An Agronomist`s thoughts on addressing Sweetpotato resilience under Changing Climate Conditions

Sweetpotato breeders' community of practice

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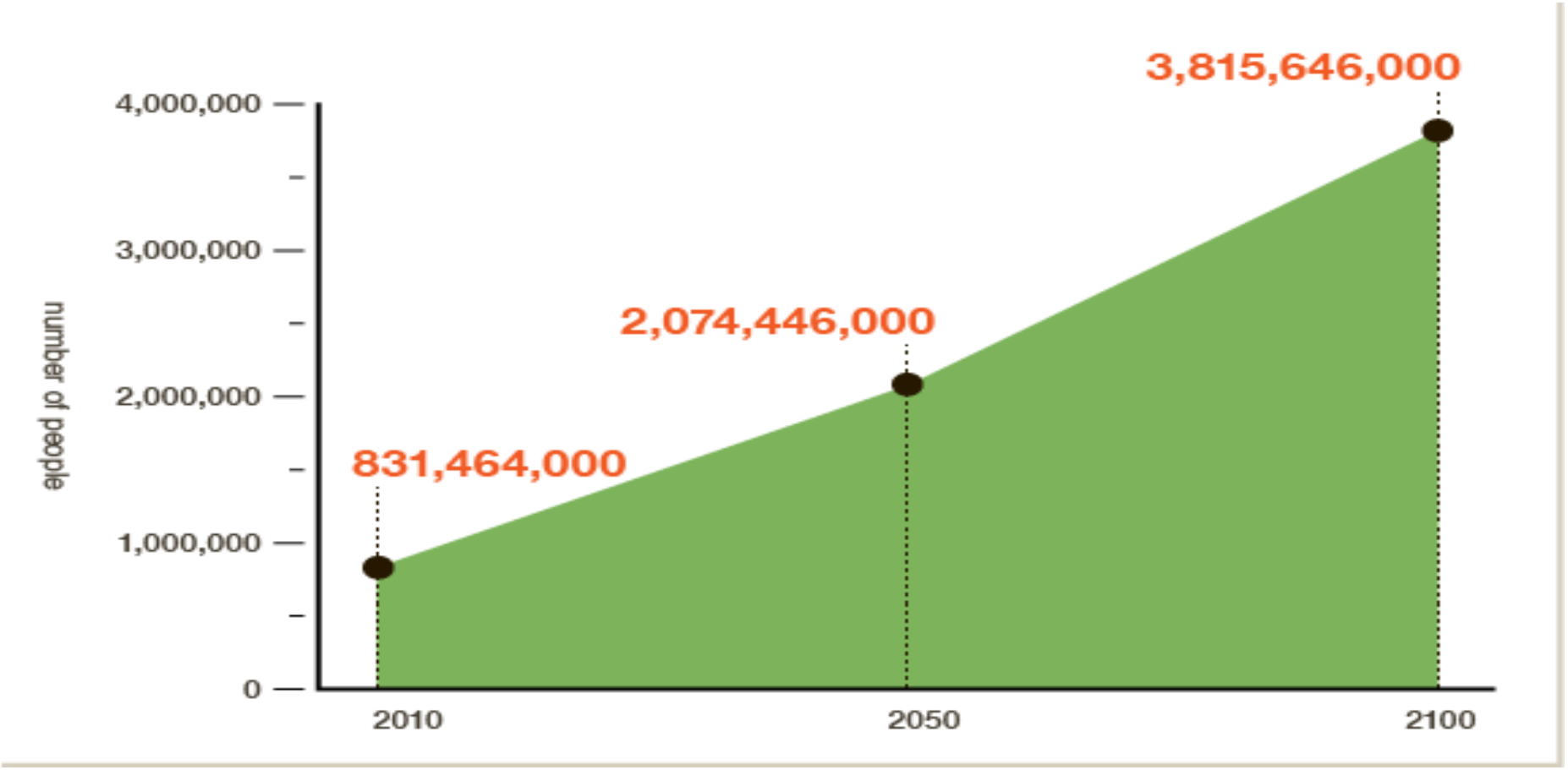
Agriculture across Africa must undergo a significant transformation to meet the multiple challenges of climate change, food insecurity, malnutrition, poverty and environmental degradation.

Objective

- To highlight overall impact of climate change on food security
- To brief the **observed suitable climate** for sweetpotato growth based on 1970-1999 data
- To review **projected climate changes** in sweetpotato growing areas and their effect on sweetpotato production
- To discuss adaptation options
- Facilitate discussion to design action points for climate resilient sweetpotato production

Big Facts

- SSA population is under continuous growth
- Population growth in SSA will double up to 2030 and triple by 2050

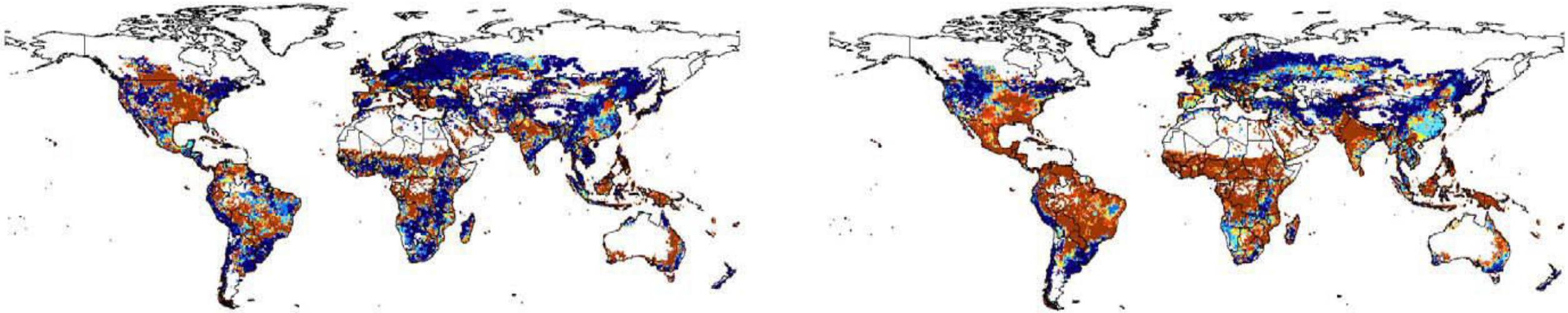


Source: [UN-DESA] United Nations Department of Economic and Social Affairs. 2013. World Population prospects, the 2012 revision, highlights and advance tables. Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat. New York. (Available from http://esa.un.org/unpd/wpp/Documentation/pdf/WPP2010_Highlights.pdf)

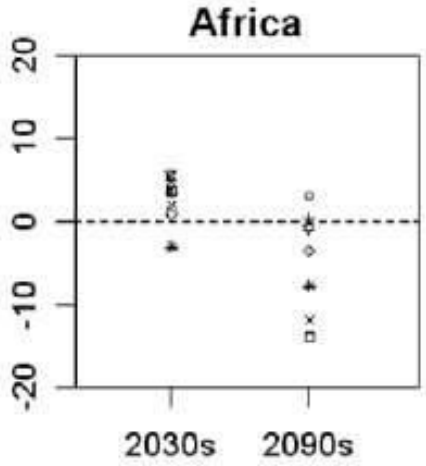
Climate change will affect crop production worldwide

a) Impacts of Climate Change on Crop Production (2030s)

b) Impacts of Climate Change on Crop Production (2090s)



Decrease with high confidence
Decrease with medium confidence
Decrease with low confidence
Increase/decrease mix
Increase with low confidence
Increase with medium confidence
Increase with high confidence
Country Boundary



Impact of climate change on crop production suitability in Africa

2030

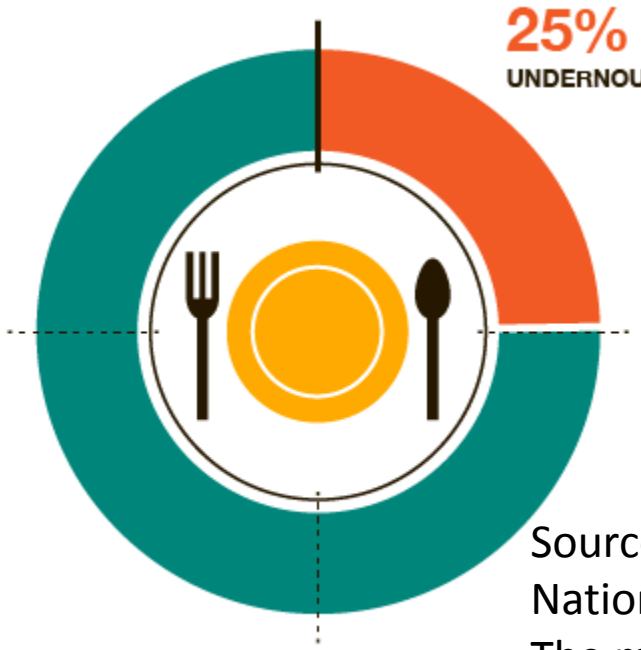
2050

Source: Liu J, Folberth C, Yang H, Ro¨ ckstro¨m J, Zehnder KAAJB (2013) A Global and Spatially Explicit Assessment of Climate Change Impacts on Crop Production and Consumptive Water Use. PLoS ONE 8(2): e57750. doi:10.1371/journal.pone.0057750

