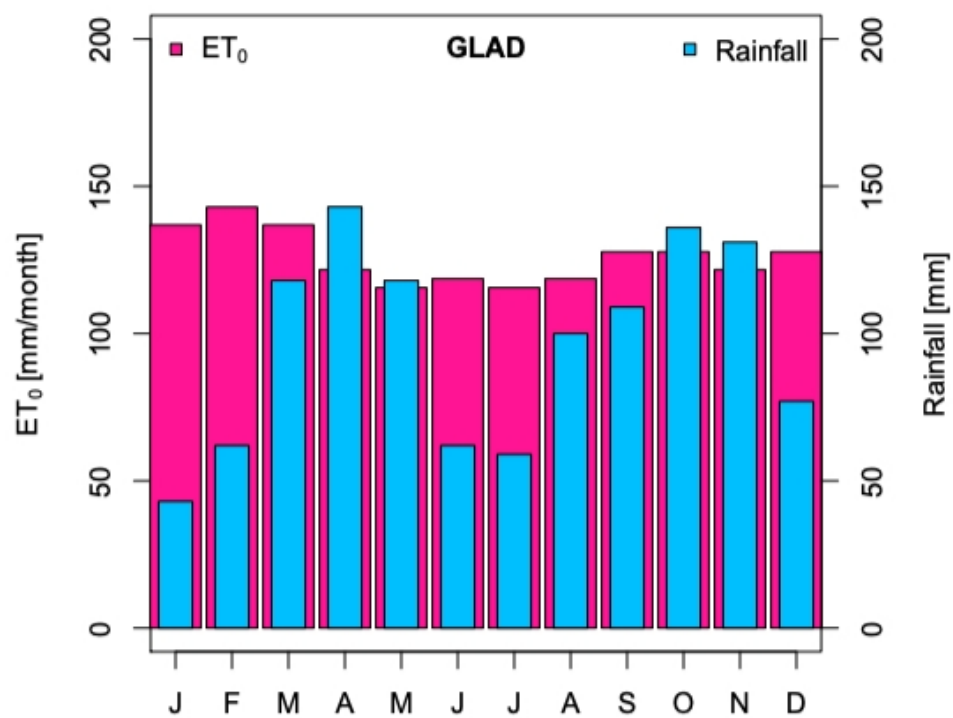
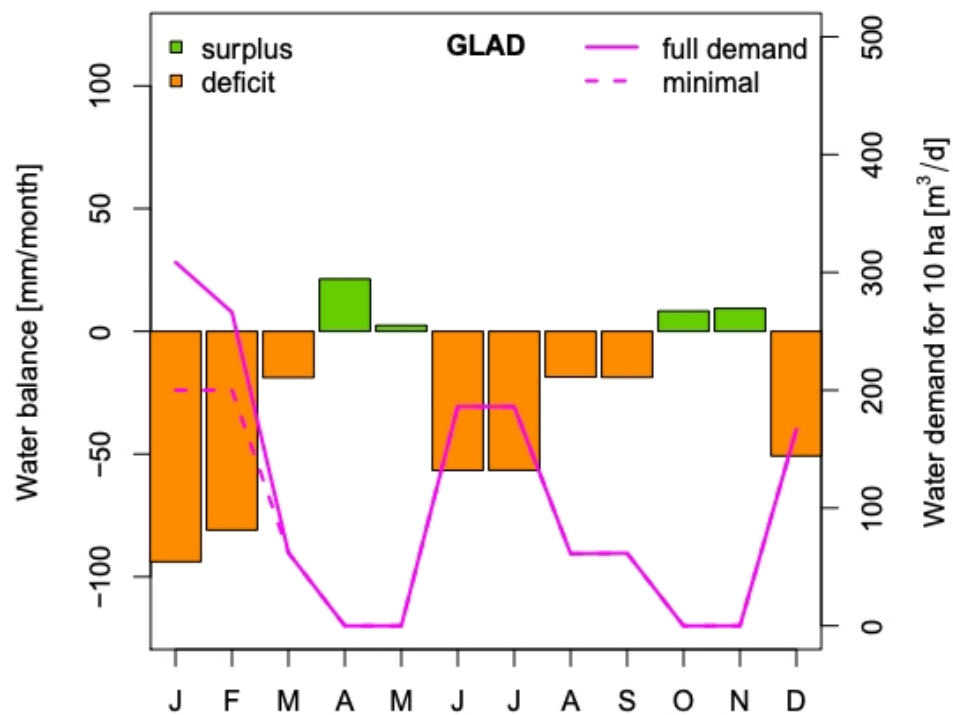
Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study

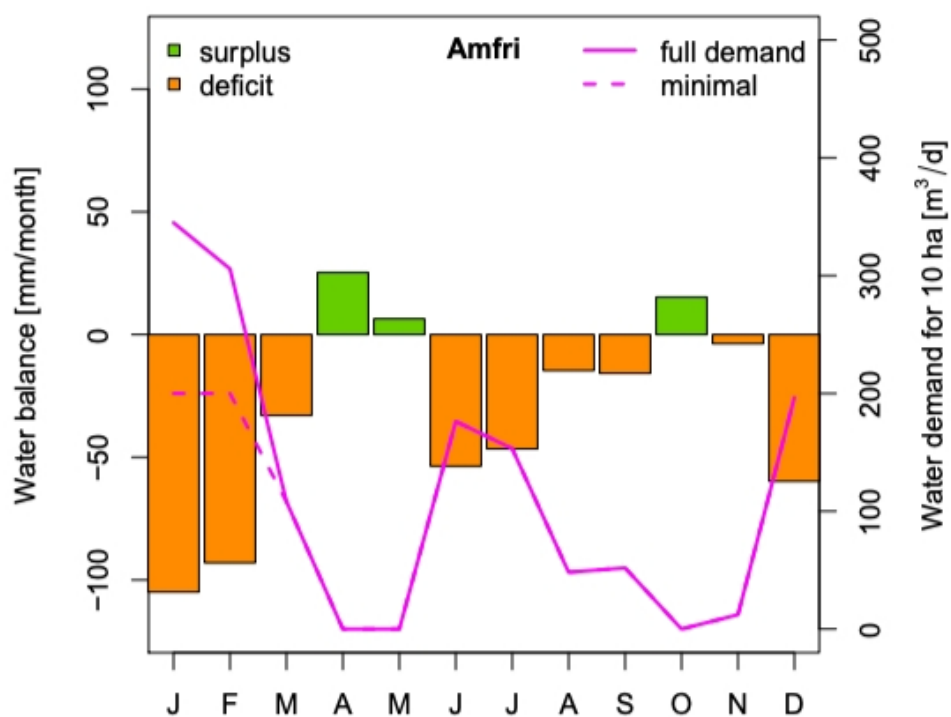


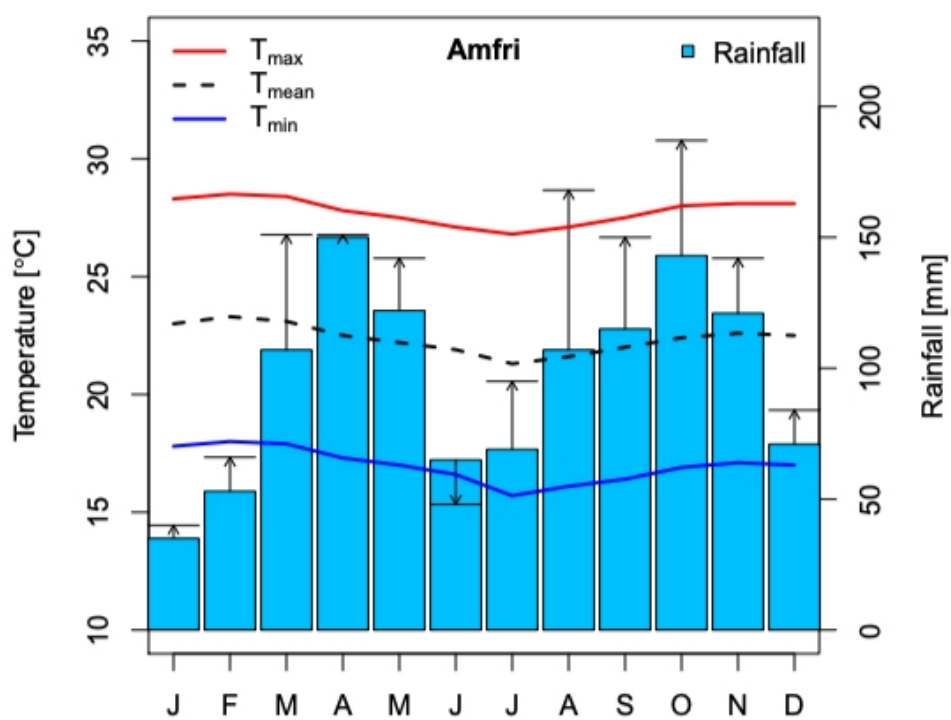
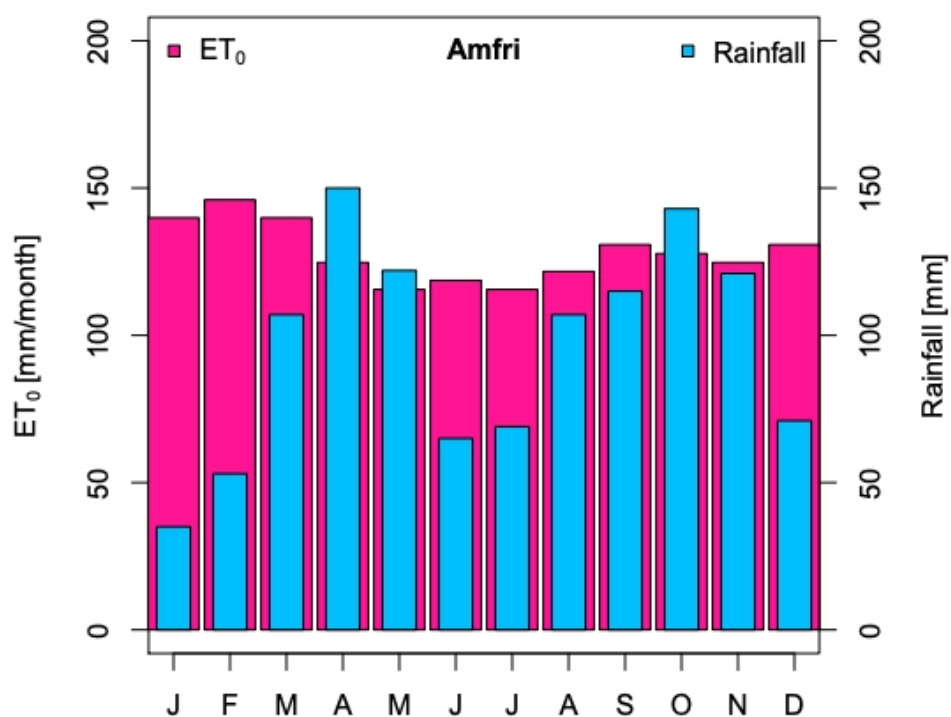


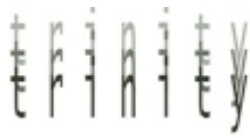


Sustainable Energy-Water Solutions for Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study









ANNEX 5 – CROP SUITABILITY MAPPING

Terroir Analysis



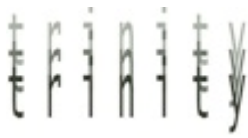
Methodology and Legends

The GIS-based terroir analysis was carried out based on climatic and soil/topography-related environmental variables and crop requirements published in public databases. GIS inputs were:

- NASA SRTM 2.0 topographic model (<https://www2.jpl.nasa.gov/srtm/>)
- The WorldClim 2.0 climatic database (<http://worldclim.org/version2>), namely the monthly mean, minimum, and maximum temperatures, plus monthly precipitation sums.
- The ISRIC Soil Property Map database (<https://www.isric.org/projects/africa-soil-profiles-database-afsp/newgeneration>), namely clay content, soil pH, and FAO drainage class
- Uganda landcover map extracted from the ESA Africa Landcover map (<http://2016africallandcover20m.esrin.esa.int>)
- Uganda Protected areas map of 2007 from WRI (<http://datasets.wri.org/dataset/uganda-protected-areas-as-of-2007>)
- Uganda Waterbodies map from WRI (<http://datasets.wri.org/dataset/waterbodies-in-uganda>)

Crop requirements were summarised based on “Plants for A Future” (<https://pfaf.org/user/Default.aspx>), “Useful Tropical Plants” (<http://tropical.theferns.info>), various FAO and other publications.

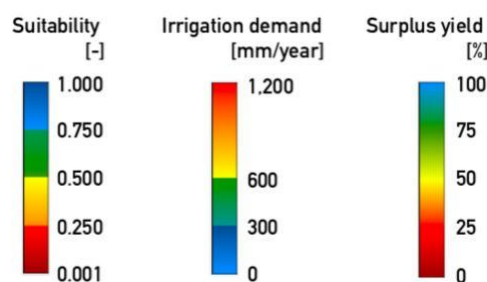
A separate 2-page block is dedicated to each crop. The section “Cultivation details” summarises available information on crop requirements, focusing on factors that can be accounted for in the GIS analysis. The main reference, e.g. the main source of information is shown right after the section heading, but all particular pieces of reference are listed in the separate “References” section. After the textual representation of crop requirements, the “Demands and Yield” section translates requirements into quantitative logical rules. There are two rules for each requirement, one giving the sufficient conditions, in which the crop can be cultivated, and another specifying optimal conditions. Yield ranges are shown for both cases where information was available.

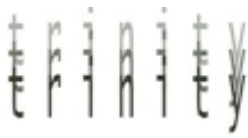


Fulfilment of conditions is calculated by fuzzy logical rules. Suitability considering a certain factor is expressed as a number ranging from 0 (=unsuitable) to 1 (fully suitable). Factor values outside the sufficient range yield 0, values inside the optimal range yield 1. In between, e.g. inside the sufficient but outside the optimal range, linear interpolation is applied. Suitability with regard to different factors is generated by taking the products of the individual suitability values. This method preserves the values of 0 and 1. It has to be noted that any suitability value that is not 0 (even 0.0001) indicates that the site is suitable for cultivating the given crop with commercially meaningful yields.

The section “Suitability” shows the results of the terroir analysis in four map panels. As the first step, all requirements except for the water demand are considered, yielding the water-independent suitability factor. This is first coupled with the water supply available from rainfall alone. This gives the “Suitability without irrigation” map. Afterwards, the water deficit of the crop compared to the lower limit of optimal water supply levels is calculated, which is shown in the “Average irrigation demand” map. Assuming that irrigation complements rainfall to this extent, suitability is re-calculated to get the “Suitability with irrigation” map. Finally, suitability scores with and without irrigation are compared to evaluate the effect of irrigation. This is shown in the indicative “Expected surplus yield” map, which is expressed in suitability score values. A close to zero value indicates that reducing the water stress of the crop does not necessarily increase yield from the low base amounts because of other active limiting factors. A higher value indicates that irrigation is indeed useful to produce higher yields. If necessary, the surplus yield can be interpreted as increase over the base yield proportional to the distance between the optimal and base yields.

Result maps have uniform legends and scaling for all crops. For reference, the land territory of Uganda (grey shading), waters (blue shading), and protected areas (white shading and thin red borders) are shown on all the maps. Legends:





VANILLA (*Vanilla planifolia*)

Cultivation details

(<https://pfaf.org/user/Plant.aspx?LatinName=Vanilla+planifolia>)

The plant thrives in hot moist insular climates with frequent, but not excessive rain and requires two drier months to check vegetative growth and bring the vines into flower.^[418] It grows best in areas where annual daytime temperatures are in the range 21 - 30°C, but can tolerate 10 - 33°C.^[418] It prefers a mean annual rainfall of 2,000 - 2,500 mm, tolerating 1,500 - 3,000 mm.^[418] An epiphytic plant, growing in pockets of humus on tree branches^[238]. It requires a position in semi-shade, well-protected from winds^[296]. Prefers a pH in the range 5.5 - 7, tolerating 4.3 - 8.^[418] Plants produced from short cuttings, around 30 cm in length, will take 3 - 5 years before they flower and start to produce fruit. If longer cuttings, around 90 - 100 cm in length, are used, then fruiting can commence after only 1 - 2 years.^[418] Under favourable conditions a plant may grow 60 - 120 cm per month^[310]. The plant has an economic life of about 10 - 15 years before yields drop and it needs replacing.^[418] The flowers usually need to be hand pollinated, especially when being cultivated outside the plants natural range. The fruits mature in 180 - 270 days from flowering.^[418] They are harvested when still green and lacking their distinctive aroma, and are then put through a lengthy curing process during which time they turn brown and develop their aroma.^[418] Yields are very variable - a good vanillery may yield about 2.5 - 4 t/ha per year of fresh fruit, which gives 500 - 800 kg/ha of cured beans.^[418] The flowers



are pollinated by a specific species of moth in the night time. In areas where the moth is absent, hand pollination is necessary^[296]. Flowering Time: Mid Spring Late Spring/Early Summer. Bloom Color: Chartreuse (Yellow-Green). Spacing: 4-6 ft. (1.2-1.8 m).

