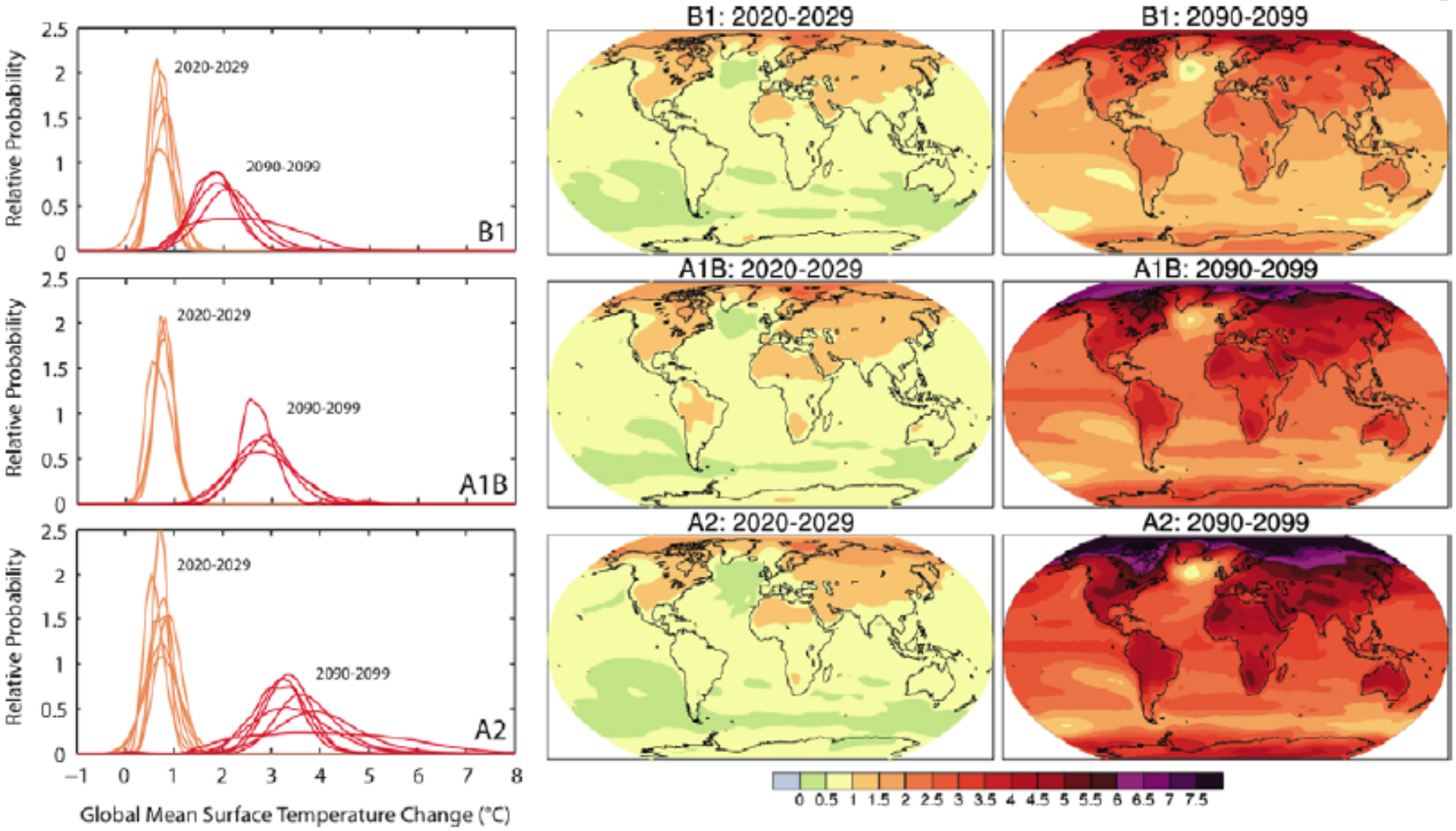
CLIMATE CHANGE AND SUSTAINABLE BIO-FUEL PRODUCTION IN AFRICA

Prof. N.H. Ravindranath
Center for Sustainable Technologies
Indian Institute of Science, Bangalore
Karnataka, India