Food and Nutrition security in Sub-Saharan Africa (SSA) will continue to be a problem

- More than a quarter of the population in SSA is undernourished

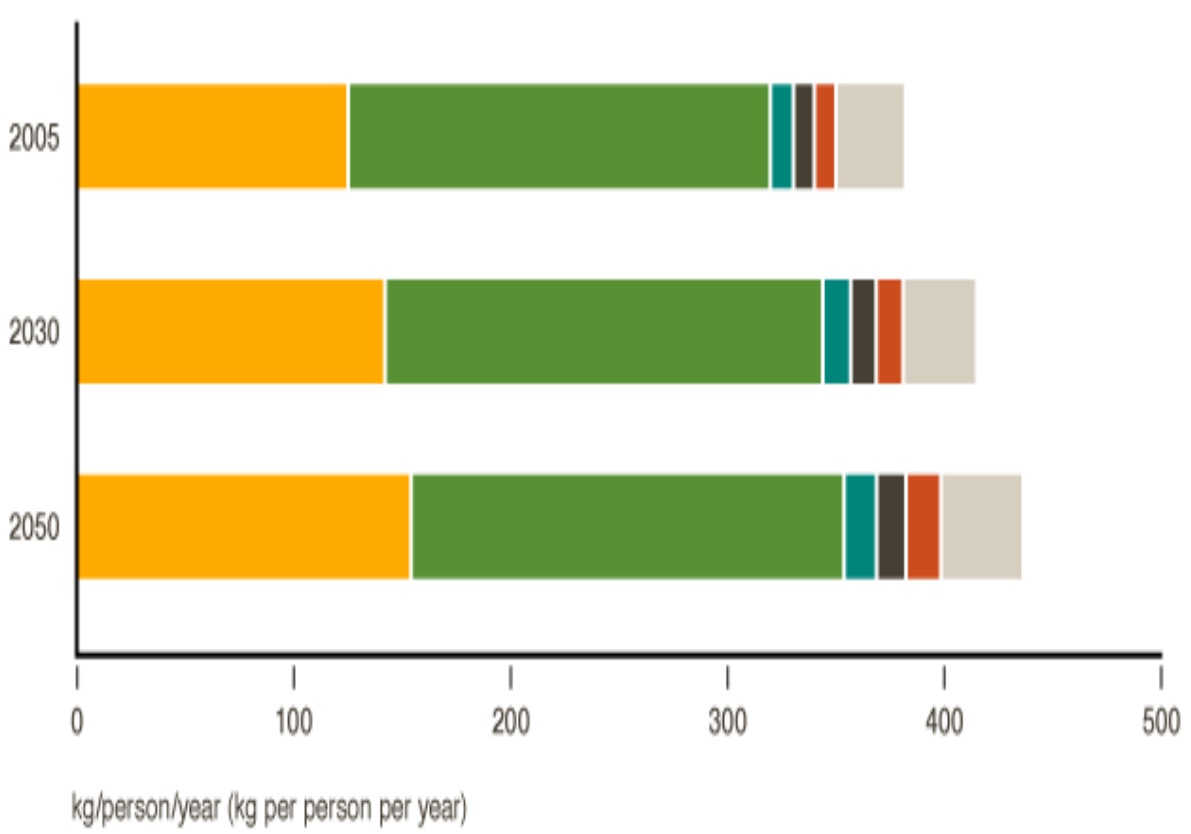
- This figure is expected to rise if countries do not implement climate change adaptation strategies



Source: [FAO] Food and Agriculture Organization of the United Nations. 2013. The state of food insecurity in the world 2013: The multiple dimensions of food security. Rome: FAO. (Available from http://www.fao.org/publications/sofi/en/)

SSA is depending more on Root, tuber and cereal crops

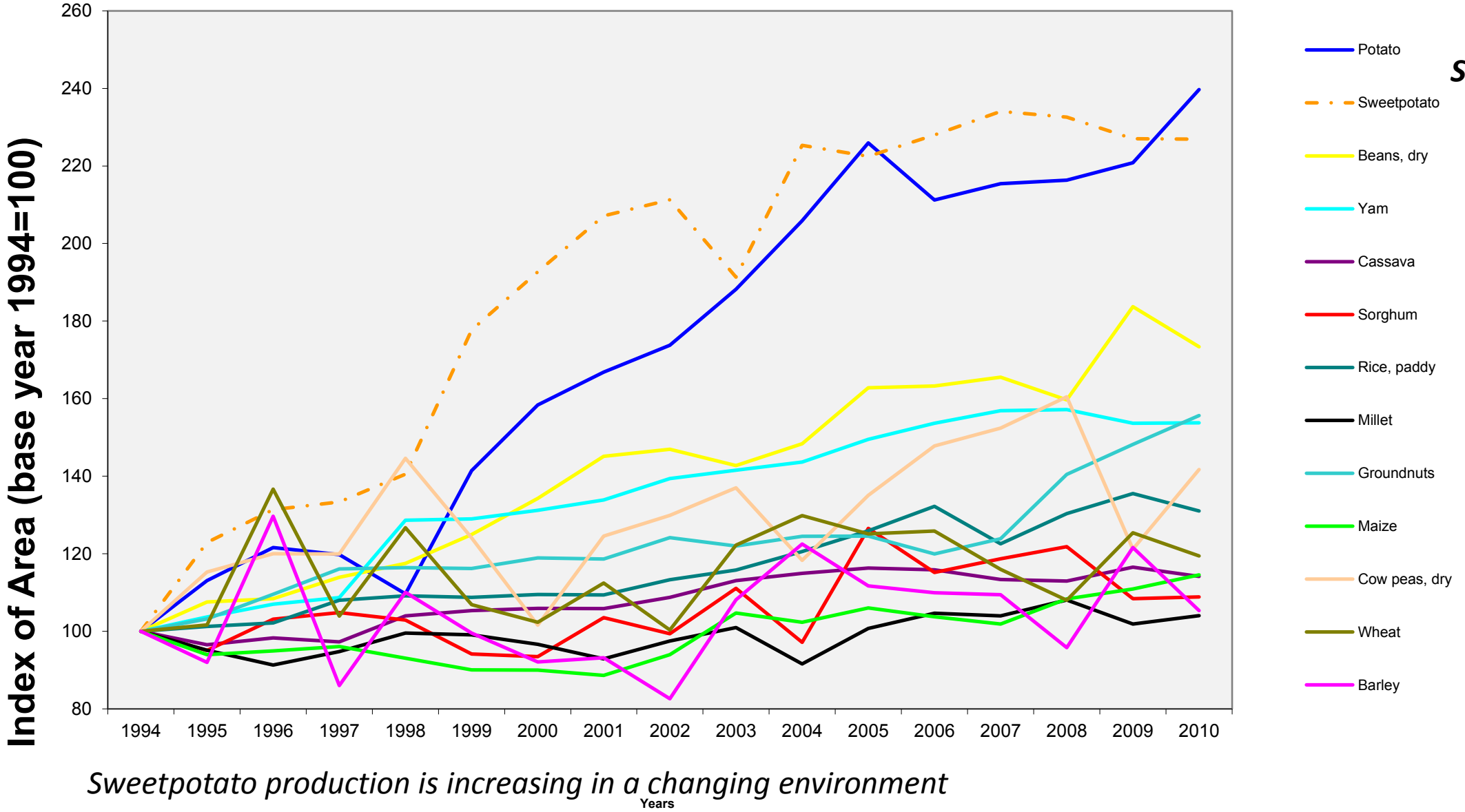
- SSA have low calories intake in the world
- Root and Tuber crops are the main source of food for SSA



Main source of food	Consumption per year (kg/person/year)		
	2005	2030	2050
Cereals	150	170	180
Root and tuber crops	200	210	210

Source: Alexandratos N, Bruinsma J. 2012. World agriculture towards 2030/2050: the 2012 revision. ESA Working Paper 12-03. Rome: Food and Agriculture Organization of the United Nations (FAO). (Available from ; http://www.fao.org/docrep/016/ap106e/ap106e.pdf)