Demands and Yield

	Sufficient	Optimal
Temperature range	10 - 33°C	21 - 30°C
Annual rainfall	1,500 - 3,000 mm	2,000 - 2,500 mm
Rainfall seasonality	frequent but not excessive, two drier months	
Soil pH	4.3 - 8	5.5 - 7
Yield	2.5 t/ha fresh fruit	4.0 t/ha fresh fruit

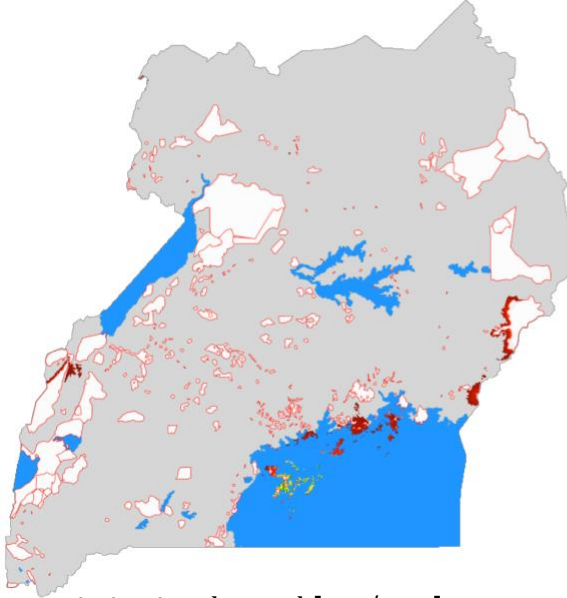
References

- 238 Bown. D. Encyclopaedia of Herbs and their Uses. Dorling Kindersley, London. 1995. ISBN 0-7513-020-31
 296 <http://www.plantzafrica.com>
 310 <http://proseanet.org/>
 418 <http://ecocrop.fao.org/ecocrop/srv/en/home>



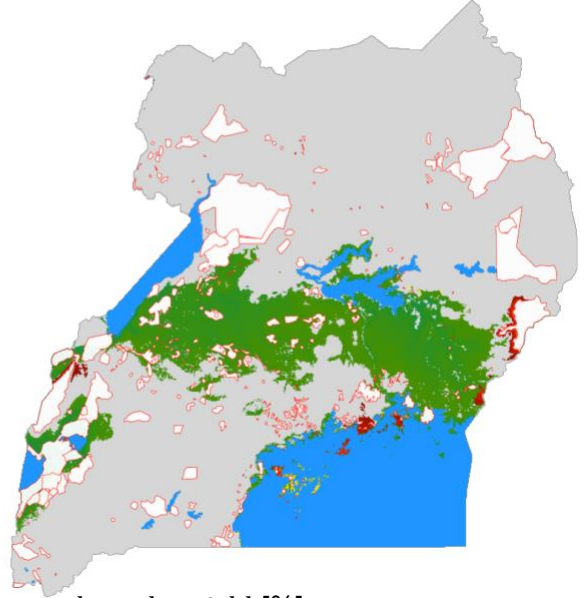
Suitability

Suitability without irrigation

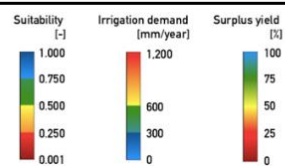
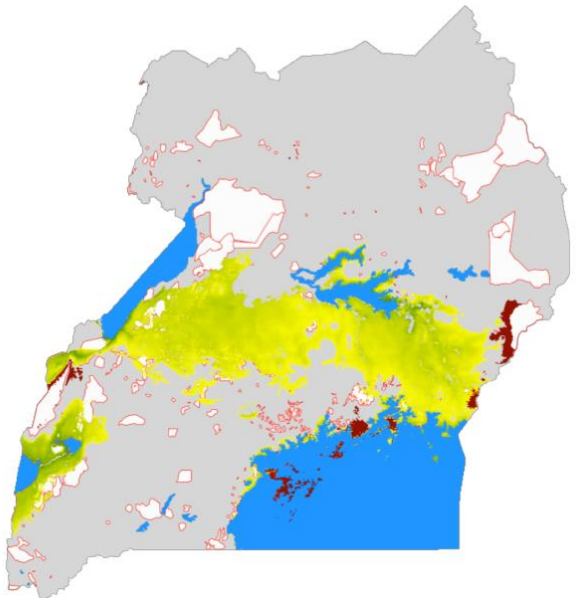
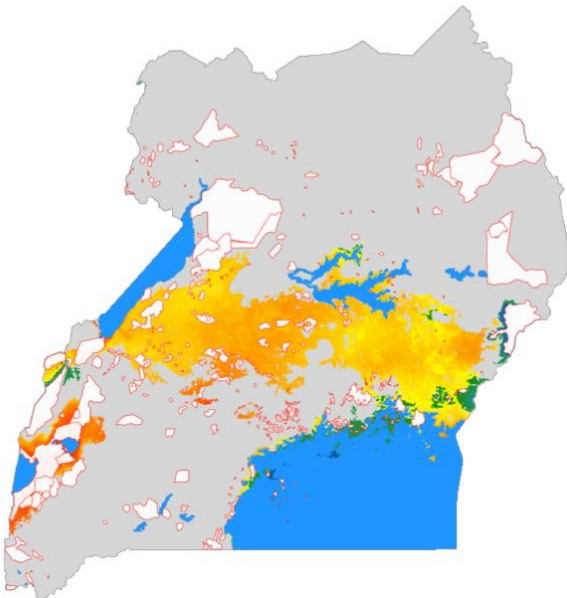


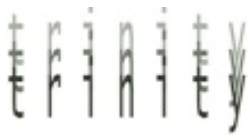
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





GINGER (*Zingiber officinale*)

Cultivation details

(<https://pfaf.org/user/Plant.aspx?LatinName=Zingiber+officinale>)

A plant of the moist to wet tropics, where it is found at elevations up to 1,900 metres. It grows best in areas where annual daytime temperatures are within the range 19 - 29°C, but can tolerate 13 - 35°C.^[418] Low temperatures will induce dormancy.^[418] It prefers a mean annual rainfall in the range 1,400 - 3,000 mm, but tolerates 700 - 4,000 mm.^[418] Prefers a well-drained, humus-rich, neutral to alkaline soil and a position in full sun or partial shade^[238]. When grown on slopes the production may result in severe erosion unless adequate soil-conservation methods have been employed.^[418] Prefers a pH in the range 6 - 7, tolerating 4.3 - 7.5.^[418] Commercially, plants are given a ten month growing season from planting out a root, being harvested when the stalks begin to wither^[238,418]. Ginger originated in South East Asia, but is nowhere known in a wild state. Yields of green ginger can be up to 38 t/ha.^[418] The expected yield of dried ginger may be 1.5 - 7.5 t/ha.^[418] The dried ginger constitutes about 25% of the raw rhizome's weight.^[418] There are some named varieties^[301]. Flowering Time: Late Winter/Early Spring(early summer, mid summer, late summer). Bloom Color: Chartreuse (Yellow-Green) Purple. Spacing: 12-15 in. (30-38 cm).



Demands and Yield

	Sufficient	Optimal
Temperature range	13 - 35°C	19 - 29°C
Annual rainfall	700 - 4,000 mm	1,400 - 3,000 mm
Terrain	low terrain gradient to prevent soil loss	
Soil pH	4.3 - 7.5	6 - 7
Yield	1.5 t/ha dried	7.5 t/ha dried

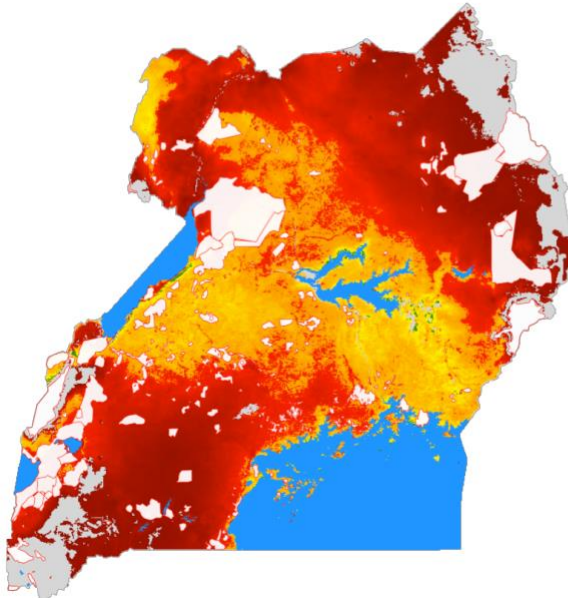
References

- 238 Bown. D. Encyclopaedia of Herbs and their Uses. Dorling Kindersley, London. 1995. ISBN 0-7513-020-31
- 418 <http://ecocrop.fao.org/ecocrop/srv/en/home>



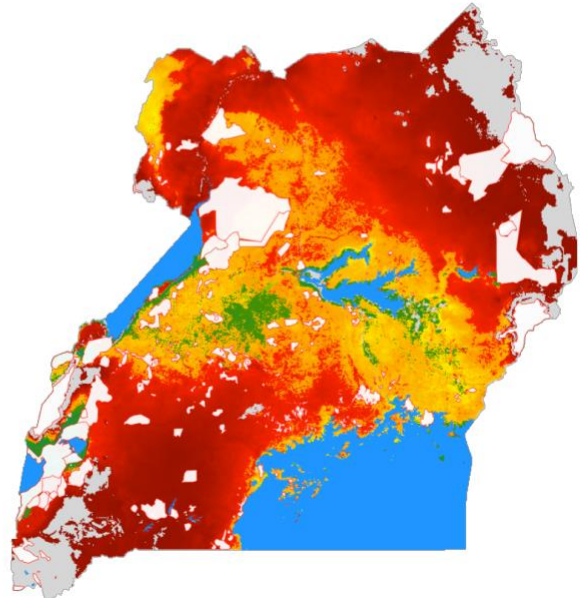
Suitability

Suitability without irrigation

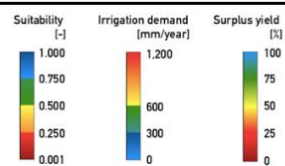
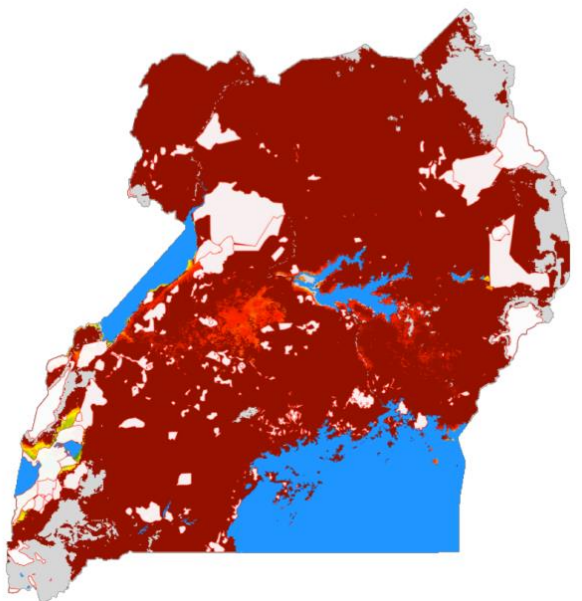
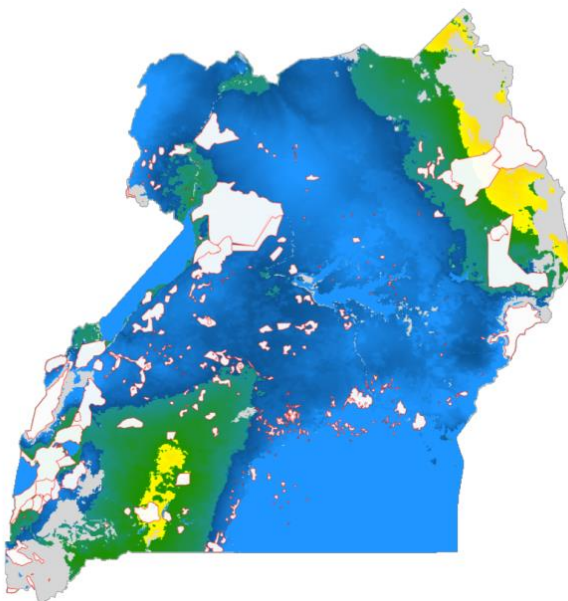


Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





COCOA (*Theobroma cacao*)

Cultivation details

(<https://pfaf.org/user/Plant.aspx?LatinName=Theobroma+cacao>)

A tree of the lowland tropics, usually found below 300 metres but occasionally found as high as 900 metres^[303]. It succeeds where the mean annual temperature is in the range 18 - 28.5°C with a maximum temperature of 30 - 33.5°C and a minimum 13 - 18°C^[303]. The absolute minimum is 10°C, below which trees are likely to suffer severe damage^[303]. Rainfall should be plentiful and well distributed throughout the year^[303]. An annual rainfall level of between 1,500 - 2,000 mm is suitable, though it is reported to tolerate an annual precipitation of 480 - 4,300 mm^[303]. Requires a fertile, moisture-retentive but well-drained soil in sun or part shade in a position sheltered from the wind^[200]. Prefers an acid soil^[307]. Prefers a pH in the range 5 - 6.5, tolerating 4 - 8^[418]. An understorey tree of the forest, it grows best in dappled shade^[307], but can even produce well in quite dense shade^[200]. In favourable conditions both flowers and fruit will be borne throughout the year^[200]. Freshly planted young trees are slow to establish and grow away, rarely growing more than 1.5 metres tall after 2 years^[419]. Weeding and temporary shade are essential within the first 3 - 4 years of establishment before the canopy closes. Plantain appears to meet most of cocoa's requirements in this respect, whereas bananas compete heavily for moisture during the dry season^[303]. There are some named varieties^[301]. Flowering Time: Blooms all year. Bloom Color: White/Near White Cream/Tan. Spacing: 12-15 ft. (3.6-4.7 m).

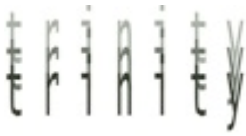


Demands and Yield

	Sufficient	Optimal
Mean annual temperature		18 - 28.5°C
Maximum temperature	33.5°C	30°C
Minimum temperature	13°C	18°C
Absolute minimum temperature	10°C	
Altitude	< 900 m	< 300 m
Annual rainfall	480 - 4,300 mm	1,500 - 2,000 mm
Soil drainage	well drained soil	
Soil pH	4 - 8	5 - 6.5
Yield		

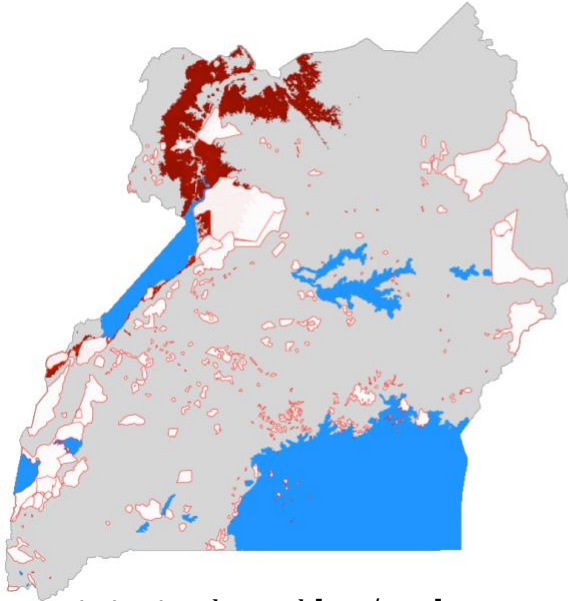
References

- 200 Huxley. A. The New RHS Dictionary of Gardening. 1992. MacMillan Press 1992 ISBN 0-333-47494-5
- 301 Traditional Herbal Medicines Karalliedde. L. and Gawarammana. I. A guide to the safer use of herbal medicines. Hammersmith Press, London 2008 978-1-905140-04-6
- 303 <http://www.worldagroforestry.org/>
- 418 <http://ecocrop.fao.org/ecocrop/srv/en/home>
- 419 ?