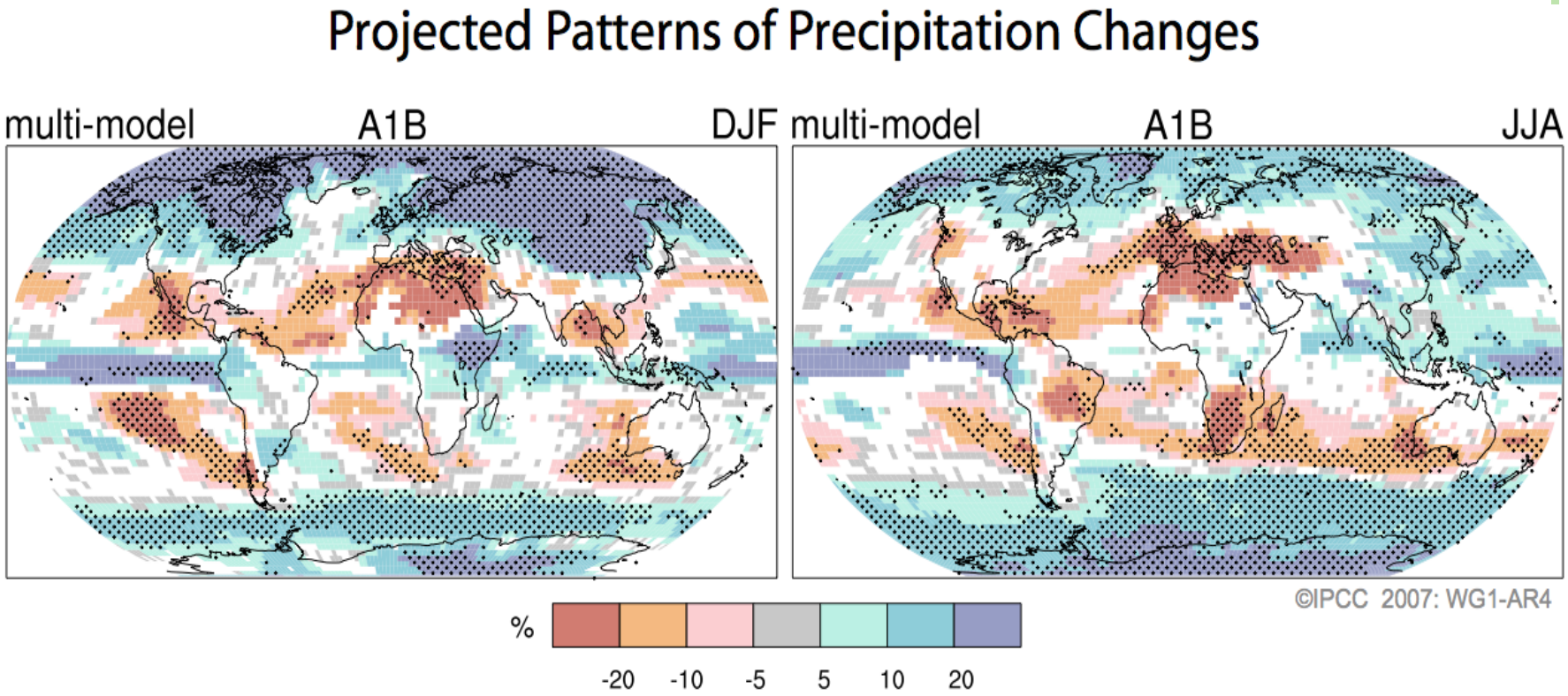
OUTLINE/ISSUES ADDRESSED

- **Projections of climate change over Africa**
- **Projected impacts of climate change**
- **Biofuel/Bioenergy options for Africa & Features**
- **Biofuel production and projections for Africa**
- **Projected impacts of climate change on biofuel production**
- **Is climate change / adaptation a serious issue in biofuel decisions?**
- **Conclusions**