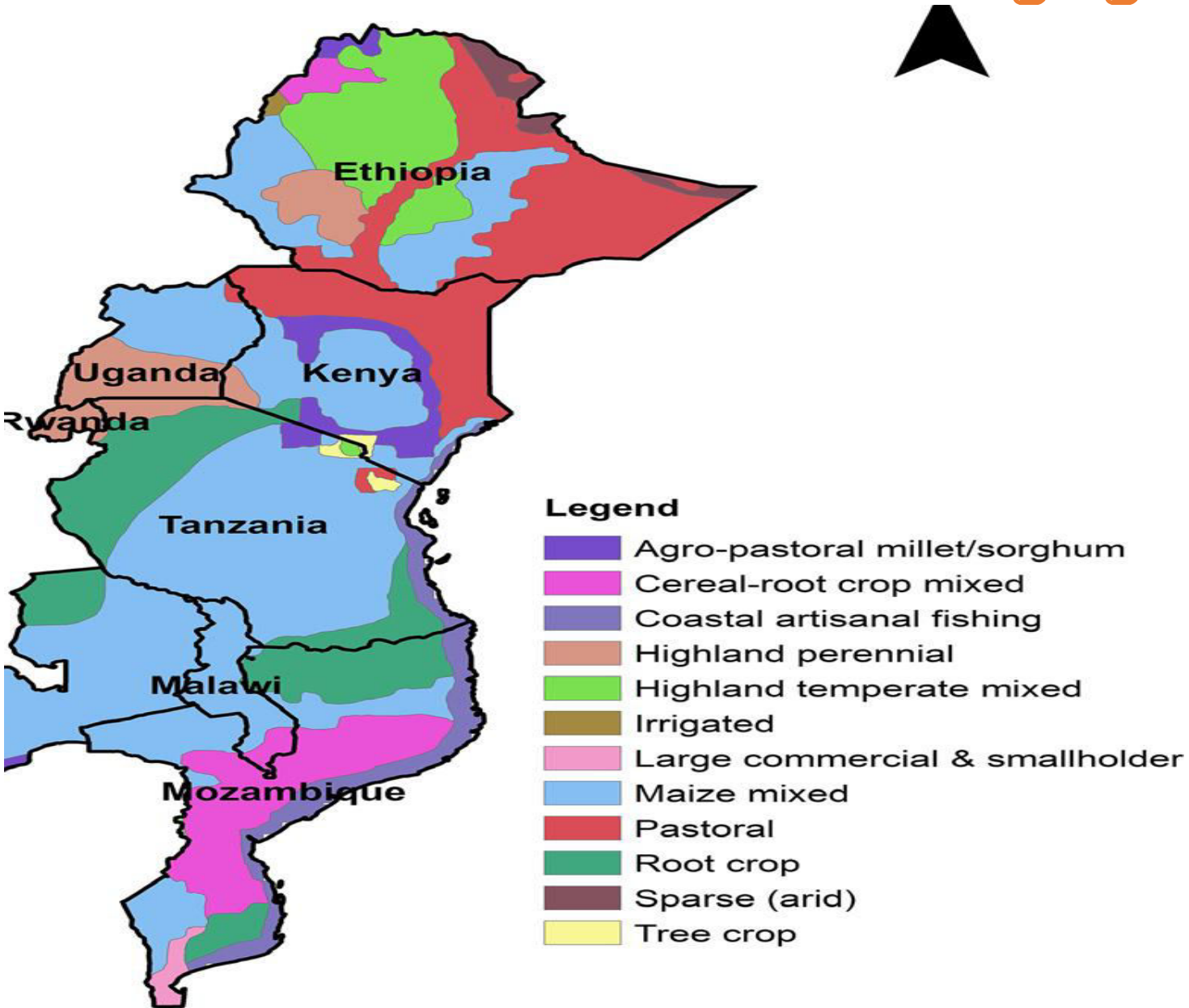
Area under sweetpotato production is increasing while most cereal crops are declining



Source: FAOSTAT and Malawi Ministry of Agriculture

Sweetpotato production is increasing in a changing environment

What is the prospect of sweetpotato in east African countries under changing climate?



What is the future temperature and precipitation in major sweetpotato growing areas?

Where can sweetpotato grow?

- loamy soil type (sand, clay) which is well aeriated and have reasonable soil fertility.
- less acidic soil with a pH of 4.5-7.5. but for best result it is recommended to grow on soil that have 5.8-6.2.

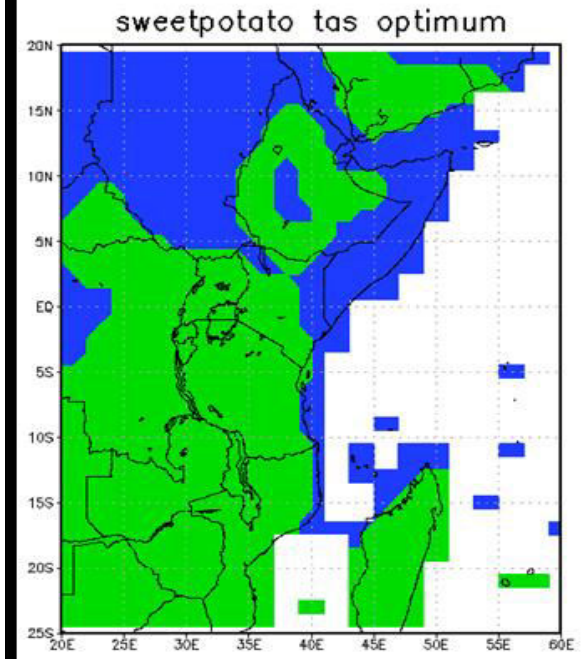
Temperature and precipitation requirement

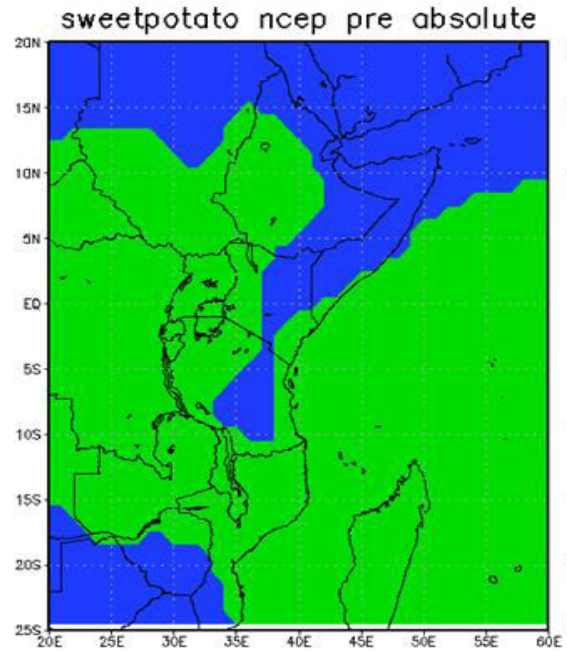
Optimal average T^0	Max T^0	Min $T^{0/day}$	Optimal average precipitation	Minimum average participation	Capacity to deal with waterlogging	Capacity to deal with drought	Growing period	Altitude	Photo sensitivity
20-25	35	15	750-1000	750	No	Yes after the first 60 days	90-201	<2400m	< 13 hr

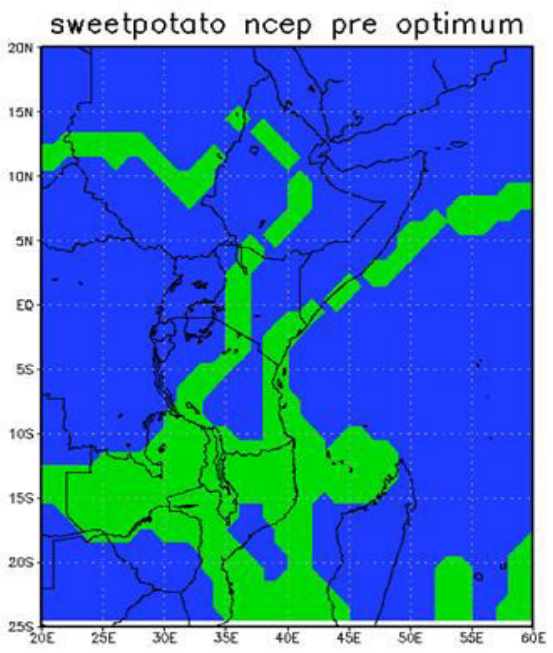
Where does these threshold sweetpotato growing areas are located in east Africa?