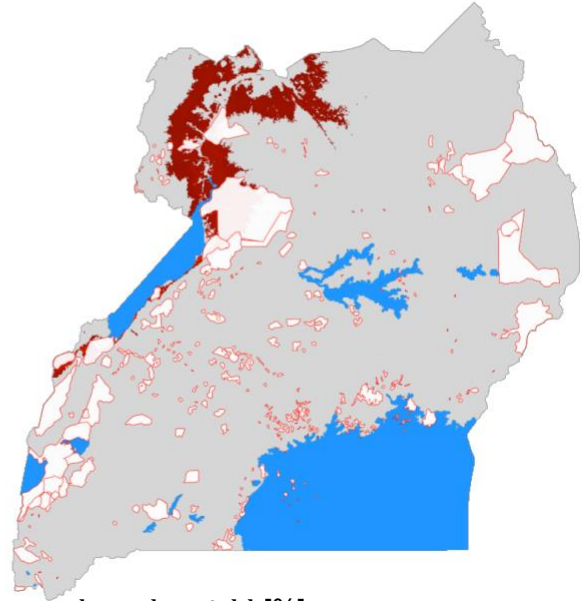
Suitability

Suitability without irrigation

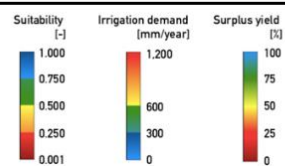
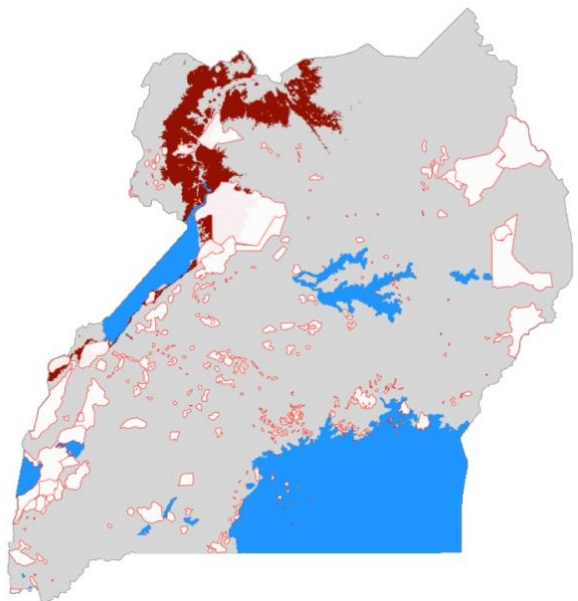
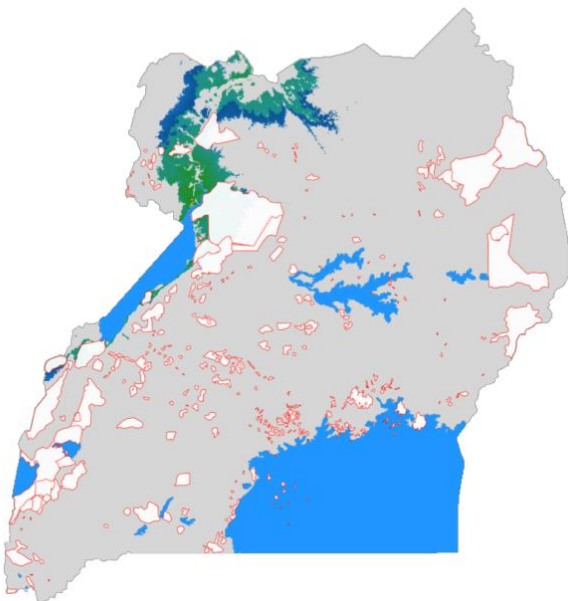


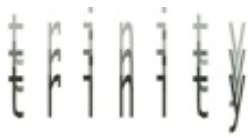
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





MANGO (*Mangifera indica*)

Cultivation details

(<https://pfaf.org/user/Plant.aspx?LatinName=Mangifera+indica>)

The optimal climate for growing mango ranges from the monsoon tropics to the frost-free subtropics, with a marked dry, or cool, season of at least three months to promote flowering^[200,303]. It succeeds at any elevation up to about 1,200 metres, but for commercial purposes 600 metres is the maximum elevation^[303,418]. It grows best in areas where annual daytime temperatures are within the range 24 - 30°C, but can tolerate 8 - 48°C^[418]. When dormant, the plant can survive short-lived temperatures down to about -1°C, but young growth can be severely damaged at 0°C^[418]. It prefers a mean annual rainfall in the range 600 - 1,500 mm, but tolerates 300 - 2,600 mm^[418]. The dry season of equatorial regions is too unreliable for commercial cultivation^[200]. Whilst trees generally grow best in moderately dry climates, some cultivars can thrive and produce even under rainforest conditions^[298]. Prefers a sunny position^[307]. Plants are not too fussy over soil, not needing very fertile conditions^[200]. However, they crop better in a rich, well-drained soil^[307], whilst very poor soil, or shallow land, is unsuitable^[200]. A pH in the range 6 - 7 is ideal^[200]. Prefers a pH in the range 5.5 - 7.5, tolerating 4.3 - 8.5^[418]. Grows best in areas sheltered from strong, drying winds^[418]. Established plants are drought tolerant, and can also withstand occasional inundation of the soil^[418]. Trees produce a taproot up to 5 metres deep^[200]. Plants take 5 - 8 years from seed before they begin to fruit^[296]. Grafted plants commence bearing in 3 - 5 years^[335]. Individual trees often flower irregularly and may



only produce one good crop every 3 - 4 year; some trees do not flower for periods of 10 - 20 years, sometimes even longer^[303,418]. Yields increase up to the 20th year, decline after the 40th year and the tree may live for 100 years or more.^[418] Flowering starts at the beginning of the rainy season and fruits ripen at the end of the rainy season^[303]. Most varieties are self-fertile, but produce larger crops when cross-pollinated^[335]. Yields of about 500 fruits per tree are average in 'on' years^[200]. A plantation of full-grown trees may produce 10 - 30 tonnes per hectare of fruit each year. Average yields are, however, often quite low with 6 tonnes being achieved in the Philippines, 3.5 tonnes in Peninsular Malaysia and 2.3 tonnes in Thailand.^[418] A very variable plant, there are many named varieties^[200,296]. Some forms of the mango produce polyembryonic seeds (more than one seedling is produced from each seed) - these forms produce a tree genetically identical to the parent^[296]. Flowering Time: Late Spring/Early Summer Mid Summer. Blooming Color: Red Pale Yellow White/Near White. Spacing: 30-40 ft. (9-12 m).

Demands and Yield

Demands and Yield

	Sufficient	Optimal
Maximum temperature	48°C	30°C
Minimum temperature	8°C	24°C
Absolute minimum temperature	0°C	
Altitude	< 1200 m	< 600 m
Annual rainfall	300 - 2,600 mm	600 - 1,500 mm



Sustainable Energy-Water Solutions for Medium to Large-Scale Irrigation of Commercial Farming in Uganda – Pre-Feasibility Study

	Sufficient	Optimal
Soil drainage	well drained, sufficiently deep soil	
Soil pH	4.3 - 8.5	5.5 - 7.5
Yield	2.3 - 6 t/ha	10 - 30 t/ha

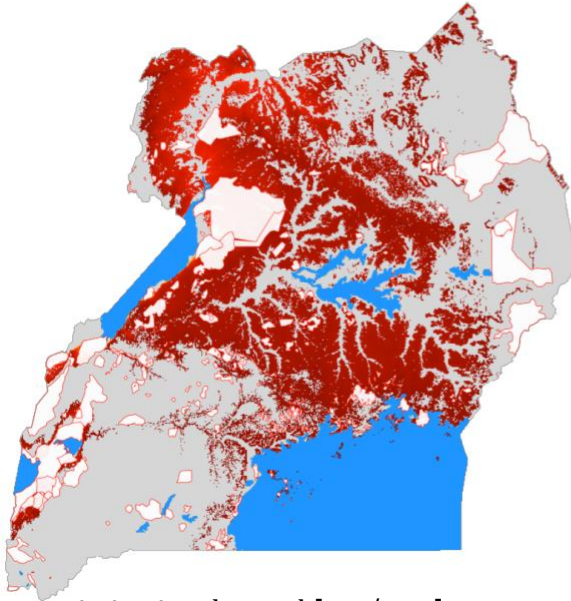
References

- 200 Huxley. A. The New RHS Dictionary of Gardening. 1992. MacMillan Press 1992 ISBN 0-333-47494-5
- 298 <http://www.prota.org>
- 303 <http://www.worldagroforestry.org/>
- 307 ?
- 335 <http://www.rngr.net/s/ttsm>
- 418 <http://ecocrop.fao.org/ecocrop/srv/en/hom>



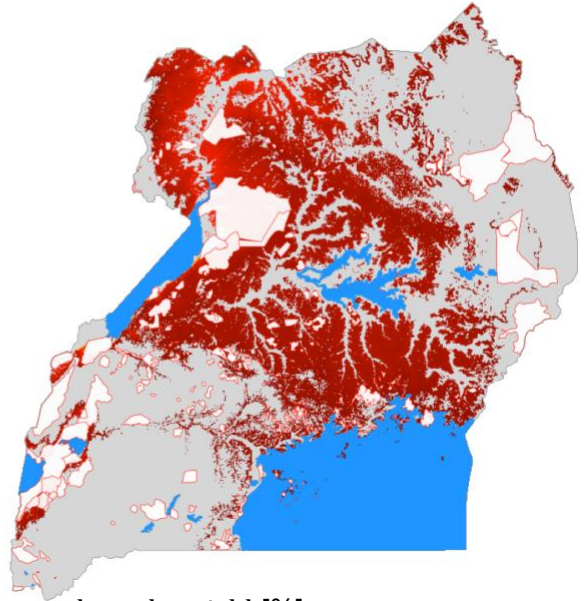
Suitability

Suitability without irrigation

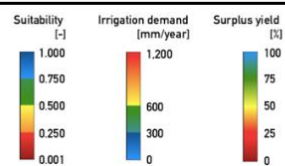
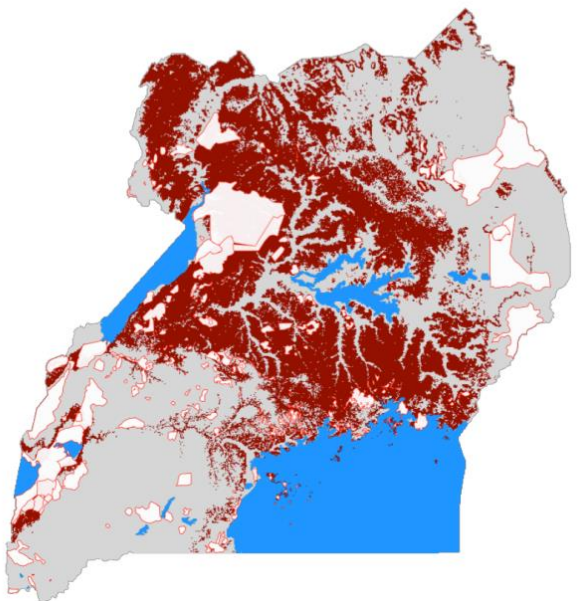
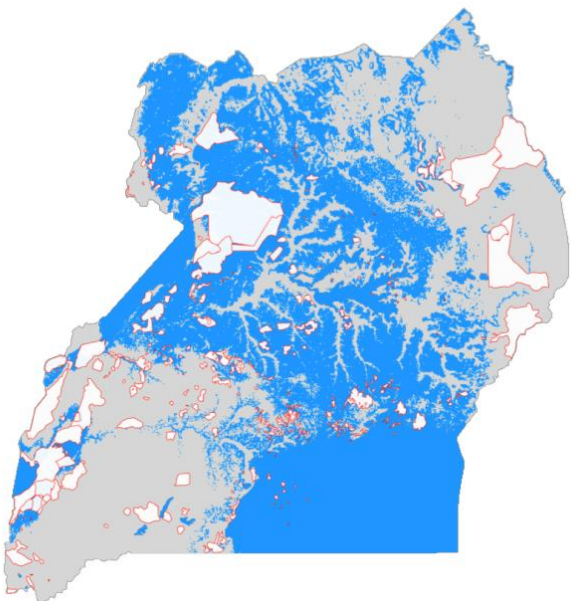


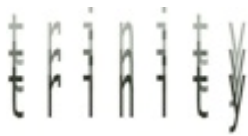
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





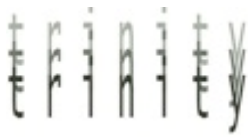
COFFEE/ARABICA (*Coffea arabica*)

Cultivation details

(<http://ecocrop.fao.org/ecocrop/srv/en/cropView?id=749>)

A globose evergreen, multi-stemmed shrub or small tree attaining heights of up to 5-10 m (when not pruned). The root system of the mature coffee tree consists of: a taproot, which is often extensively branched, robust, and generally short (0.3 to 0.5 m), but may grow as long as 1.0 m in deep soils.

The optimum temperature for the germination of coffee seeds is about 30°-32°C, below 10°C germination is very slow. *C. Arabica* is often intercropped with food crops, such as corn, beans or rice, during the 1st few years. Some varieties have been reported to withstand -4°C. Temperatures at -5 - -8°C may kill the plant within an hour or two. At temperatures from 0-2°C, which are not unusual in some production areas, the foliar tissue and green shoots are killed. This is manifested by almost complete defoliation of the shrubs, the drying out of the young branches (black tip), and with an appreciable loss in the harvest. Perennial. Begins to bear in 2-3 years, is in full bearing at 6-8 years, and produces economic yields for 30-40 years on average, though in some cases only 10-15 years, and in others up to 50-70 years. Fruits mature 210-270 days after flowering, and the growth cycle is 240-330 days. It can in equatorial regions be grown at elevations from 1300 to 2800 m, with 1500-1900 being usual, at 15°N or S it can be grown down to about 500 m. In the subtropics it is grown from sea level to 1000 m. The latitudinal range is between 22°N and 27°S. The plant can tolerate low temperatures, but not frost, and it does best with an average temperature between 15 and 24 °C (59 and 75 °F).^[10] Temperatures greater than 86°F (30°C) cause plant stress leading to a cessation of photosynthesis.^[4] Mean temperatures of less than 59°F (15°C), limit plant growth and are



considered suboptimal.^[4] Rainfall of 1,500 to 2,000 mm per year is required along with a dry period of two to three months for the Arabica.^[1] Irrigation is required where annual rainfall is less than 1,000 mm.^[1] One to 2 months of less than 50 mm rain facilitates uniform flowering. With too much rainfall the plant tends to develop wood at the expense of flowers and fruits. Heavy rain during and after harvest is not desirable. It will only flower when days are 13 hours or shorter. Medium humidity is best, periods of mist and low clouds are beneficial but arabica require 2-3 drier months for the initiation of flower buds. The soil pH should be from 4.5 to 6, but excellent plantations can also be found on neutral (pH 7) soils^[2]. Optimum yield of clean dry coffee beans is 2-3 t/ha obtained in Kenya, while average yields are about 0.5 t/ha in Brazil and 0.9 t/ha in Africa. For a long time coffee was cultivated in the shade. This is still done in many areas but is losing popularity because better results can be obtained without shade or with very light shade if other practices, such as trimming, weeding, and fertilization are followed.^[1]

Demands and Yield

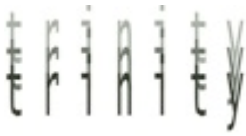
	Sufficient	Optimal
Mean temperature ^[3]	14 - 30°C	17 - 23°C
Maximum temperature	30°C	24°C
Absolute minimum temperature	0°C	
Altitude	900-2800	1200-1900
Annual rainfall	> 1000 mm	1660 - 1800 mm ^[3]
Soil pH	4.5 - 7	6.1 - 6.5
Yield	0.5 t/ha dry beans	2 - 3 t/ha dry beans



References

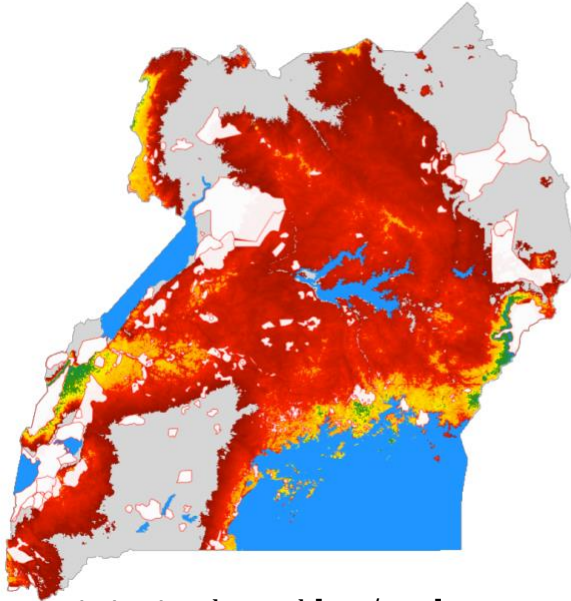
- 1 <https://www.britannica.com/plant/coffee-plant-genus>
- 2 R. Coste, H. Camblony 1991, Coffee The plant and the product. London: Macmillan. ISBN 978-0-33357-296-2
- 3 <https://www.perfectdailygrind.com/2017/11/coffee-producers-guide-soil-management-farm-conditions/>
- 4 <http://www.fao.org/3/ae938e/AE938E.pdf>
- 10 Taye Kufa Obso (2006). Ecophysiological Diversity of Wild Arabica Coffee Populations in Ethiopia: Growth, Water Relations and

Hydraulic Characteristics Along a Climatic Gradient. Cuvillier Verlag. p. 10. ISBN 978-3-86727-990-1.