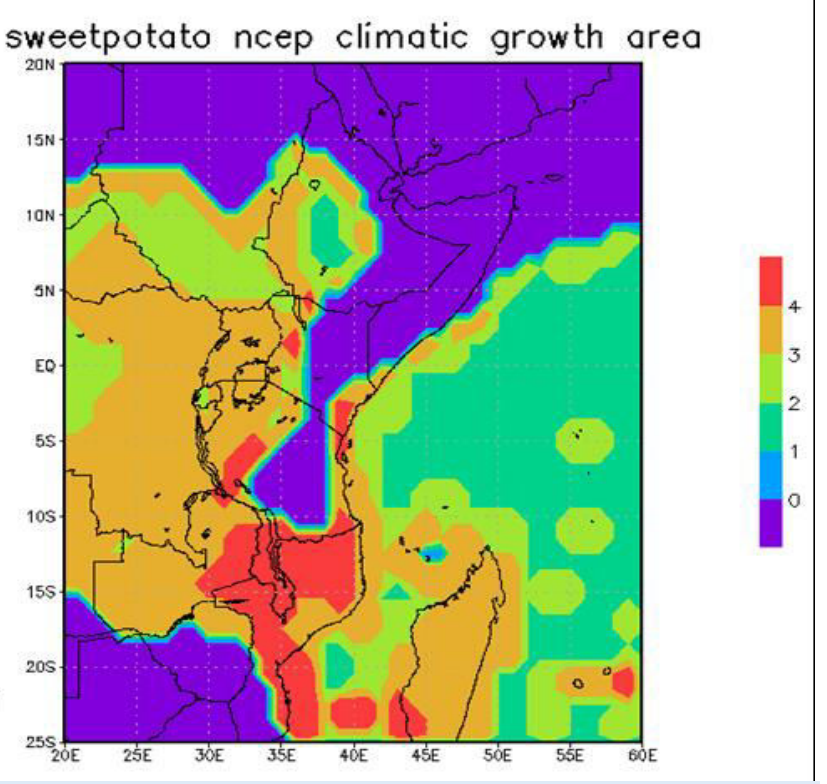
SOURCE: Richard Washington & Helen Pearce (2012): climate change in east African agriculture: recent trends, current projection, crop climate suitability, and prospect for improved climate model information

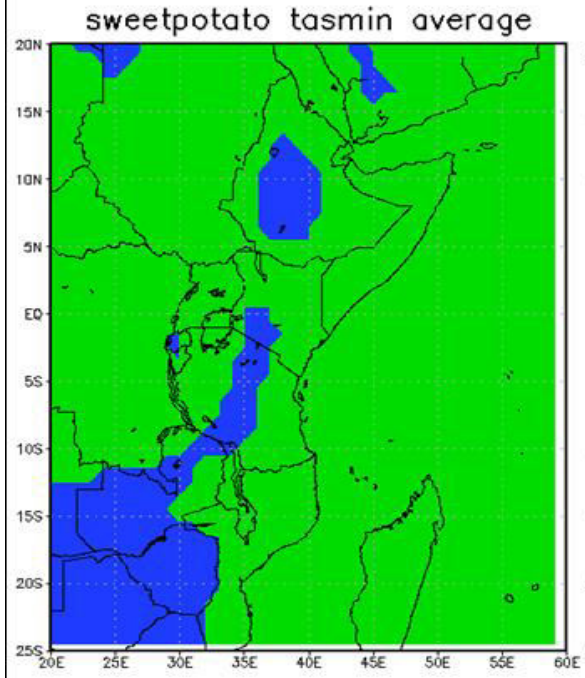
- Washington and Pearce (2012), plotted the optimum areas for sweetpotato growth by using optimum, minimum, maximum and absolute range of T^0 and precipitation data from 1970 to 1999 (Figure).
- The existing maximum temperature in Eastern Africa is suitable for SP
- However, the minimum and optimum temperature is a limiting factor in Sudan, Central and Eastern Ethiopia, Central Tanzania
- Precipitation is a primary limiting factor in the cultivation of sweet potato over the eastern part of the east Africa
- Therefore, Eastern part of Ethiopia, Kenya and Tanzania are currently less suitable for sweetpotato production

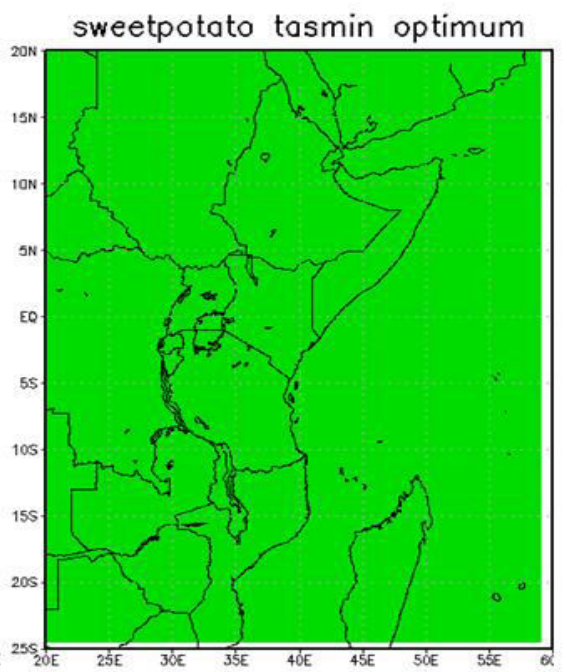


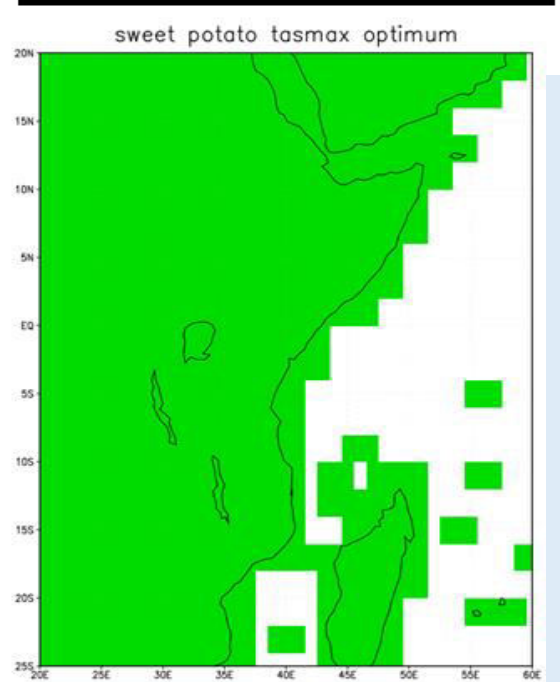






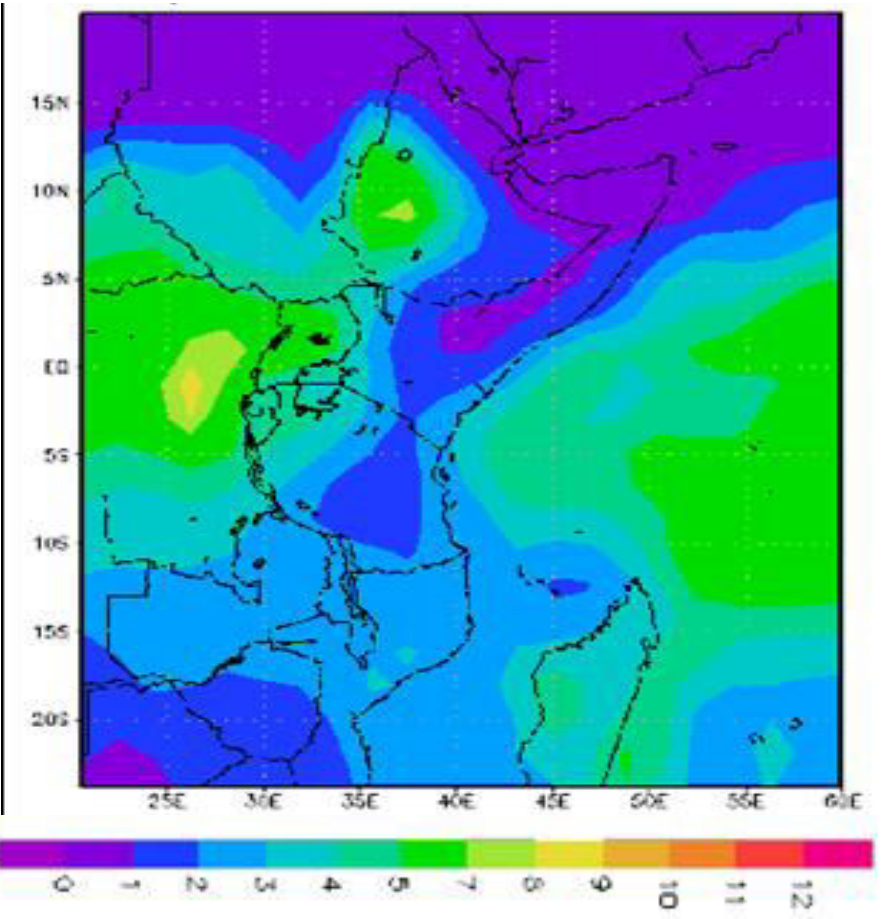




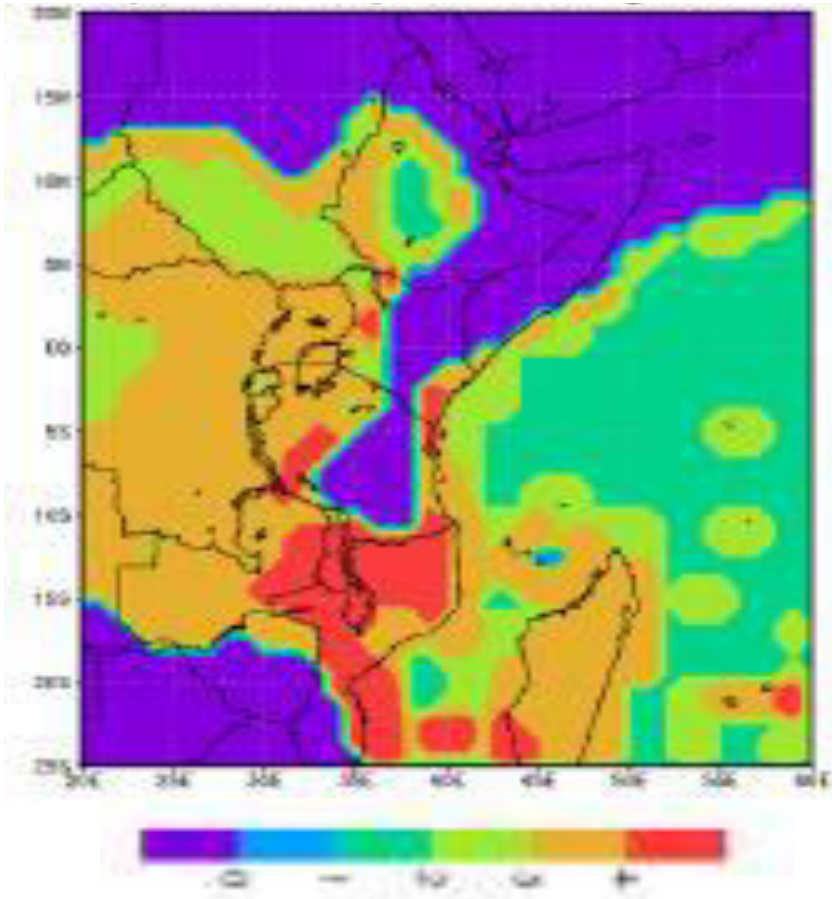


Thresholds of production across the region, as realized from mean climatic conditions, for sweet potato. Maps are provided using both the (a) NCEP using the CRU temperature dataset

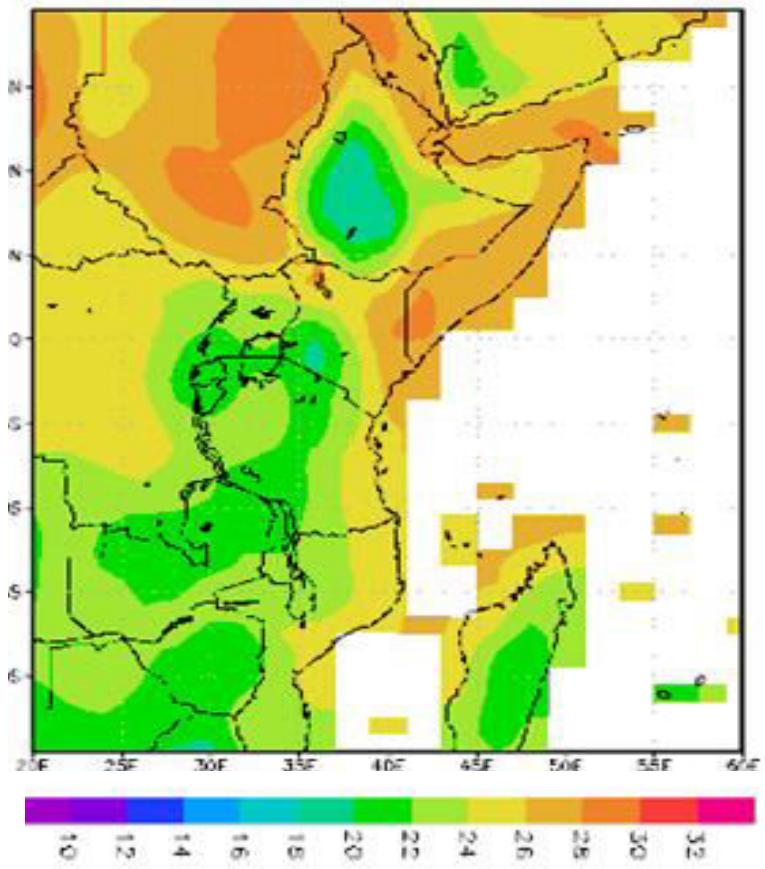
PRICIPTATION 1970-1999



SUITABLE AREA FOR SP GROWTH 1970-1999



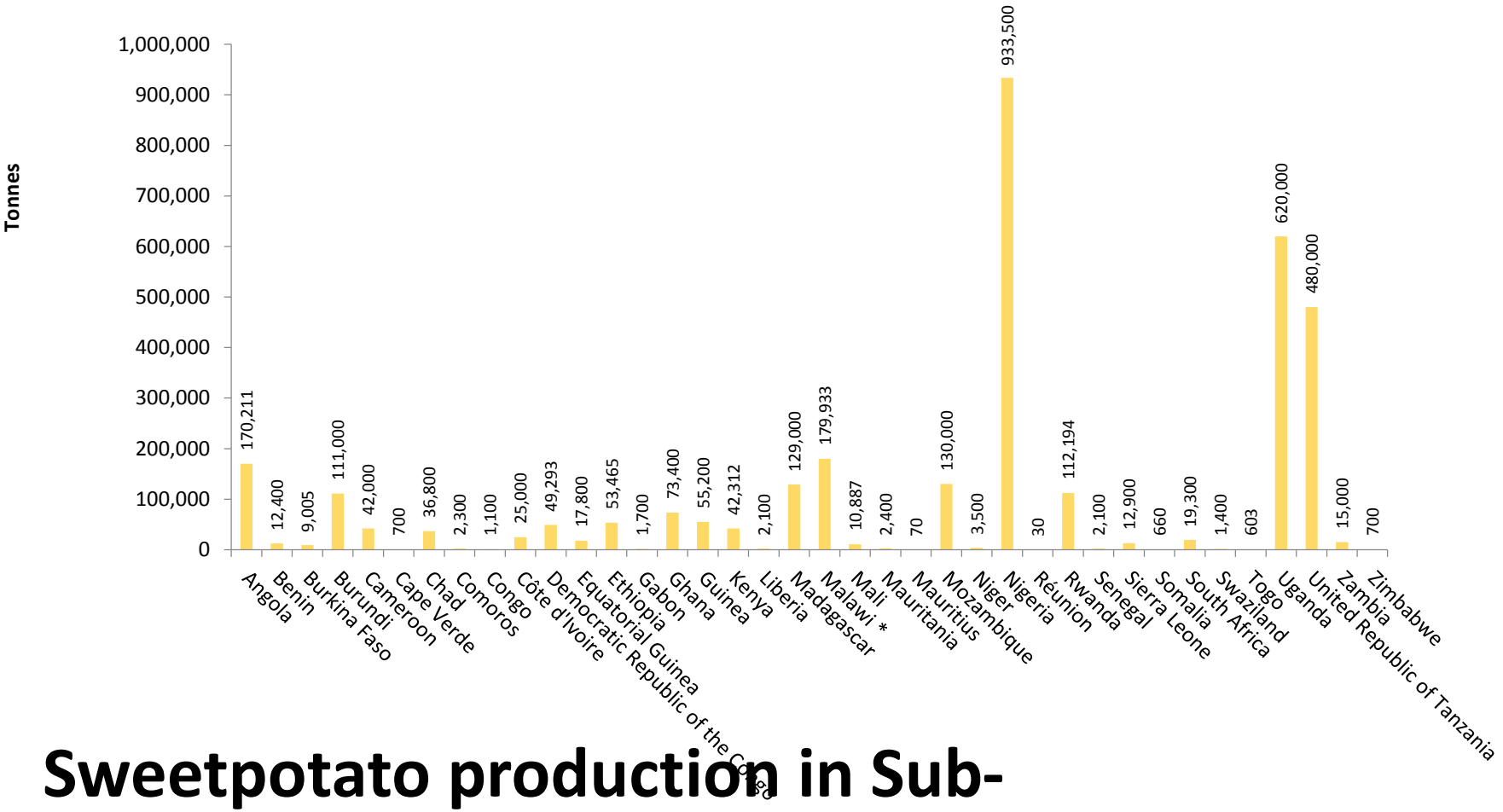
TEMPRATURE 1970-1999



Suitability	countries	Rainfall (mm/day)	T^0
Optimum	Mozambique, Zambia,Malawi, Tanzania, kenya	3-4	24-26
Suitable	Ethiopia, sudan, kenya, ugandarwanda, Malawi, zambia	3-4	20-26

Potential Vs Actual production areas

Small proportion of the potential areas are growing sweetpotato currently



Sweetpotato production in Sub-Saharan Africa

What does the future climate holds for sweetpotato?

- There are wider predictions about the negative effect of climate change on productivity of major crops in SSA
- For example: Maize yield decline by 10% and areas suitable for maize growth shrinks by 3% in 2050.
- The negative impact of climate change is due to the high temperature, low precipitation and short growth period in SSA.