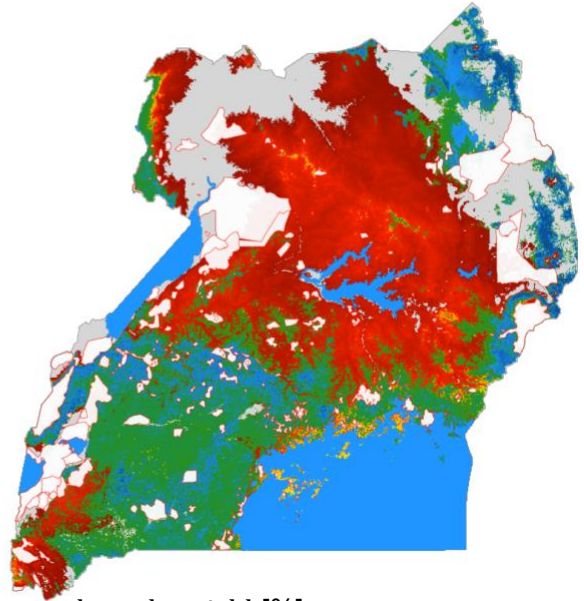
Suitability

Suitability without irrigation

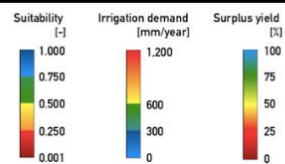
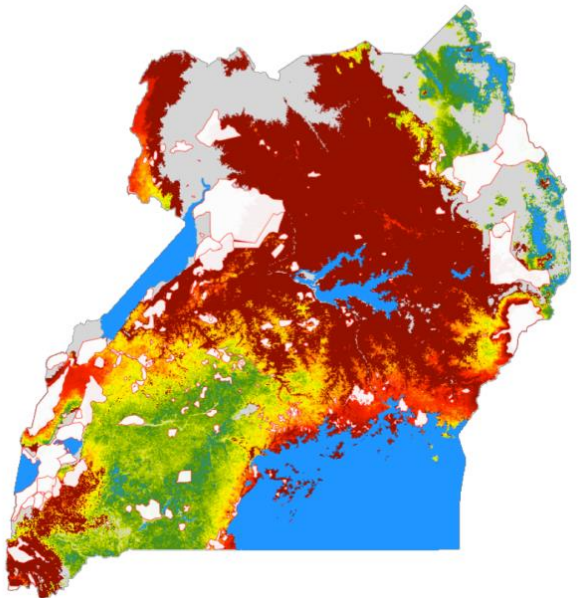
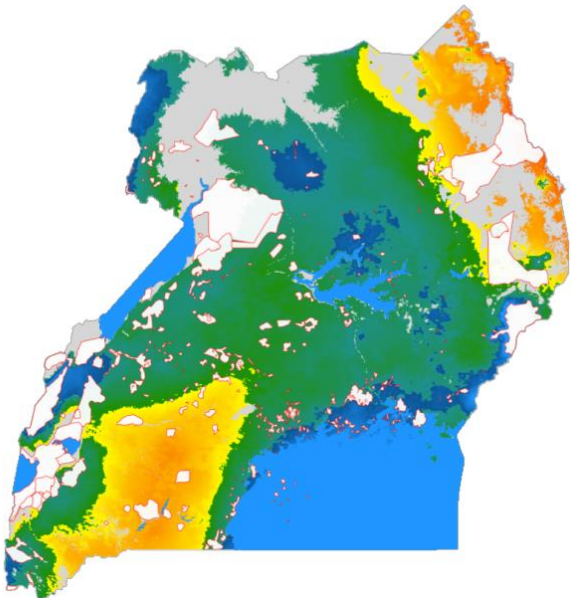


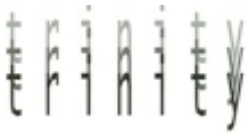
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





COFFEE/ROBUSTA (*Coffea canephora*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Coffea+canephora>)

A plant of the moister tropics, where it is usually found at elevations between 200 - 800 metres, occasionally up to 1,300 metres.^[303] It grows best in areas where annual daytime temperatures are within the range 20 - 30°C, but can tolerate 12 - 36°C.^[418] It can be killed by temperatures of 5°C or lower.^[418] It prefers a mean annual rainfall in the range 1,700 - 3,000 mm, but tolerates 900 - 4,000 mm.^[418] One to 2 months of less than 50 mm rain facilitates uniform flowering.^[418] Prefers a well-drained fertile, neutral to slightly acid soil.^[200] Succeeds in shallow soils in areas of high rainfall, and will stand temporary waterlogging.^[418] Prefers a pH in the range 5 - 6.3, tolerating 4 - 8.^[418] Plants can begin to flower and fruit within 3 - 4 years from seed. The yield increases up to the age of 14 years.^[418] The plant has an economic life of 20 - 80 years (average 50 years), with declining yields. The tree may live as long as a hundred years. Well managed plantations may produce up to 2 tonnes per hectare of fresh berries.^[418] A distinct dry season is favourable for flower initiation.^[320]



Demands and Yield

	Sufficient	Optimal
Maximum temperature	36°C	30°C
Minimum temperature	12°C	20°C
Absolute minimum temperature	6°C	
Altitude	< 1300 m	< 800 m
Annual rainfall	900 - 4,000 mm	1,700 - 3,000 mm
Rainfall seasonality	1-2 drier months (<50 mm)	
Soil drainage	moderately well drained	well drained
Soil pH	4 - 8	5.0 - 6.3
Yield		2 t/ha fresh berries

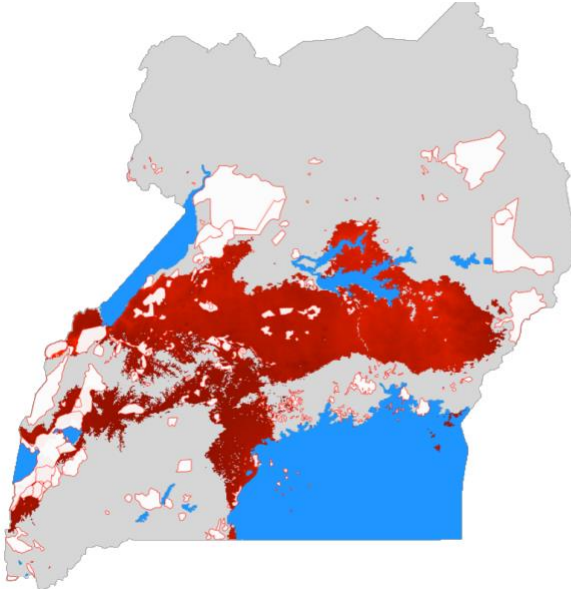
References

- 200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5
- 303 <http://www.worldagroforestry.org/>
- 320 Jensen. M. 1999. Trees Commonly Cultivated in SE Asia. FAO Regional Office, Bangkok. ISBN 974-89377-5-5
- 418 <http://ecocrop.fao.org/ecocrop/srv/en/home>

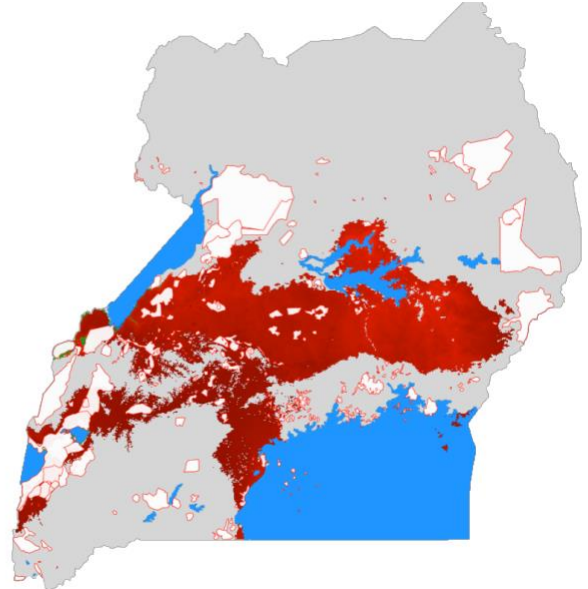


Suitability

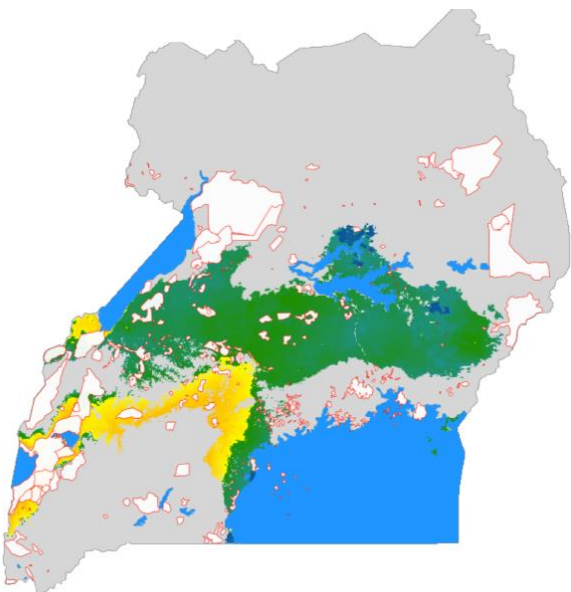
Suitability without irrigation



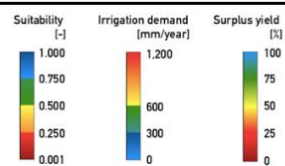
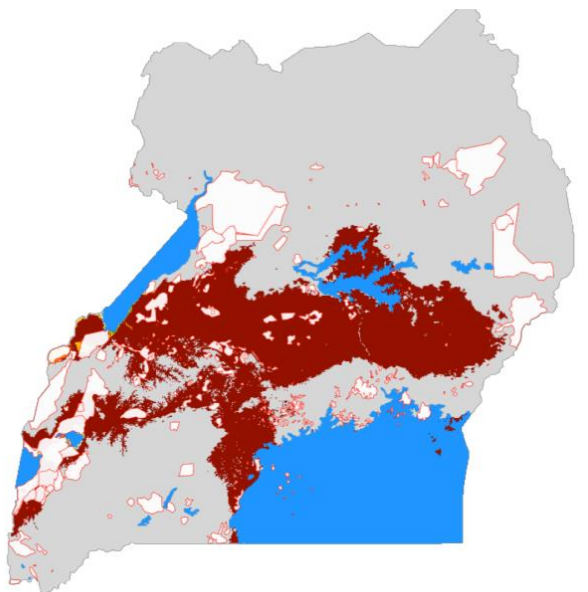
Suitability with irrigation

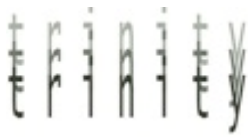


Average irrigation demand [mm/year]



Expected surplus yield [%]





MORINGA TREE (*Moringa oleifera*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Moringa+oleifera>)

The moringa tree (also called as drumstick or horseradish tree) succeeds in warm temperate to tropical areas and can be found at elevations from sea-level to about 1,000 metres^[303]. It grows best in areas where annual daytime temperatures are within the range 20 - 35°C, but can tolerate 7 - 48°C.^[418] The plant is quite cold hardy and is not harmed by light frosts, but it can be killed back to ground level by a freeze. It quickly sends out new growth from the trunk when cut, or from the ground when frozen.^[303] It prefers a mean annual rainfall in the range 700 - 2,200 mm, but tolerates 400 - 2,600 mm.^[418] Easily grown in a well-drained soil in a sunny position, tolerating a wide range of soil types.^[200,307] It grows best on fertile and well drained sandy soil, clay or clay loam but is in general suitable for light, medium and heavy soils though it will not withstand salinity. It has a special tolerance to shallow soil and is tolerant of low fertility.^[404] Prefers a pH in the range 5.5 - 7, tolerating 5 - 8.5.^[418] Established plants are quite drought tolerant but yield much less foliage when continuously under water stress.^[303] Grows better if given shelter from strong winds.^[418] Moringa is an extremely fast-growing tree, and within 1- 3 months trees can reach 2.5 metres in height.^[303] Growth rates of 3 - 4 metres per year is not unusual for young plants.^[299] Young trees raised from seed start flowering after 2 years. In trees grown from cuttings the first fruits may be expected 6 - 12 months after planting.^[299] Flowering often precedes or coincides with the formation of new leaves, and can occur throughout the year in non-seasonal climates.^[299] Constant pruning of up to 1.5 metres per year is suggested to obtain a thick-limbed and multibranched shrub.^[303] It coppices and pollards well.^[303] The sweet smelling flowers are produced throughout the



year.^[404] In the warmer parts of its range the plant can produce a second crop of seeds each

year.^[418] There is at least one named variety.^[301]

Demands and Yield

	Sufficient	Optimal
Maximum temperature	48°C	35°C
Minimum temperature	7°C	20°C
Absolute minimum temperature	0°C	
Annual rainfall	400 - 2,600 mm	700 - 2,200 mm
Soil drainage	moderately well drained	well drained
Soil pH	5-8.5	5.5-7
Yield	7.5 t/ha fresh foliage	80 t/ha fresh foliage
	170 kg/tree fresh seeds	481 kg/tree fresh seeds

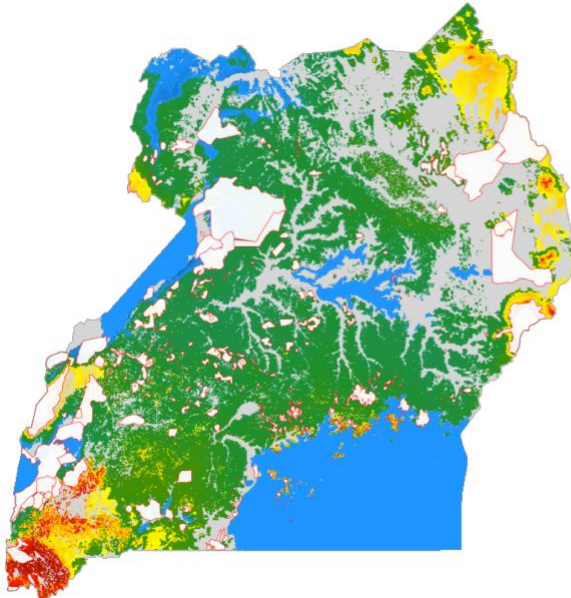
References

- 200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5
- 299 <http://www.prota.org>
- 301 Facciola. S. 1998. Cornucopia II. Kampong Publications, California. ISBN 0-9628087-2-5
- 303 <http://www.worldagroforestry.org/>
- 307 Barwick. M. 2004. Tropical and Subtropical Trees - A Worldwide Encyclopaedic Guide. Thames & Hudson, London. ISBN 0-500-51181-0
- 404 <http://www.digitalspecies.blogspot.com>
- 418 <http://ecocrop.fao.org/ecocrop/srv/en/home>



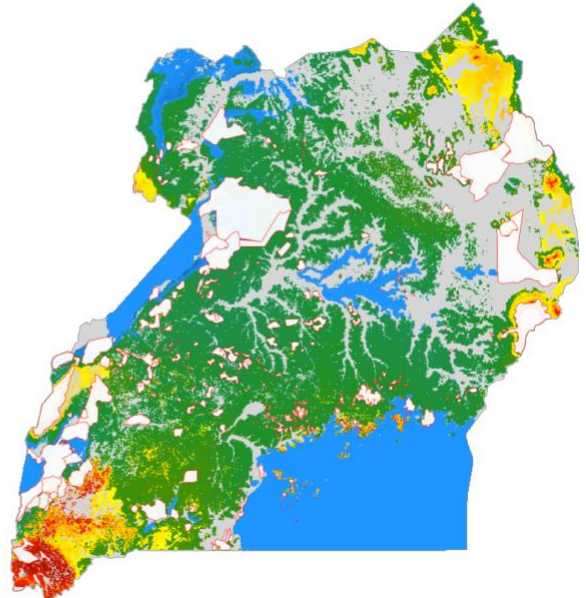
Suitability

Suitability without irrigation

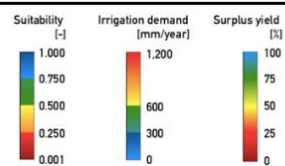
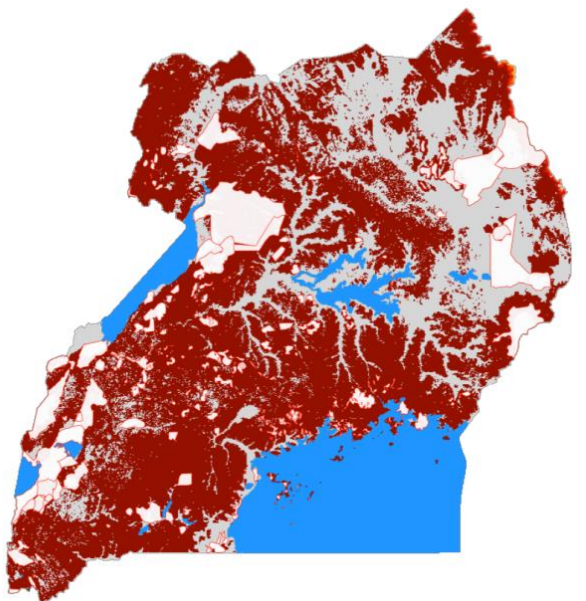
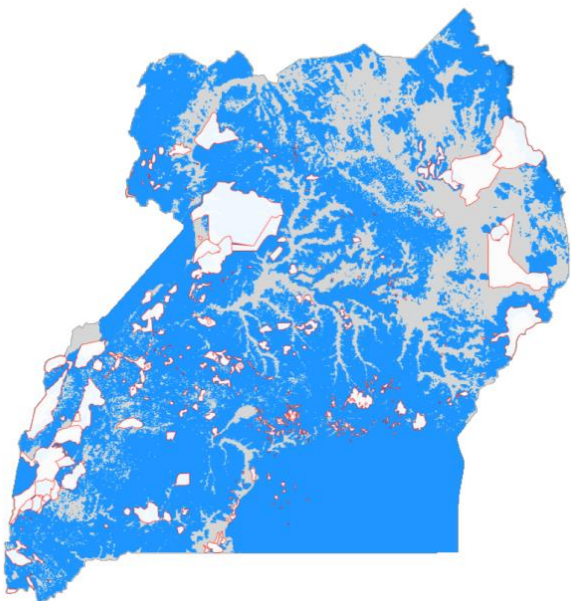


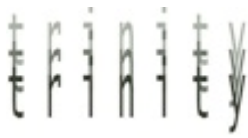
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





PASSION FRUIT (*Passiflora edulis*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Passiflora+edulis>)

Although it is a subtropical species, the passion fruit can also be grown at higher elevations in tropical areas.^[262] It can be grown between sea level and 900 metres in the subtropics, and from 900 - 2,000 metres or even higher in the tropics.^[418] It grows best in areas where annual daytime temperatures are within the range 20 - 30°C, but can tolerate 18 - 34°C.^[418] When dormant, the mature plant can survive temperatures down to about -2°C, but young growth cannot tolerate any frost.^[418] Temperatures below 15-20 °C inhibit germination, emergence, and seedling growth.^[2] It prefers a mean annual rainfall in the range 900 - 2,000 mm, but tolerates 600 - 2,500 mm.^[418] Requires a humus-rich, moist but well-drained soil and a position in dappled shade.^[262] Requires a well-drained soil with plenty of moisture in the growing season, otherwise it is not fussy.^[1,3] *Passiflora* species tend to flower and fruit more freely when grown in soils of only moderate fertility.^[200] Prefers a circumneutral soil, disliking very acid or very alkaline conditions.^[262] Prefers a pH in the range 6 - 8, tolerating 5.5 - 8.5.^[418] Prefers a position sheltered from cold winds.^[418] The plant has naturalised and become invasive in many countries, including New Zealand and South Africa.^[413] Seedling plants can commence fruiting within 1 - 2 years, cuttings can start fruiting in the same year.^[335] Plants have a commercially economic lifespan of 3 - 6 years.^[418] Two crops a year are normally produced.^[418] Average annual yield of fruit may be about 8 - 15 tonnes per hectare, but yields up to 50 tonnes have been reported from Kenya.^[418] A shallow-rooted plant.^[418] Flowers shed their pollen before the pistils are receptive and so plants need another cultivar flowering at a slightly different time in order to fertilize the flowers.^[200] The



species is self-fertile, though some of its forms, such as *Flavicarpa*, require cross-pollination.^[262] Plants are very tolerant of pruning and can be cut back to ground level if required to rejuvenate the plant.^[202] Plants in this genus are notably resistant to honey fungus.^[200]

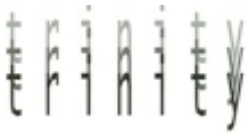
There are two distinct forms of this species:

- *P. Edulis edulis* is the type species. It has purple fruits and occurs in cooler regions and at higher altitudes in the tropics.
- *P. Edulis flavicarpa* has larger, yellow fruits. It is native to the tropical lowlands.