Future temperature and precipitation at major sweetpotato growing areas in east Africa

(Washington and Pearce, 2012)

Temperature

Suitability	Current	2030			2050			2090		
		B1	A1B2	A2	B1	A1B2	A2	B1	A1B2	A2
Optimum	24-26	1-1.5	1-1.5	1-1.5	1.5-2	1.5-2	1.5-2	2.5-3	2.5-3.5	3-4
Suitable	22-26	0.5-1	1-1.5	1.5-2	1.5-2	1.5-2	2-2.5	2.5-3	3-3.5	3-4

Precipitation

Suitability	Current	2030			2050			2090		
		B1	A1B2	A2	**B1**	A1B2	A2	B1	A1B2	A2
Optimum		-0.5	0	0	**-0.5**	+0.5	+0.5	+0.5	+0.5	+0.5
Suitable		3-4	1-1.5	1-1.5	**-0.5**	+0.5	+0.5	+0.5	+0.5	+0.5

Precipitation shows consistent spatial pattern of change over east African countries in 21st century. However, uneven distribution accompanied by short growth period is expected

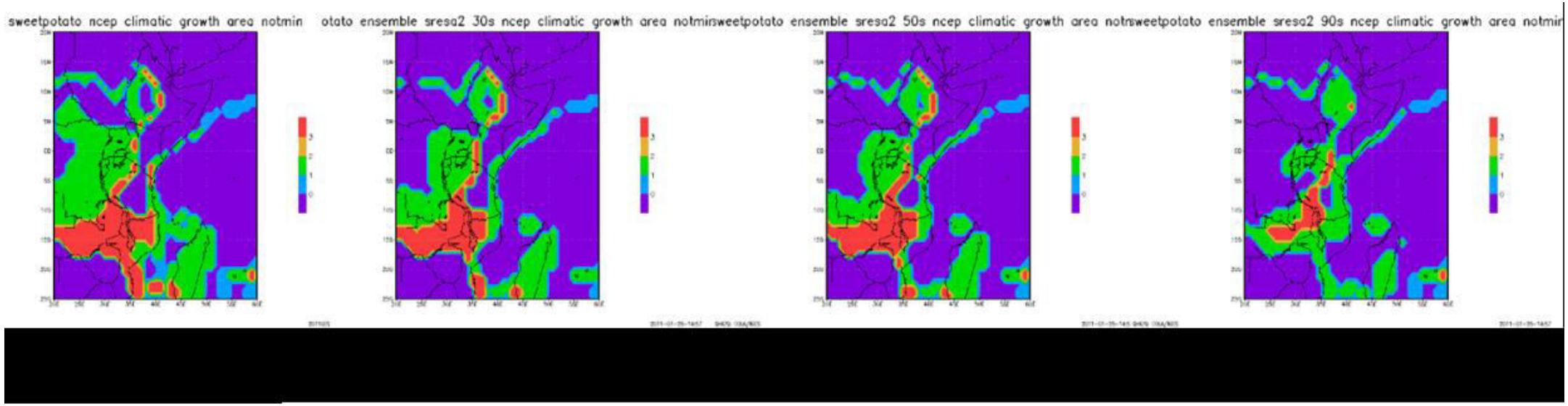
Prediction of suitable climate areas for sweetpotato growth (Washington and Pearce, 2012)

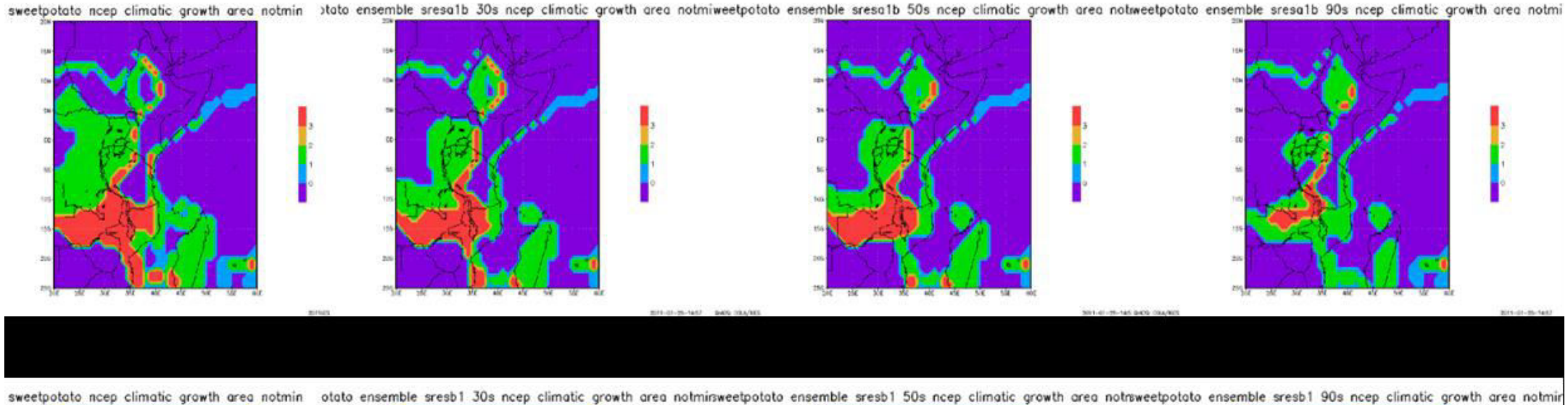
- The overall extent of the sweet potato crop growth area remains the same over the 21st century
- However the previously optimal areas of cultivation are uniformly decreased in size with less suitable mean conditions indicating the potential for decreased yields.
- Optimum growth areas will slightly shift to average by 2050 and to less than average suitability by the end of the century
- Areas which are not suitable for sweetpotato production currently will have average suitability after 2050 but not optimal.
- For example central south Ethiopia highlands will have mean suitable condition for sweetpotato production
- Generally, the current optimum suitable area for sweetpotato production will shrink in size.

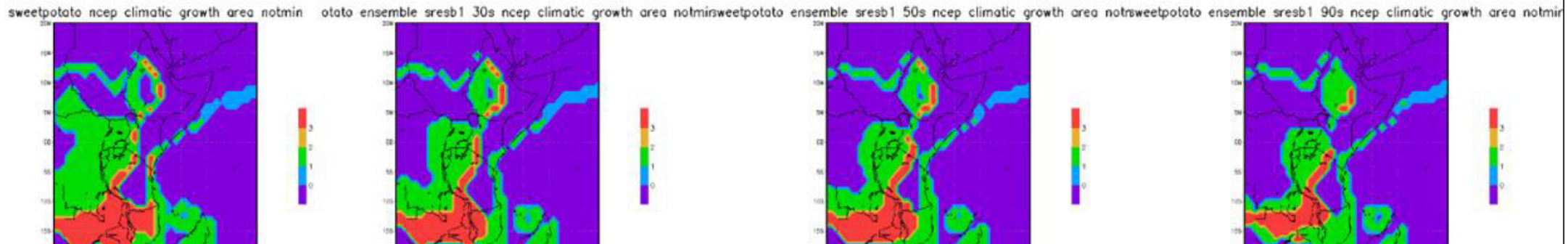
What is the implication for sweetpotato breeders?

- As discussed earlier the **temperature** is the main factor limiting suitability of sweetpotato in east Africa than precipitation

Projected sweetpotato climatic growth area for 2030, 2050 and 2090 under the low (B1), Medium (A1B2) and high (A2) emission scenarios







Source: Richard & Helen, 2012

Possible effect of the predicted high temperature

- Temperature affects storage root formation, storage root bulking and vine growth of sweetpotato.
- According to *gajanayake et al., 2013* night temperature greater than 17^0c significantly reduced the storage root yield and T^0 greater than 40/32 reduced the yield of sweetpotato by 94% than the 24^0C.
- These processes are mediated by the interaction of phytohormones such as auxins, cytokinins, jasmonic acids, abscisic acid and coordinated expression of several genes which are influenced by environmental and edaphic factors (Ravi et al., 2009)

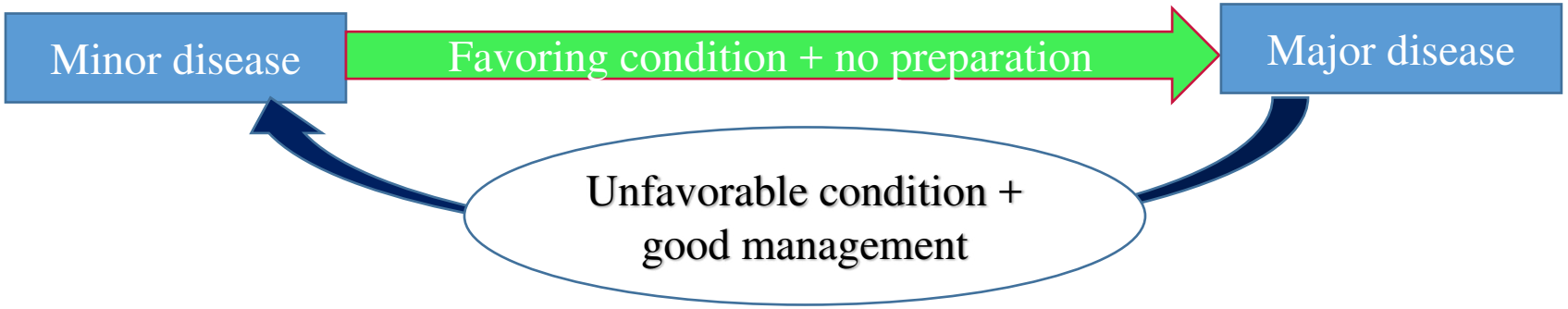
- Wang et al., 2015 found many stage specific genes that regulates sweetpotato root development.

- However, there is limited information how temperature affects the expression of these genes
- Prediction of T^0c ranges from 26/24 to 34 ^{0}C in major Sweetpotato growing areas of SSA.

- The possibility of high temperature is evident in the changing environment that its effect on storage root development and overall yield should be investigated.

Temperature effect on major SP diseases

- Suitability prediction?



- No clear information about the SPVD ecological niches. Niche identification will help the development of prediction models.
  - Effect on the biology of the virus?
  - Suitability for virus transmitting vectors (Aphid and white fly)
  - Effect on alternate host of the virus?

- For example: Maize Lethal Necrosis (MLN) is predicted to expand to southern Africa and expansion/contraction of areas is predicted in the existing hotspots (ASARECA POLICY NEWSLETTER, 8 April 2016, Volume 19 Number 6)

Does climate affect the major SP insect pest?

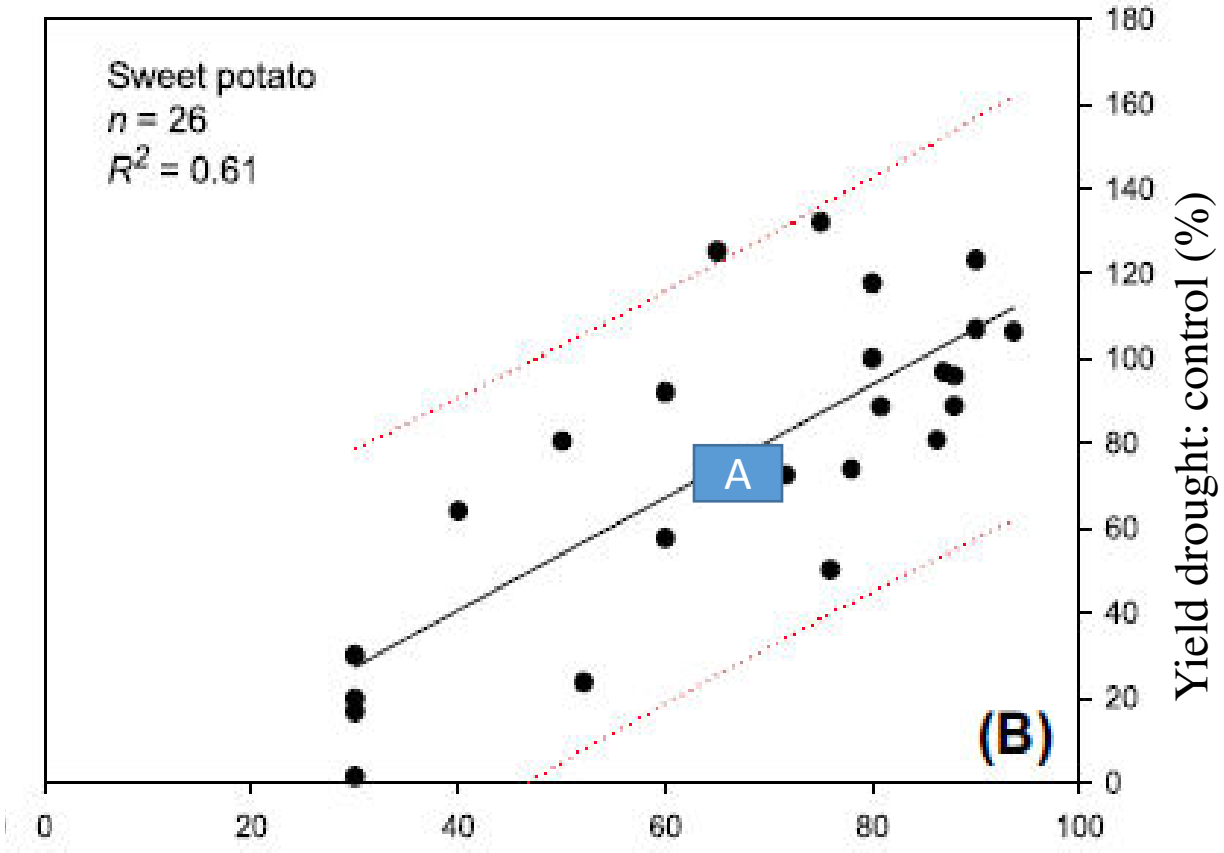
- Information on future climate suitability for major sweetpotato insect pest is scarce.
- Sweetpotato weevil is the most important insect.
- In some countries sweetpotato butterfly is emerging as important insect of SP
- The predicted high temperature and soil cracking will favor SP weevil and Butterfly reproduction.
  - **Sweetpotato whitefly** (Workshop Report on the Adaptation to Pest Risks under Future Climates in Africa, 28- 30 May 2014, Kampala, Uganda)
  - Prefer tropical and subtropical habitats.
    - Suitable T^0 ranges from 20-25^{0}C
    - Decrease in tropical and increase in sub-tropical and temperate regions.
    - The predicted T^0 increase in the SP growing areas has negative effect for whitefly.

      However, projected new areas will still face the risk.

water stress: the current and future challenge

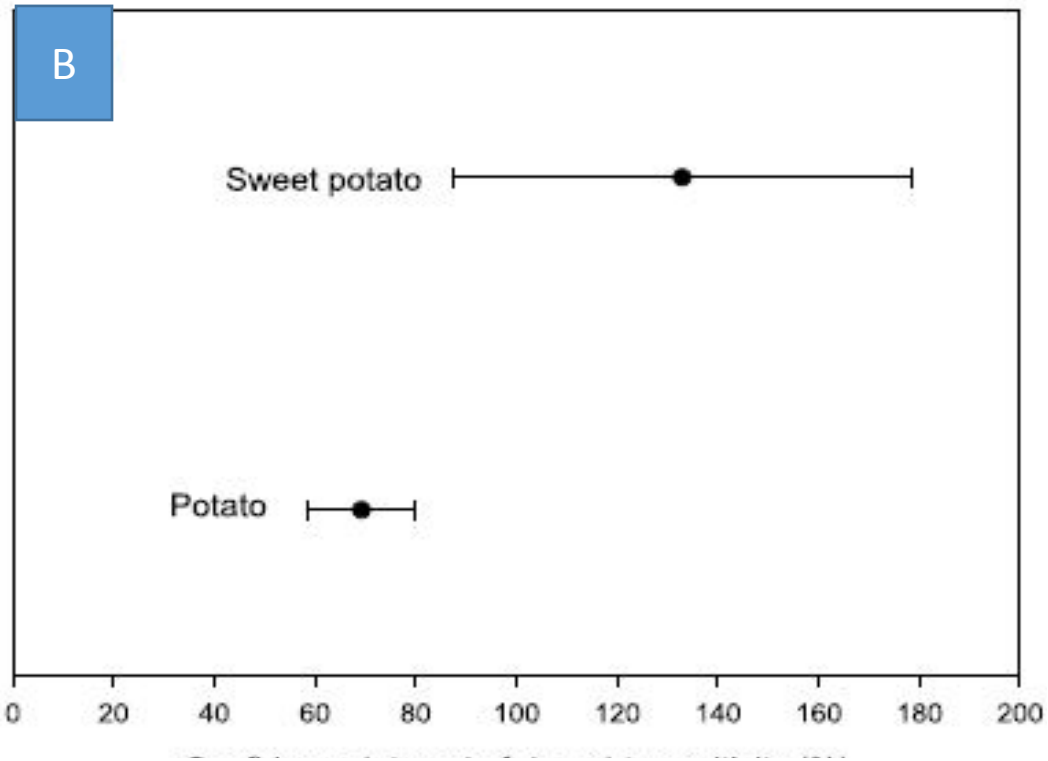
- Shortage of water is existing and future problem
- Drought → yield reduction and loss of planting material
- Although, precipitation in eastern African region is predicted to be consistently higher in the future, it will also be erratic with short growth season.
- Therefore, future adaptation strategy should focus dealing with factors related to erratic rain fall and shortage of growth season
- **Erratic rain fall**: un even distribution through the growth season, flooding, dis-countunity in the middle of the growth season etc

Drought sensitivity of sweetpotato



Water stress drought: control (%)

Does Sp tolerate drought stress as we think?