There are some named varieties of each form.^[46,183,200,301]

Demands and Yield

	Sufficient	Optimal
Maximum temperature	34°C	30°C
Minimum temperature	17°C	20°C
Absolute minimum temperature	0°C	
Annual rainfall	600 - 2,500 mm	900 - 2,000 mm
Soil drainage	well drained	well drained
Soil pH	5.5 - 8.5	6 - 8
Yield	8 t/ha	15 t/ha



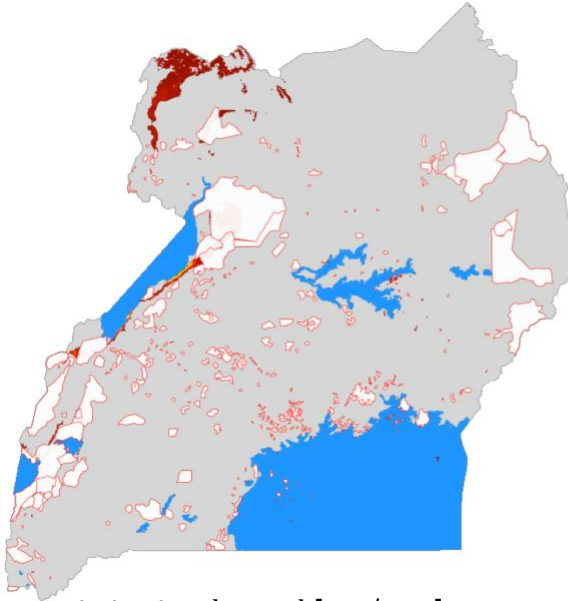
References

- 46 Uphof. J. C. Th. 1959. Dictionary of Economic Plants. Weinheim publisher.
- 183 Facciola. S. 1990. Cornucopia - A Source Book of Edible Plants. Kampong Publications. ISBN 0-9628087-0-9
- 200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5
- 202 Davis. B. 1990. Climbers and Wall Shrubs. Viking publisher. ISBN 0-670-82929-3
- 262 Vanderplank. J. 1991. Passion Flowers. Cassell. London. ISBN 0-304-34076-6
- 299 <http://www.prota.org>
- 301 Facciola. S. 1998. Cornucopia II. Kampong Publications, California. ISBN 0-9628087-2-5
- 303 <http://www.worldagroforestry.org/>
- 307 Barwick. M. 2004. Tropical and Subtropical Trees - A Worldwide Encyclopaedic Guide. Thames & Hudson, London. ISBN 0-500-51181-0
- 335 Martin, F. W.; Campbell, C. W.; Rubertbe, R. M. 1987. Perennial Edible Fruits of the Tropics : an Inventory. U.S. Dept. of Agriculture, Agricultural Research Service
- 404 <http://www.digitalspecies.blogspot.com>
- 413 Global Invasive Species Database: <http://www.issg.org/database/welcome/>
- 418 <http://ecocrop.fao.org/ecocrop/srv/en/home>



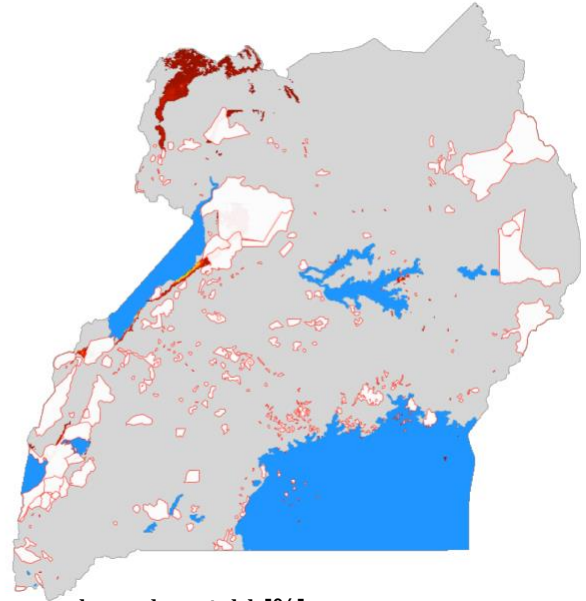
Suitability

Suitability without irrigation

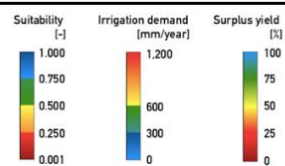
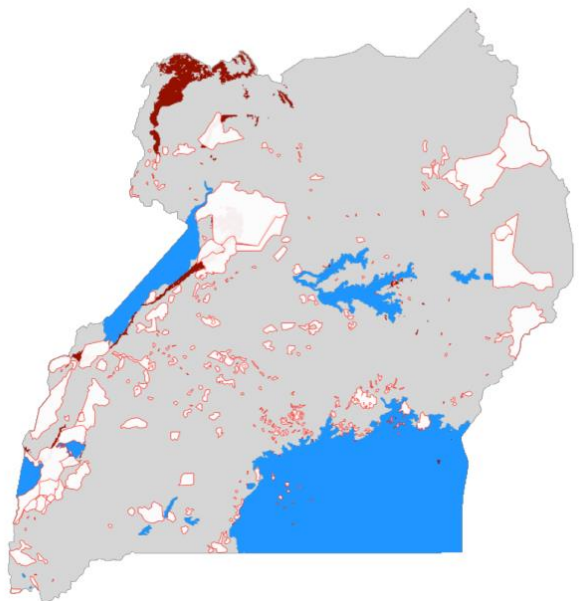
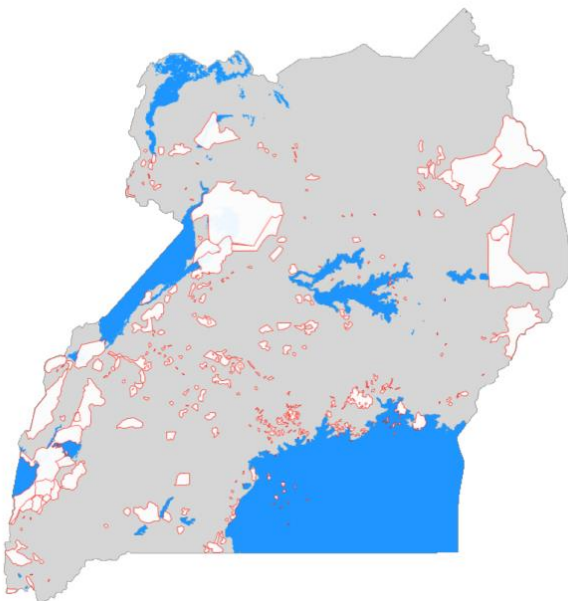


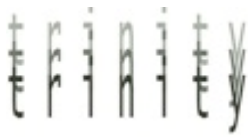
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





CASHEW (*Anacardium occidentale*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Anacardium+occidentale>)

A plant for lowland tropical and subtropical areas, succeeding at elevations up to 1,000 metres.^[324]

Grows well in hot, semi- arid, frost- free climates, fruiting well with an annual precipitation of 500 - 900 mm.^[200] It occurs in warm and humid climates with an annual rainfall of 1,000 - 3,500 mm.^[303,324] Prefers a pronounced dry season of 3 - 4 months.^[324] Plants are not tolerant of frost, preferring a minimum temperature no lower than 18°C.^[238,303] Plants produce their best crops when grown not too far from the coast.^[63] Cashews can also be grown satisfactorily in semi-arid areas but can show erratic production as a result of relative small variations in rainfall.^[324] An easily grown plant requiring very little attention once established, it succeeds in soils that are too poor to support other crops.^[63,200] Prefers a well-drained sandy soil and a position in full sun.^[238] The species can bear heavy, waterlogged clay soils or saline soils but with an extreme poor growth.^[404] Brackish soils near seashores and inundated or swampy soils are not suited.^[404] Tolerates a pH in the range 4.5 - 6.5.^[200] Established plants are drought resistant.^[200,324] Tolerant of maritime exposure.^[63] Normally, about 92 % of the trees yield by the third year from planting. The average yield per tree increases from about 2 kg at 3-5 years to 4 kg at 6-10 years and 5-10 kg when trees are 11-15 years of age. Thereafter, trees yield in excess of 10 kg as the trees get older.^[999]



Demands and Yield

	Sufficient	Optimal
Maximum altitude	1000 m	
Absolute minimum temperature	0°C	18°C
Annual rainfall	500 - 3,500 mm	500 - 900 mm
Dry season length		3-4 months
Soil drainage	imperfectly drained	well drained
Soil pH	4.5 - 6.5	
Yield	2 kg dry nuts/tree	5-10 kg dry nuts/tree

References

63 Howes. F. N. 1948. Nuts. Faber publishers.

200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5

238 Bown. D. Encyclopaedia of Herbs and their Uses. Dorling Kindersley, London. 1995. ISBN 0-7513-020-31

303 <http://www.worldagroforestry.org/>

324 Wickens G.E. 1995. Edible Nuts. Non-Wood Forest Products, Handbook 5. <http://www.fao.org/docrep/>FAO, Rome. ISBN 92-5-103748-5

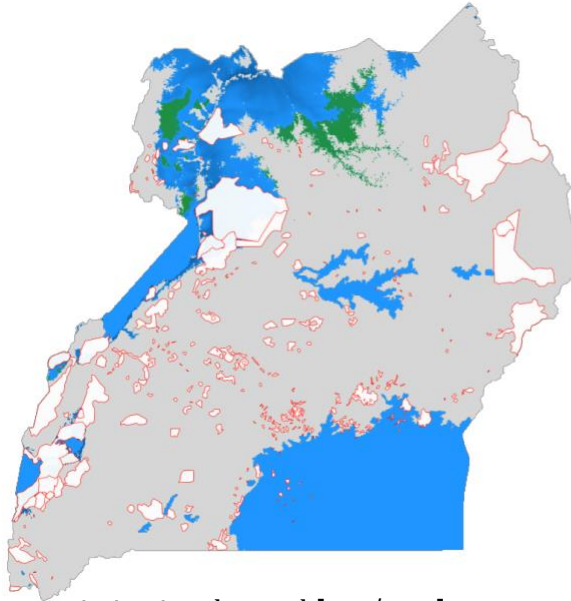
404 <http://www.digitalspecies.blogspot.com>

999 <http://www.fao.org/3/ac451e/ac451e04.htm>



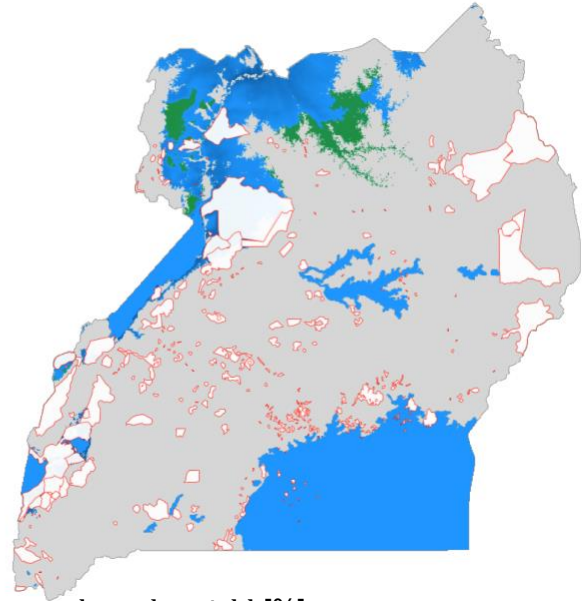
Suitability

Suitability without irrigation

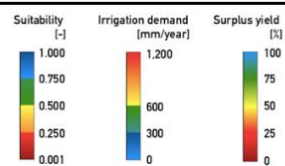
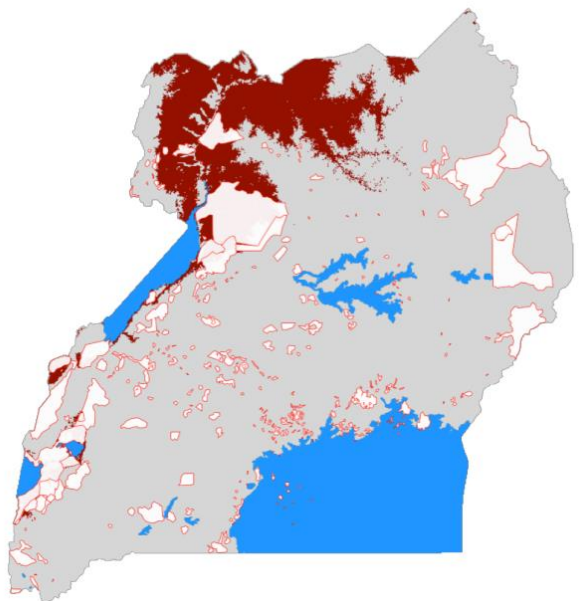
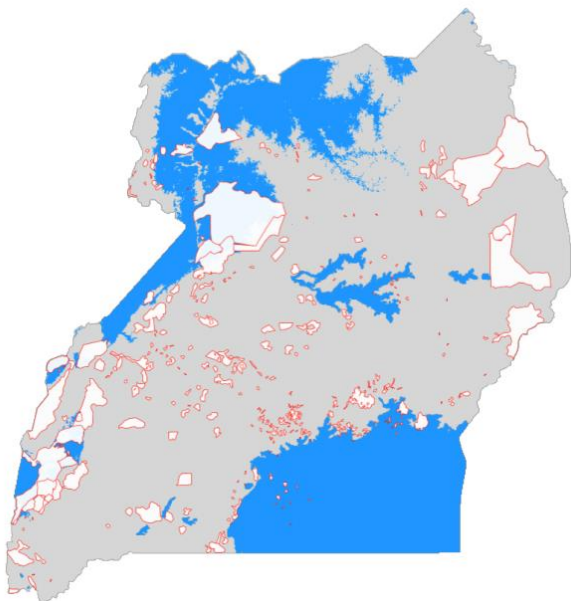


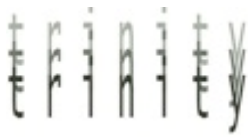
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





STEVIA (*Stevia rebaudiana*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Stevia+rebaudiana>)

A plant of the subtropics and tropics, where it can be cultivated at elevations from sea level up to 1,500 metres. It grows best in areas where annual daytime temperatures are within the range 18 - 30°C, but can tolerate 15 - 43°C.^[418] When dormant, the plant can survive temperatures down to about -6°C, but young growth can be severely damaged at 0°C.^[418] It prefers a mean annual rainfall in the range 1,000 - 1,400 mm, but tolerates 500 - 1,800 mm.^[418] Prefers a sandy soil, requiring a warm sunny position.^[200] Prefers a pH in the range 5 - 6.5, tolerating 4 - 7.5.^[418] A first harvest can take place 2 months after planting, which is about 6 months after sowing the seed.^[418] Further harvests can be taken at monthly intervals and can continue for about 5 years before the plants will need to be replaced.^[418] Flowering occurs 40 - 60 days after sowing or cutting. Long days, however, promote more leaf production resulting in a higher content of stevioside, on dry-matter basis.^[418] In Japan, the yield in the first year is 400 - 500 kilos per hectare of the dried leaves, while yields in the following years vary between 1.5 - 2 tonnes of dry leaves. In western Java a yearly production of 3 tonnes of dry leaves is possible.^[418]

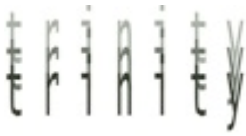


Demands and Yield

	Sufficient	Optimal
Maximum altitude	1000 m	
Absolute minimum temperature	0°C	18°C
Annual rainfall	500 - 3,500 mm	500 - 900 mm
Dry season length		3-4 months
Soil drainage	imperfectly drained	well drained
Soil pH	4.5 - 6.5	
Yield	2 kg dry nuts/tree	5-10 kg dry nuts/tree

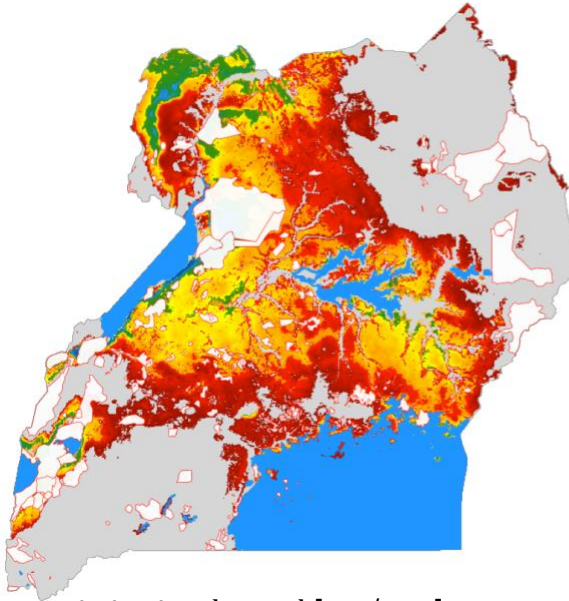
References

- 200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5
418 <http://ecocrop.fao.org/ecocrop/srv/en/home>



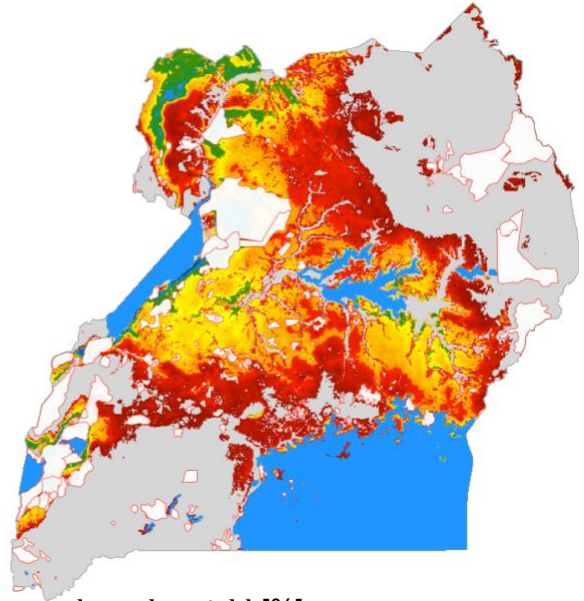
Suitability

Suitability without irrigation

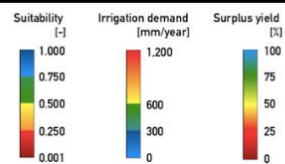
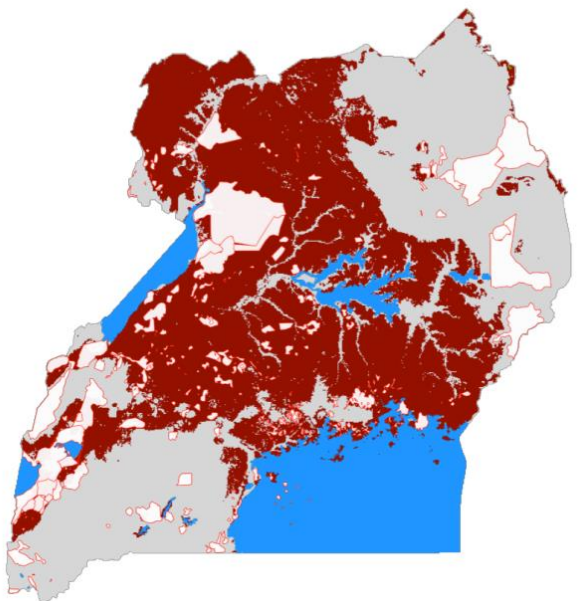
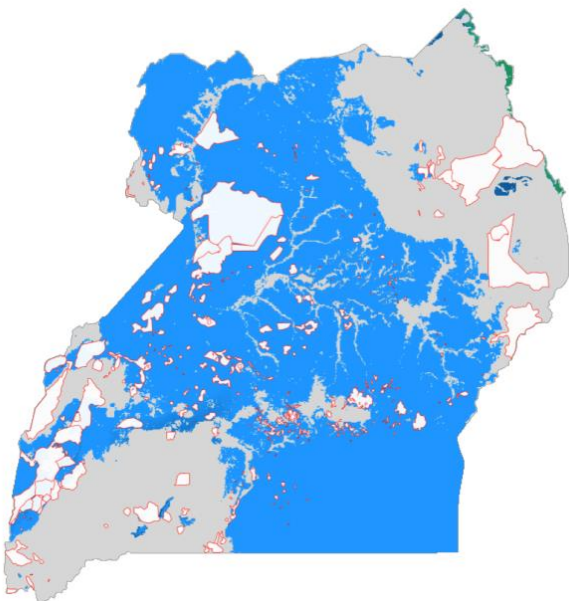


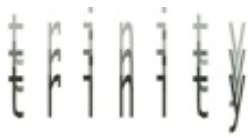
Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





TEA (*Camellia sinensis*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Camellia+sinensis+assamica>)

Found from the warm temperate zone, through the subtropics and into the tropics of southern Asia, *Camellia sinensis* originated in an area of monsoon climates and mild winters. The plant has proved very amenable to cultivation and is now grown as far north as 42° North and south to Argentina at 27° South.^[303] The var *sinensis* can tolerate winter temperatures falling occasionally as low as -5 to -10°C, and grows best in the warm temperate to subtropical zone, whilst var *assamica* is less cold tolerant and is found from the subtropics to tropical areas. Depending on latitude, the plant can be grown at elevations from sea level to 2,300 metres.^[303] Whilst a minimum mean annual rainfall of 1,700 mm is required for economic production,^[303] the plant is reported to tolerate an annual precipitation in the range of 700 - 3,500 mm.^[269,303] Rainfall should not fall below 50 mm per month for any prolonged period.^[303] Generally, optimum temperatures for shoot growth are 18 - 30°C.^[303] The maximum high temperature for *camellia sinensis* plants is 45°C but when it is above 35°C, its growth will be inhibited and leaves found to be seared.^[2] Prefers a woodland soil but thrives in a warm open well-drained loam if leafmould is added.^[1,11,200] A calcifuge plant, preferring a pH between 5 and 7.^[11,200] Prefers a pH of 4.5 - 5.6.^[303] Prefers the partial shade of a light woodland or a woodland clearing.^[166,200] Tea is generally more productive without shade, but shade trees may be necessary to reduce air temperatures during hot periods. Shelter belts of trees planted between fields are beneficial in protecting tea against prevailing strong winds.^[303] Climatic conditions have a great influence on the quality of the tea, especially on the flavour. Fast shoot growth - for instance at low altitudes, during the best part of the growing season



or shortly after the bushes have been pruned back - is detrimental to the quality of tea, particularly the flavour, but induces high production. Nevertheless, high yields and excellent quality tea can be obtained in tropical countries on fertile soils, especially at elevations of 1,200 - 1,800 metres above sea-level. At still higher elevations, the tea will have a well-developed flavour but it will lack strength and yields will be lower.^[303] In Assam yields range from 1,200-2,250 kg/ha, but clonal tea yields in Sri Lanka have attained 6,700 kg/ha.^[3] An acre of tea can yield 800 to 3,600 pounds of made tea each year. One pound of made tea requires 4.5 pounds of fresh picked tea or 2 to 3 thousand shoots. One to two thousand pounds per acre is considered a high yield.^[4]

Demands and Yield

	Sufficient	Optimal
Maximum temperature	35°C	30°C
Minimum temperature	0°C	18°C
Annual rainfall	700 - 3,500 mm	1,700 - 3,500 mm
Dry season length		0 months
Soil drainage		well drained
Soil pH	4.5-7	5-5.6
Altitude	0 - 2,300 m	1,200 - 1,800 m
Yield	1200 kg/ha	2,250 kg/ha



Sustainable Energy-Water Solutions for Medium to Large-Scale Irrigation of Commercial Farming in Uganda – Pre-Feasibility Study

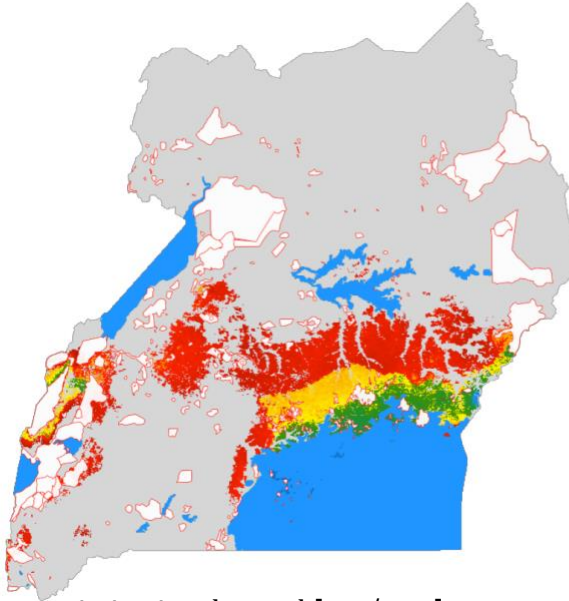
References

- 1 F. Chittendon. 1956. RHS Dictionary of Plants plus Supplement. Oxford University Press
- 2 <http://www.viconyteas.com/directory/tea-encyclopedia/camellia-sinensis.html>
- 3 https://hort.purdue.edu/newcrop/duke_energy/Camellia_sinensis.html#Yields%20and%20Economics
- 4 <https://www.serenityteasips.com/tea-101>
- 11 Bean. W. 1981. Trees and Shrubs Hardy in Great Britain. Vol 1 - 4 and Supplement. Murray Publishers.
- 166 Taylor. J. 1990 The Milder Garden. Dent Publishers.
- 200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5
- 269 Duke. J. 1983. Handbook of Energy Crops
- 303 <http://www.worldagroforestry.org/>



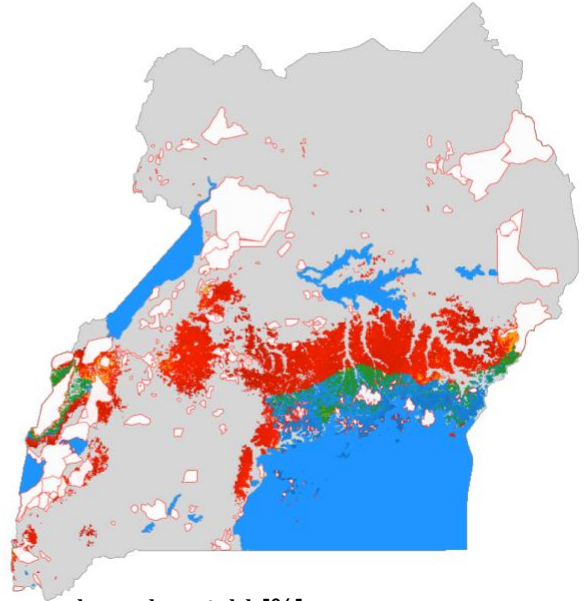
Suitability

Suitability without irrigation

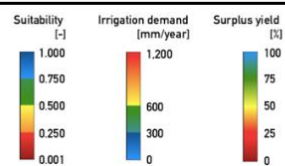
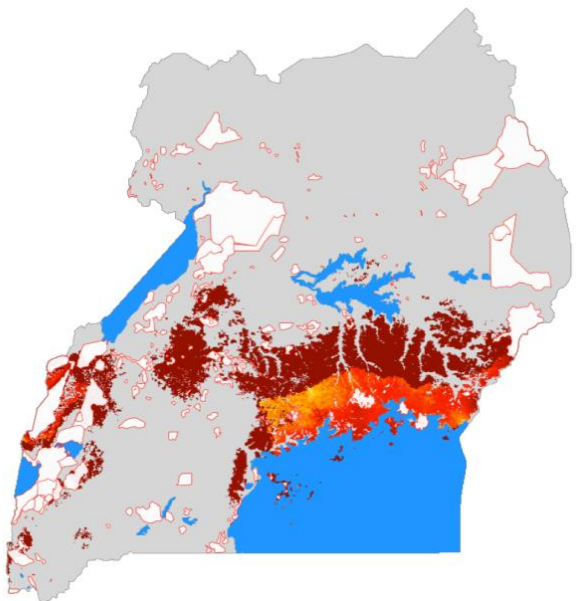
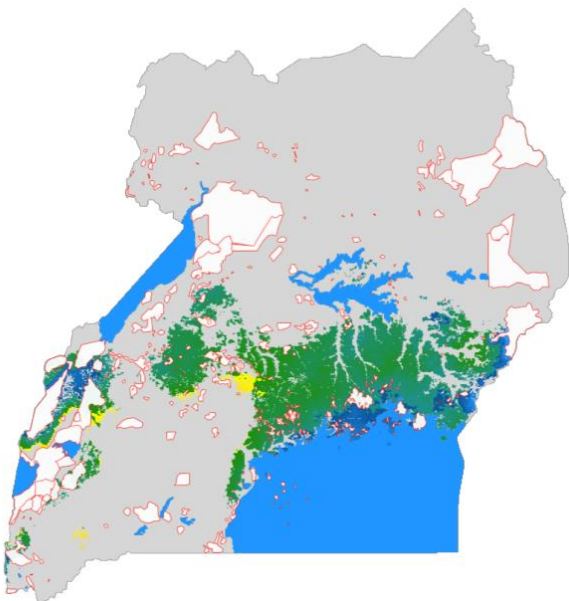


Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





CHIA (*Salvia hispanica*)

Cultivation details

(<https://pfaf.org/user/Plant.aspx?LatinName=Salvia+hispanica>)

Requires a light to medium well-drained fertile soil in a warm sunny position.^[200] Plants are not very frost tolerant.^[200] This species is widely cultivated for its edible seed in Mexico. Many of the plants cultivated under this name are in fact *S. lavandulifolia*.^[200] The cultivation of *S. hispanica* requires light to medium clay or sandy soils.^[26] The plant prefers well-drained, moderately fertile soils, but can cope with acid soils and moderate drought.^{[23][26]} Annual rainfall is optimally between 780-1,560 mm, yet it tolerates 660-2,130 mm.^[10] Sown chia seeds need moisture for seedling establishment, while the maturing chia plant does not tolerate wet soils during growth.^[23] Temperature should be optimally between 18-26°C.^[10] Tolerates 10-29°C.^[10] Martinez reports that in Mexico 1,000 - 3,000 kilos of the seeds may be produced per hectare.^[331]

Demands and Yield

	Sufficient	Optimal
Maximum temperature	29°C	26°C
Minimum temperature	10°C	18°C
Annual rainfall	660 - 2,130 mm	780 - 1,560 mm
Soil drainage		well drained
Yield	1,000 kg seeds/ha	3,000 kg seeds/ha



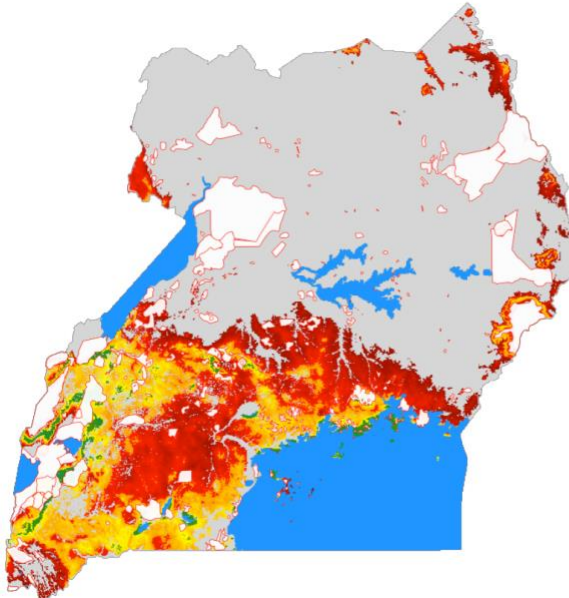
References

- 10 <http://dx.doi.org/10.5424/sjar/2017153-9935>
- 23 <http://www.uky.edu/Ag/CCD/introsheets/chia.pdf>
- 26 Muñoz, Loreto A.; Angel Cobos; Olga Diaz; José Miguel Aguilera 2013. Chia Seed (*Salvia hispanica*): An Ancient Grain and a New Functional Food. *Food Reviews International*. 29 (4): 394–408. doi:10.1080/87559129.2013.818014.
- 200 Huxley. A. 1992. *The New RHS Dictionary of Gardening*. MacMillan Press, ISBN 0-333-47494-5
- 331 Standley P.C. & J. A. Steyermark 1946-1976. *Flora of Guatemala*. <http://www.archive.org/>