Confidence interval of drought sensitivity

Source: Daryanto *et al. (2016); Drought effect on yield of root and tuber crops: A meta-analysis*

Drought cont`d

- Many sweetpotato varieties are currently registered as drought tolerant?
  - What is the standard used?
  - Is there common standards used across countries to quantify drought tolerance?
  - What do we mean by a variety is drought tolerant (what is the minimum threshold water level).

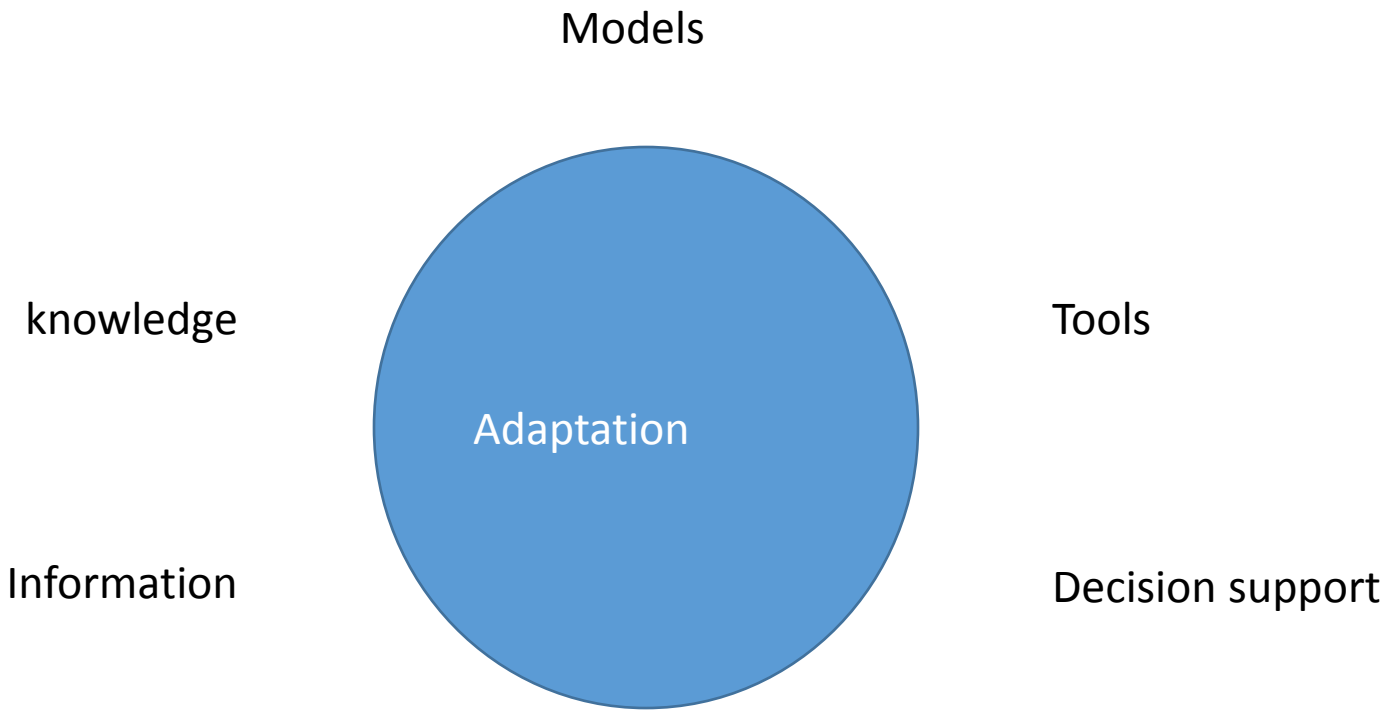
Looking at agronomic practices to reduce water stress

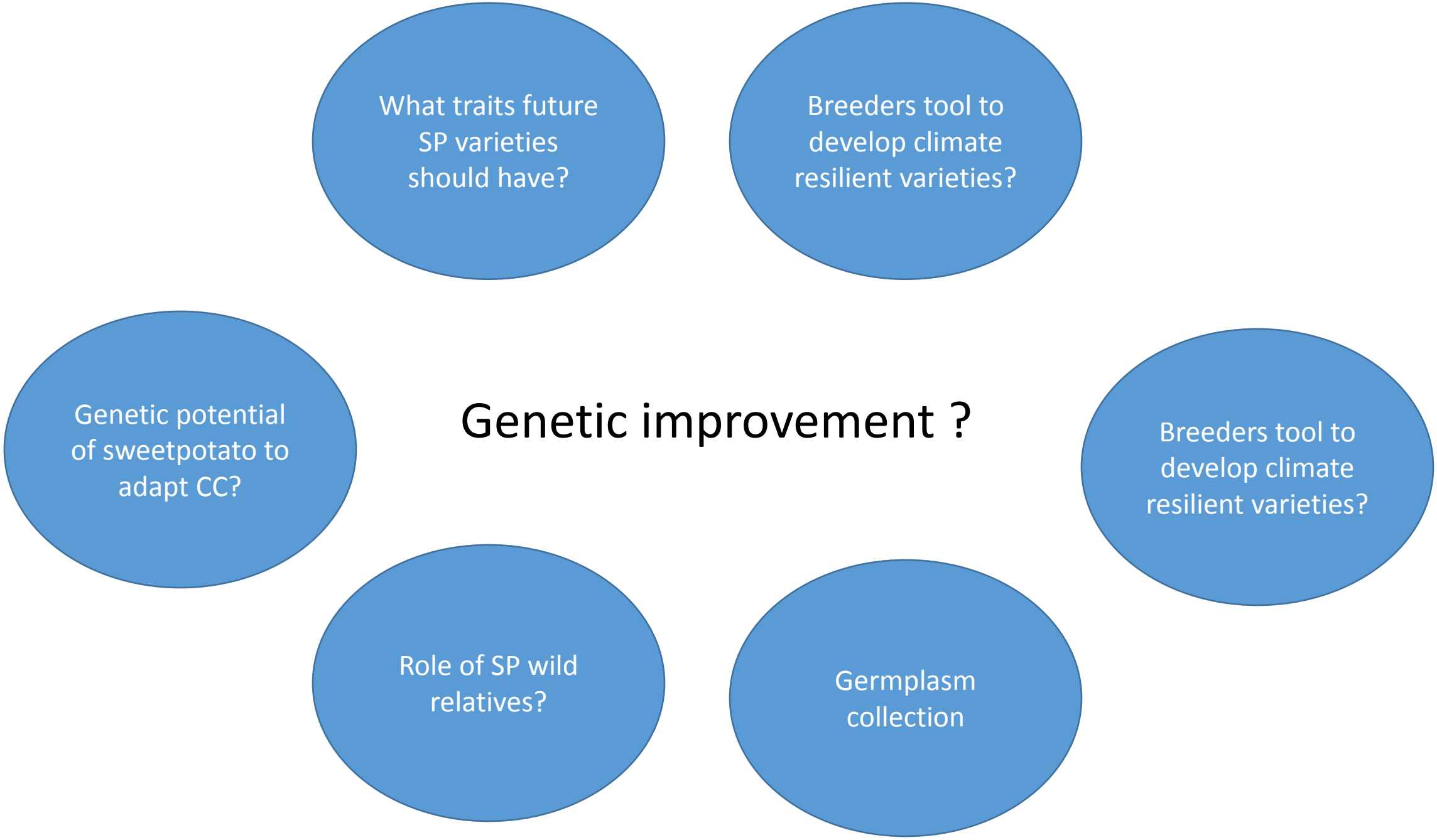
Other climate change related challenges

- Shortage of arable land will cause
  - decline in soil fertility due to over cultivation
  - Competition for irrigation water
  - Need for high value market oriented crops
- Low capacities of Sp farmer to adapt to CC
- Low investment on technology development and extension service
- Exchange, dissemination and adoption for sweetpotato
- Poor awareness by policy makers

What climate change adaptation for resilient sweetpotato production will work best?

- Where are we?




What traits future SP varieties should have?
Breeders tool to develop climate resilient varieties?
Genetic potential of sweetpotato to adapt CC?
Genetic improvement ?
Breeders tool to develop climate resilient varieties?
Role of SP wild relatives?
Germplasm collection

Technology development and dissemination

- What technology is required to fit sweetpotato in a changing environment ?

Agronomic?

Water scarcity management: Improving water use efficiency through more efficient technologies?

Small scale irrigation technologies

Population growth followed by shortage of arable land and intensive cultivation leads to decline of fertility. Increasing, use of marginal lands which are less fertile

Seed system technologies

Quick multiplication in TC

Net tunnel?

Planting material conservation? Triple S?

What if virus increases at farm level?

Small net tunnel

Conclusion

- Information regarding impact of climate change on sweetpotato is scares. Therefore, it is timely to understand the impact and develop knowledge, models and tools to support sweetpotato adaptation in changing environment

- Compared to many other food crops, sweetpotato is less affected by climate change. Yet, other none climatic factors, such as consumer preference, policy issues should be clearly identified and addressed in time.

- If correct and timely adaptation strategies are designed, sweetpotato `s contribution to food and nutrition security in a changing climate is significant

Thank you!