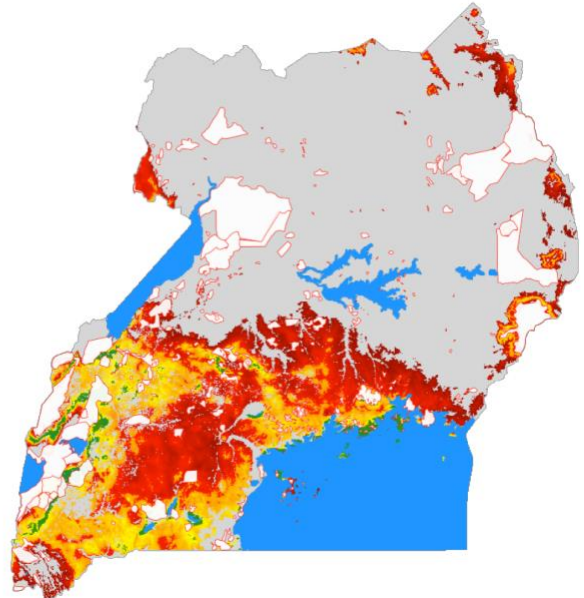
Suitability

Suitability without irrigation

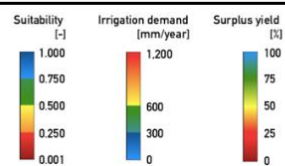
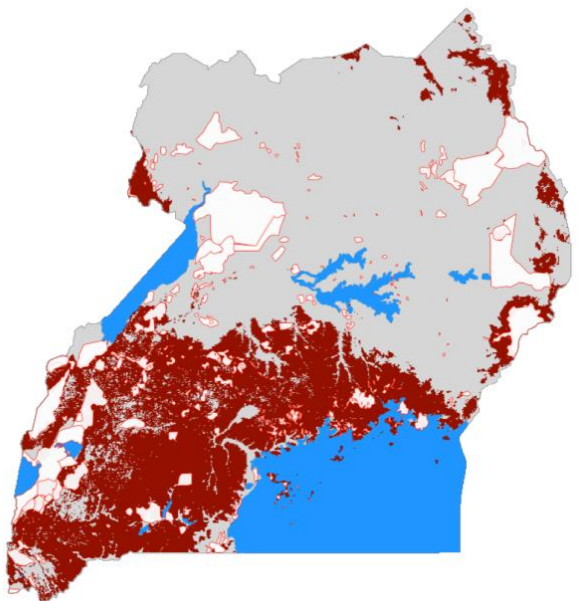
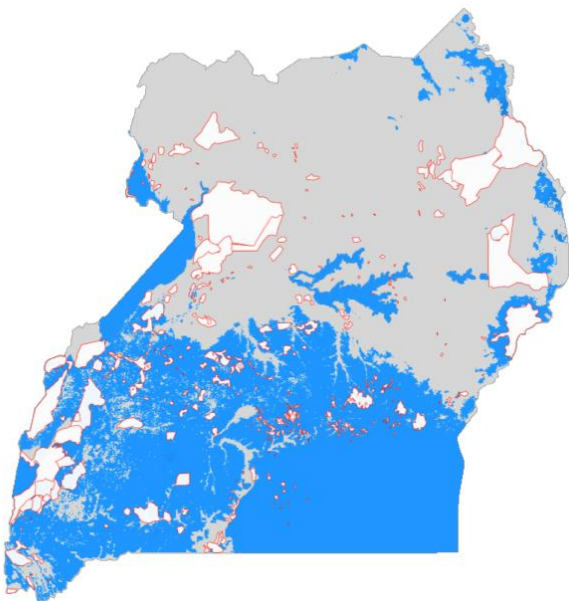


Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





CHILI (*Capsicum annum*, *C. frutescens*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Capsicum+frutescens>)

Grows well in lowland tropical regions and at an elevation up to 2,000 metres.^[300] It is also cultivated as an annual in the subtropics and warm temperate areas. It prefers a temperature in the range 21 - 25°C, not growing well if temperatures exceed 32°C.^[300] Plants are not tolerant of frost.^[34] Annual precipitation of 600 - 1,200 mm is considered to be adequate.^[300] Excessive rainfall can reduce flowering and fruit set, as well as encourage diseases.^[300] Prefers a very warm sunny position and a humus- rich, fertile, well-drained loam.^[300] Prefers a light sandy soil that is slightly acid.^[201] Prefers a pH in the range of 5.5 - 5.6.^[300] but tolerates 4.3 to 8.3. Often grown as an annual crop, the first harvest can be obtained about 2 (*C. annum*) to 3 (*C. frutescens*) months after sowing the seed.^[300] Yields of 12 - 20 tonnes per hectare can be obtained.^[300]

Demands and Yield

	Sufficient	Optimal
Maximum temperature	32°C	25°C
Minimum temperature	0°C	21°C
Annual rainfall	600 - 1,200 mm	
Soil drainage		well drained



Sustainable Energy-Water Solutions for Medium to Large-Scale Irrigation of Commercial Farming in Uganda – Pre-Feasibility Study

	Sufficient	Optimal
Soil pH	4.3 - 8.3	5.5 - 5.6
Altitude	0 - 2,000 m	
Yield	12 t/ha	20 t/ha

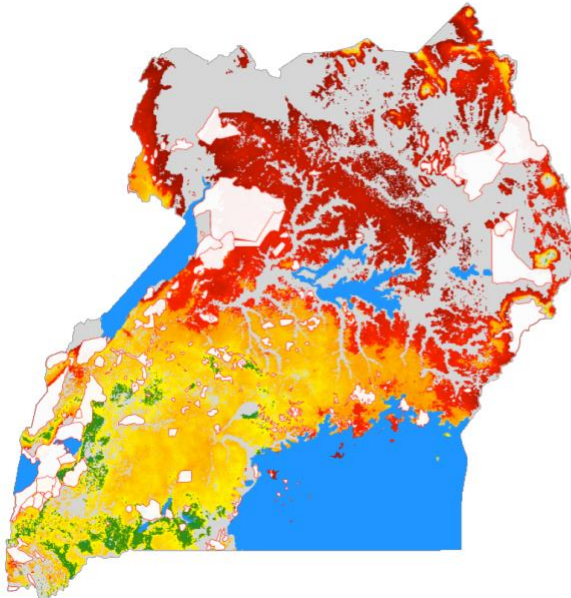
References

- 34 Harrison. S. Wallis. M. Masfield. G. 1975. The Oxford Book of Food Plants. Oxford University Press
- 201 Allardice.P. 1983. A - Z of Companion Planting. Cassell Publishers Ltd. ISBN 0-304-34324-2
- 300 Tindall. H. D. 1983. Vegetables in the Tropics. MacMillan, Oxford. ISBN 0-333-24268-8



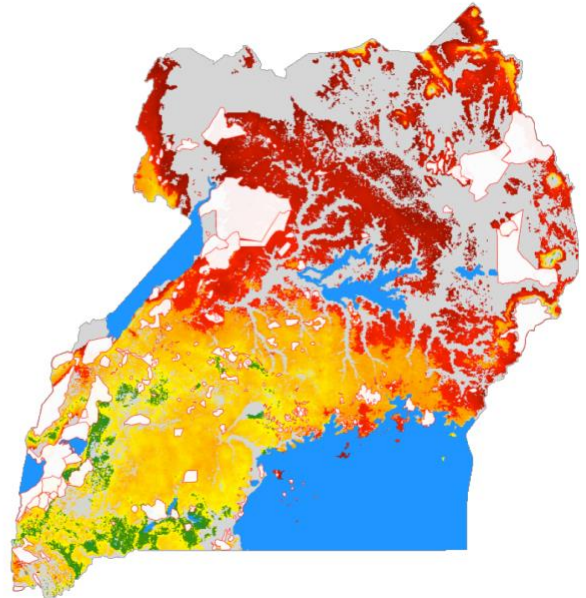
Suitability

Suitability without irrigation

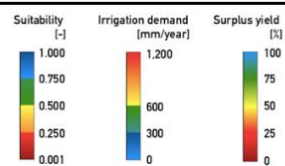
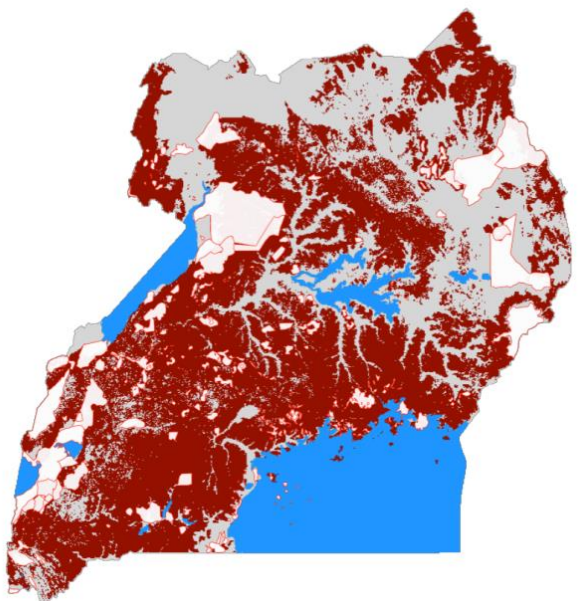
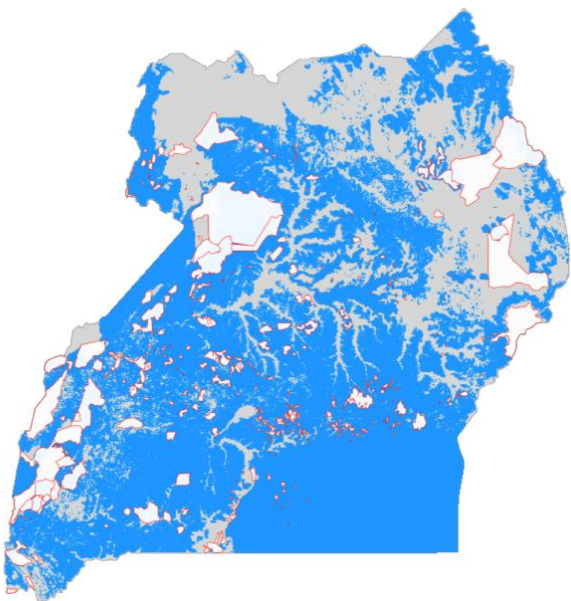


Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





AVOCADO (*Persea americana*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Persea+americana>)

Different forms of the plant can succeed in a range of climates, ranging from subtropical with occasional frosts to lowland and highland tropics, where it can be grown at elevations as high as 2,800 metres. It grows best in areas where annual daytime temperatures are within the range 14 - 40°C, but can tolerate 10 - 45°C.^[418] When dormant, the plant can survive temperatures down to about -4°C, but young growth can be severely damaged at -1°C.^[418] It prefers a mean annual rainfall in the range 500 - 2,000 mm, but tolerates 300

- 2,500 mm.^[418] Prefers a rich, neutral to alkaline soil and a position in full sun.^[307]

Succeeds on all kinds of soil.^[200] Requires a well-drained soil, the plant is intolerant of water-logging.^[200,296] Prefers a pH in the range 5 - 5.8, tolerating 4.5 - 7.^[418] Requires a position sheltered from strong winds.^[296] Yields of 15 tonnes per hectare have been recorded, but averages are about half that figure.^[200] The three main races of avocado are as follows:

- Mexican. This is the hardiest form, succeeding in subtropical climates and not well adapted to lowland tropical conditions.^[303] It can withstand short periods when temperatures drop as low as -6°C.^[303] The optimum temperature for growth is between 14 - 25°C.^[303] It has the highest oil content, over 20% and up to 30%.^[200]
- Guatemalan. This form is semitropical. It can withstand short periods when temperatures drop as low as -4°C.^[303] The optimum temperature for growth is between 15 - 28°C.^[303] It has a medium oil content generally between 10 - 20%.^[200]



- West Indian. This form is wholly tropical and grows well in a lowland tropical climate.^[303]

It can grow in a temperature range of 12 - 40°C, though the optimum is between 24 -

32°C.^[303] It has the lowest oil content, generally below 10%, down to around 3%.^[200]

Demands and Yield

	Sufficient	Optimal
Maximum temperature	45°C	40°C
Minimum temperature	10°C	14°C
Annual rainfall	300 - 2,500 mm	500 - 2,000 mm
Soil drainage		well drained
Soil pH	4.5 - 7	5 - 5.8
Altitude	< 2,800 m	
Yield	3 t/ha	7-15 t/ha

References

200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5

296 Norrington. L. 2001. Tropical Food Gardens. Blooming Books (Melbourne) ISBN 1-876473-41-x

303 <http://www.worldagroforestry.org/>

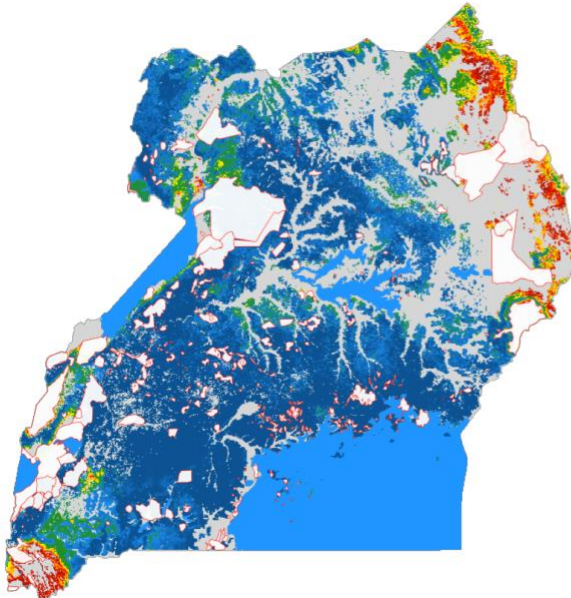
307 Barwick. M. 2004. Tropical and Subtropical Trees - A Worldwide Encyclopaedic Guide. Thames & Hudson, London ISBN 0-500-51181-0

418 <http://ecocrop.fao.org/ecocrop/srv/en/home>



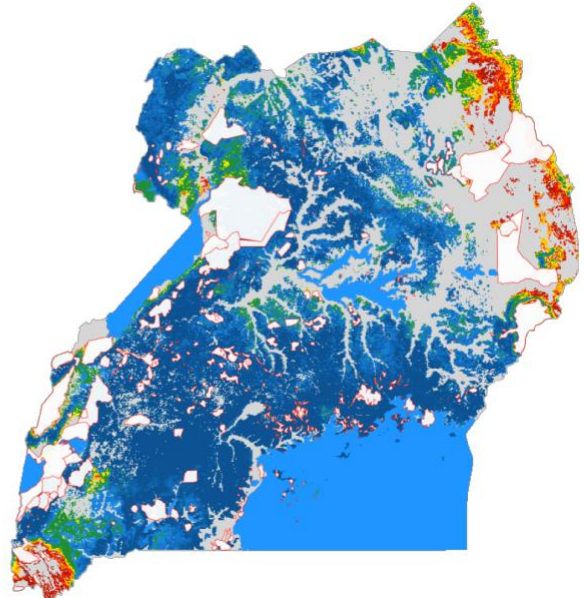
Suitability

Suitability without irrigation

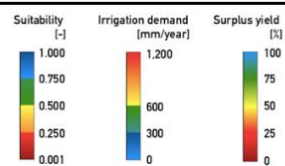
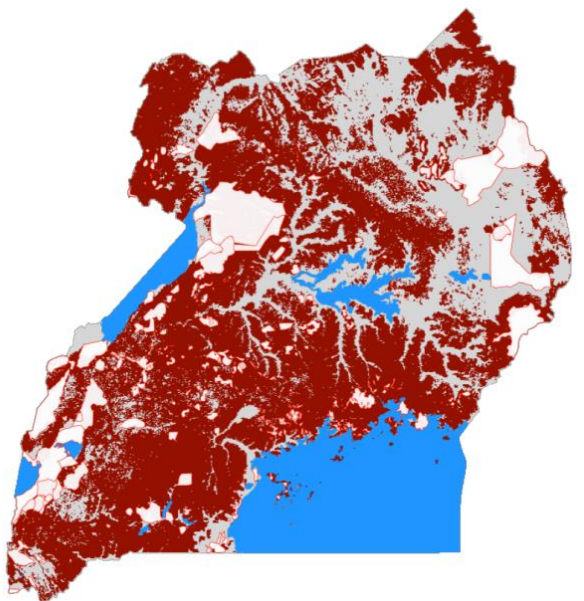
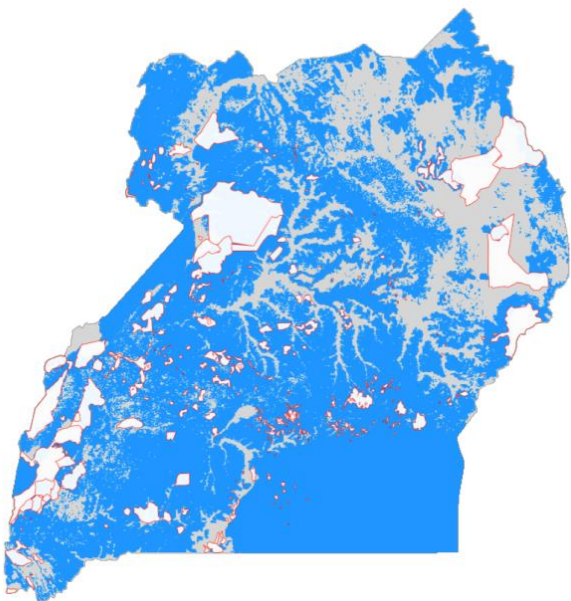


Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





SUGARCANE (*Saccharum officinarum*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Saccharum+officinarum>)

Most commercial sugarcane is grown at latitudes between 35°N and S in the tropics, usually at elevations from sea level to 1,600 metres.^[418] The plant grows best in areas where the mean annual rainfall is in the range 1,500 - 2,000 mm, tolerating 1,000 - 5,000 mm.^[418] It prefers a mean annual temperature within the range 24 - 37°C, though can tolerate 15 - 41°C.^[418] There are large differences between different cultivars in their tolerance to cold and susceptibility to frost.^[418] Generally, long-term exposure to temperatures below 10°C can be lethal, whilst even short periods at 0°C causes the leaves to become chlorotic, at about -3°C young plants turn brown and the terminal buds and leaves of mature cane die, when the temperature reaches -11.5°C the whole plant dies.^[418] Grows best in a sunny position. A very greedy plant, soon exhausting the soil of nutrients.^[459] The plant is considered to be moderately tolerant to saline soil conditions and relatively tolerant of acid soils.^[418] Grows best in a position sheltered from strong winds.^[418] Prefers a pH in the range 5 - 8, but can tolerate 4.5 - 9.^[418] Well-grown plants can become invasive.^[200] When irrigated, yields of 100 - 150 tons of cane can be obtained from mature plants.^[418] Young plants can yield 60 - 90 tons.^[418]

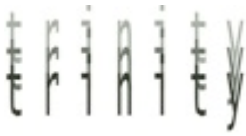


Demands and Yield

	Sufficient	Optimal
Maximum temperature	41 °C	37 °C
Minimum temperature	15 °C	24 °C
Annual rainfall	1,000 - 5,000 mm	1,500 - 2,000 mm
Soil pH	4.5 - 9	5 - 8
Altitude	< 1,600 m	
Yield	60 t/ha	100 - 150 t/ha

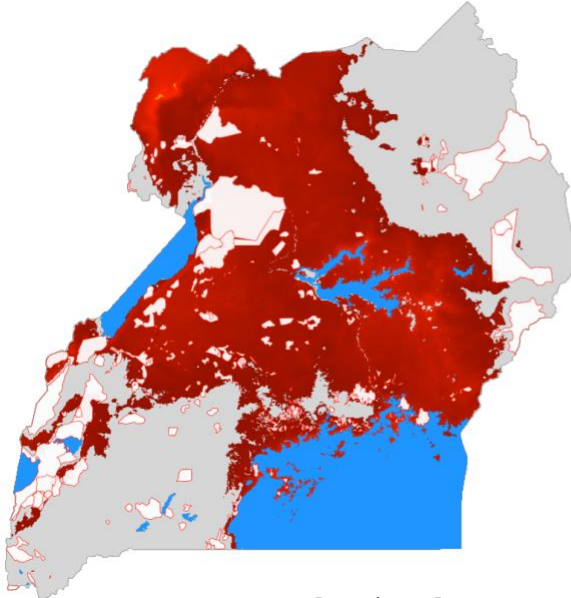
References

- 200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5
- 418 <http://ecocrop.fao.org/ecocrop/srv/en/home>
- 459 Safford W.E. 1905. The Useful Plants of the Island of Guam. Contributions from the United States National Herbarium Vol 9. Smithsonian Institute; Washington. <http://www.biodiversitylibrary.org/>



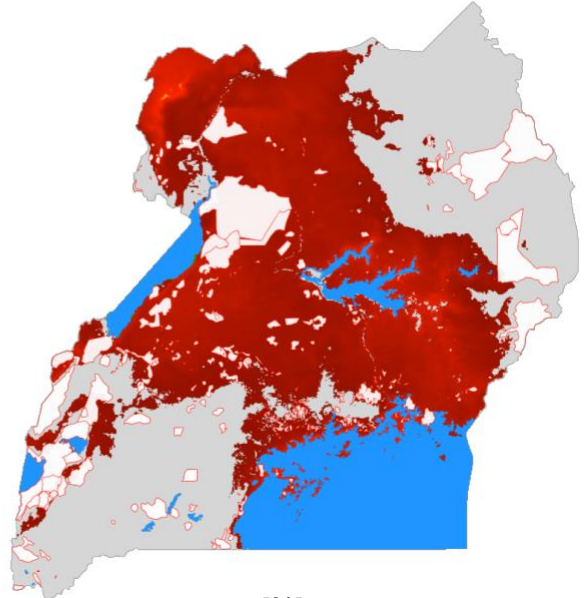
Suitability

Suitability without irrigation

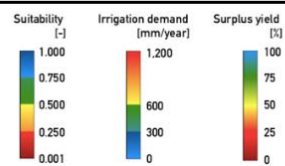
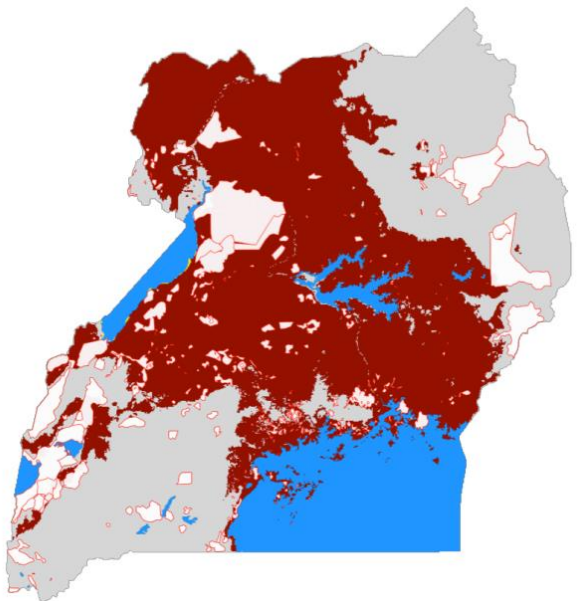
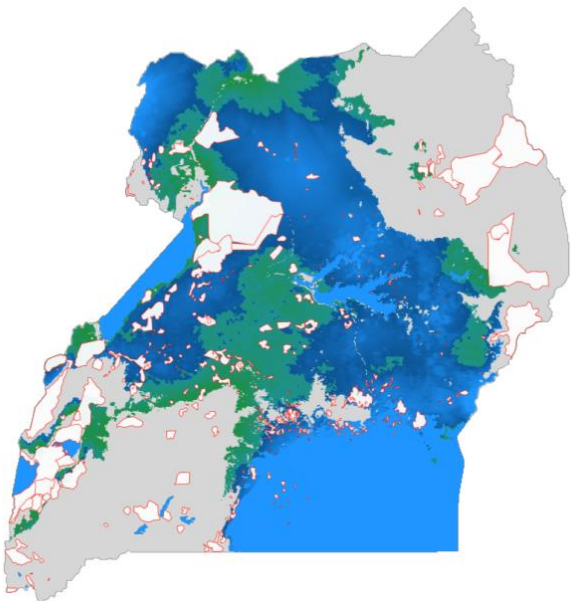


Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





RICE (*Oryza sativa*)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Orzya+sativa>)

Rice can be grown in the moist tropics, subtropics and warm temperate zone, succeeding at elevations up to 2,500 metres in tropical areas. It grows best in areas where annual daytime temperatures are within the range 20 - 30°C, but can tolerate 10 - 36°C.^[418] Growth ceases below 10°C and plants have no tolerance to frost.^[418] It prefers a mean annual rainfall in the range 1,500 - 2,000 mm, but tolerates 1,000 - 4,000 mm.^[418] Requires a wet to inundated soil and a position in full sun.^[238] Prefers a pH in the range 5.5 - 7, tolerating 4.5 - 9.^[418] Depending upon variety, rice can mature a crop of seed in anything from 60 - 200 days.^[418] There are many named varieties that have been developed from the original wild form and can be grown in a wide diversity of climates and soil types.^[200] Yields range from less than 1 t/ha under very poor rainfed conditions to more than 10 t/ha in intensive temperate irrigated systems.^[9]

Demands and Yield

	Sufficient	Optimal
Maximum temperature	36°C	30°C
Minimum temperature	10°C	20°C
Annual rainfall	1,000 - 4,000 mm	1,500 - 2,000 mm
Soil pH	4.5-9	5.5-7



Sustainable Energy-Water Solutions for Medium to Large-Scale Irrigation of Commercial Farming in Uganda – Pre-Feasibility Study

	Sufficient	Optimal
Soil drainage	Poorly drained	
Altitude	< 2,500 m	
Yield	1 t/ha	10 t/ha

References

9 <http://ricepedia.org/rice-as-a-crop/rice-productivity>

200 Huxley. A. 1992. The New RHS Dictionary of Gardening. MacMillan Press, ISBN 0-333-47494-5

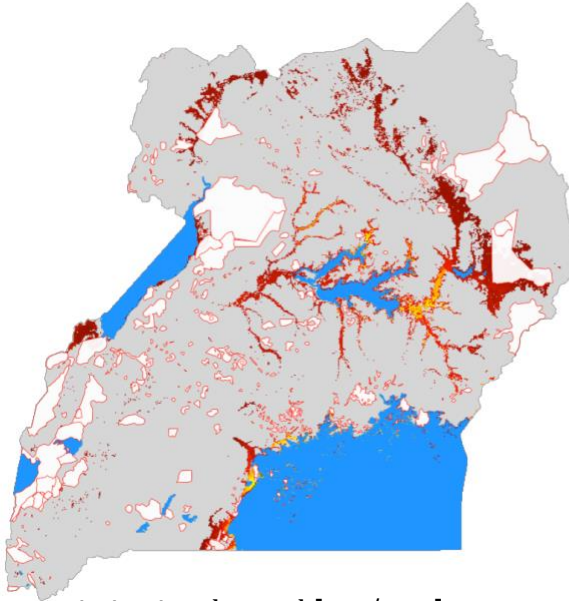
238 Bown. D. Encyclopaedia of Herbs and their Uses. Dorling Kindersley, London. 1995. ISBN 0-7513-020-31

418 <http://ecocrop.fao.org/ecocrop/srv/en/home>



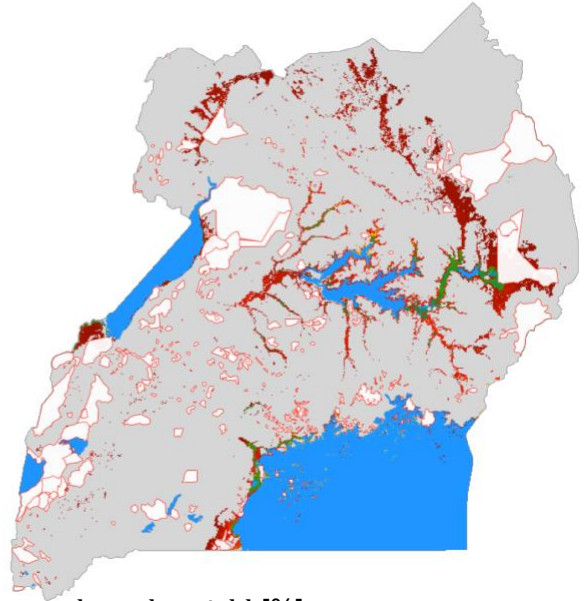
Suitability

Suitability without irrigation

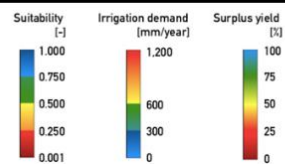
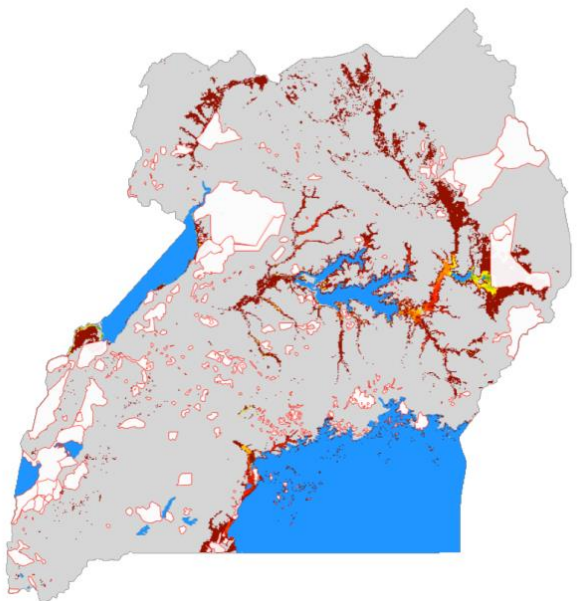
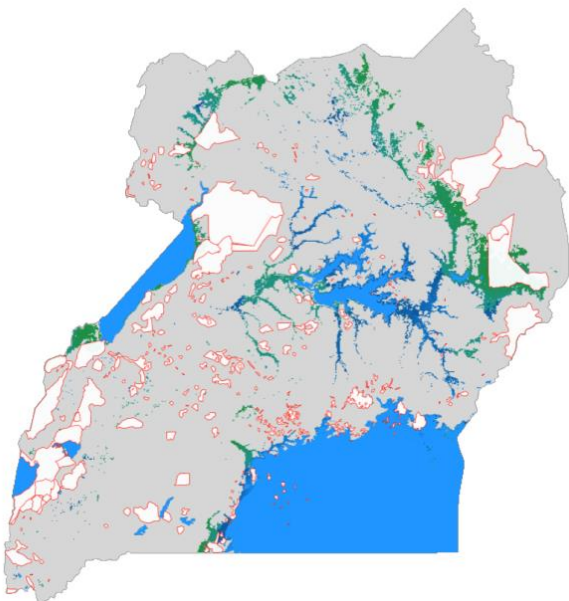


Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]





HEMP (Cannabis sativa)

Cultivation details

(<http://tropical.theferns.info/viewtropical.php?id=Cannabis+sativa>)

Cannabis is reported to tolerate an annual precipitation range of 300 - 4,000 mm, an average annual temperature range of 6 - 27°C and a pH in the range of 4.5 to 8.2.^[269] When grown for fibre, it requires a mild temperate climate with at least 670 mm annual rainfall, with abundant rain whilst the seeds are germinating and until young plants become established.^[269] Cannabis is very adaptable to soil and climatic conditions.^[269] It prefers a rich loamy soil with plenty of humus^[171] but it succeeds in ordinary garden soil^[1] and also in calcareous soils.^[171] Cannabis thrives on rich, fertile, neutral to slightly alkaline, well-drained silt or clay loams with moisture retentive subsoils, it does not grow well on acid, sandy soils.^[269] Of the many types of hemp, some are adapted to most vegetated terrains and climates.^[269]

Demands and Yield

	Sufficient	Optimal
Mean temperature	6 - 27°C	
Annual rainfall	300 - 4,000	670 - 2,000
Soil pH	4.5 - 8.2 mm	6.3 - 6.8 mm
Soil drainage		Well drained

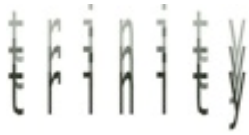


Sustainable Energy-Water Solutions for Medium to Large-Scale Irrigation of Commercial Farming in Uganda – Pre-Feasibility Study

	Sufficient	Optimal
Yield	N/A	N/A

References

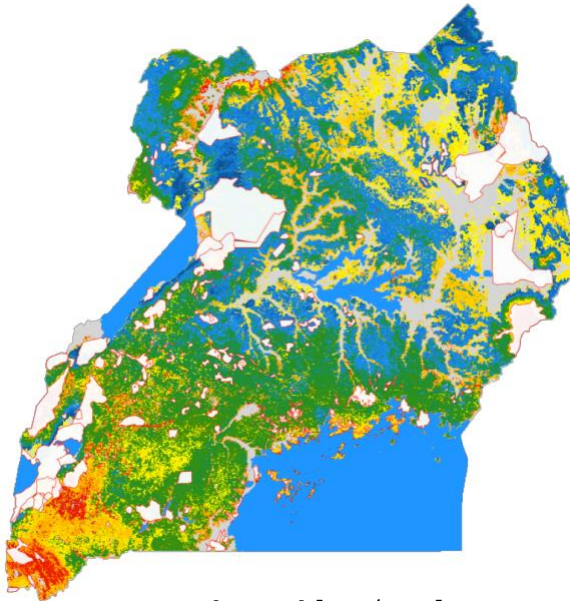
- 1 F. Chittendon. 1956. RHS Dictionary of Plants plus Supplement. Oxford University Press
- 171 Hill. A. F. 1952. Economic Botany. The Maple Press.
- 269 Duke. J. 1983. Handbook of Energy Crops.



Sustainable Energy-Water Solutions for
Medium
to Large-Scale Irrigation of Commercial
Farming in Uganda – Pre-Feasibility Study

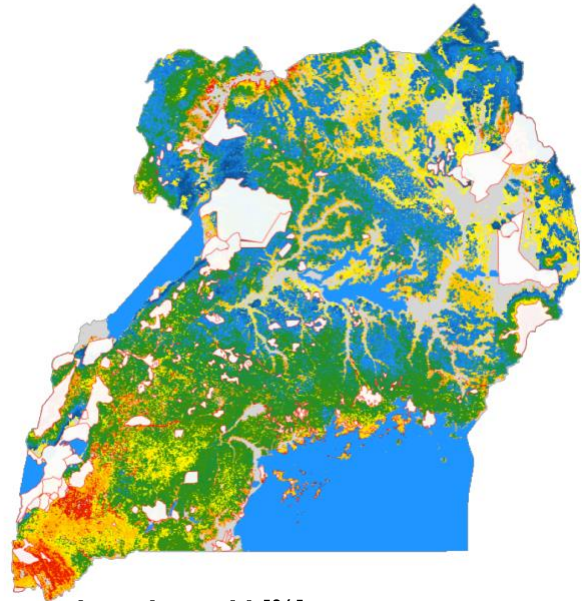
Suitability

Suitability without irrigation



Average irrigation demand [mm/year]

Suitability with irrigation



Expected surplus yield [%]