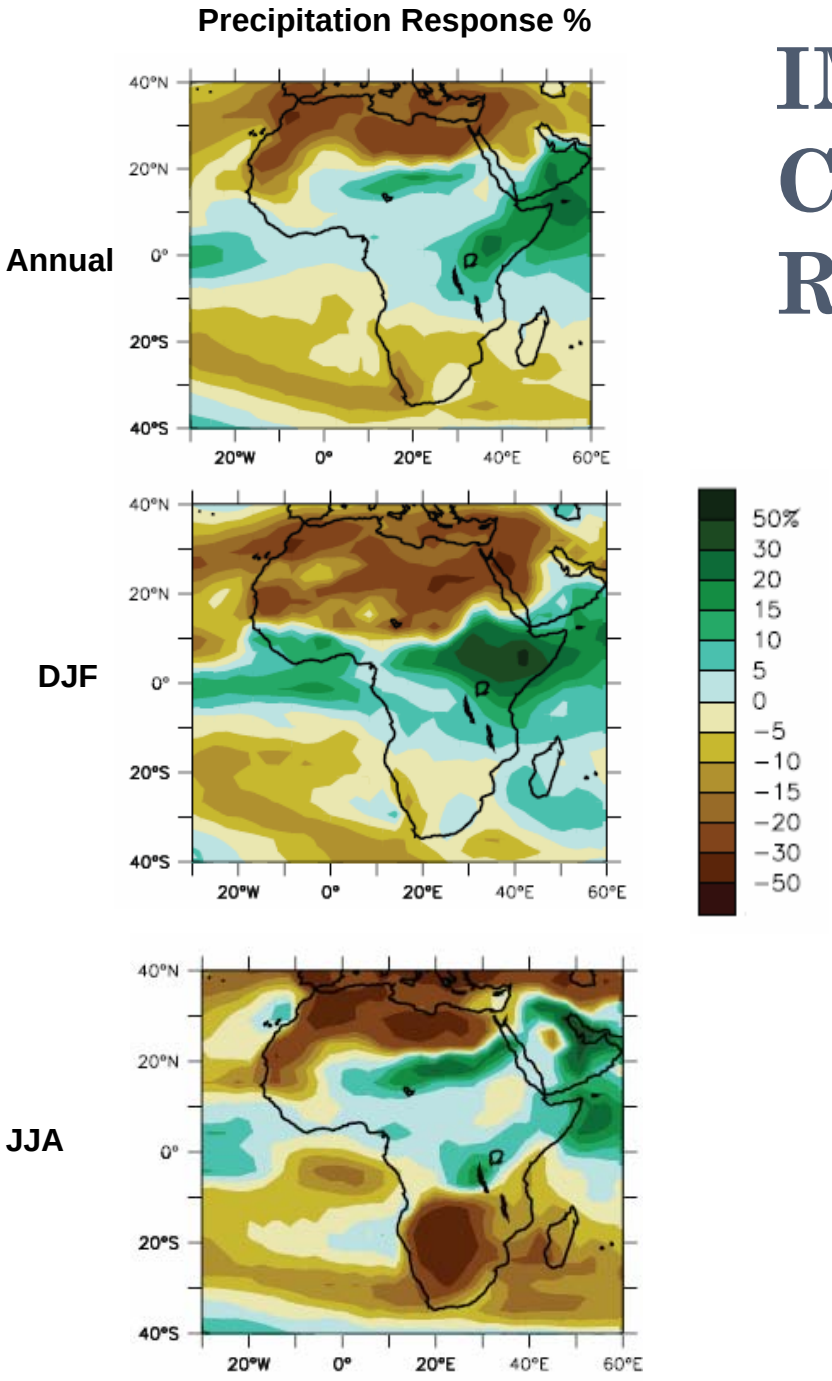
Projections of Future Climate



Projections of Future Changes in Climate



IMPACT OF CLIMATE CHANGE ON RAINFALL.



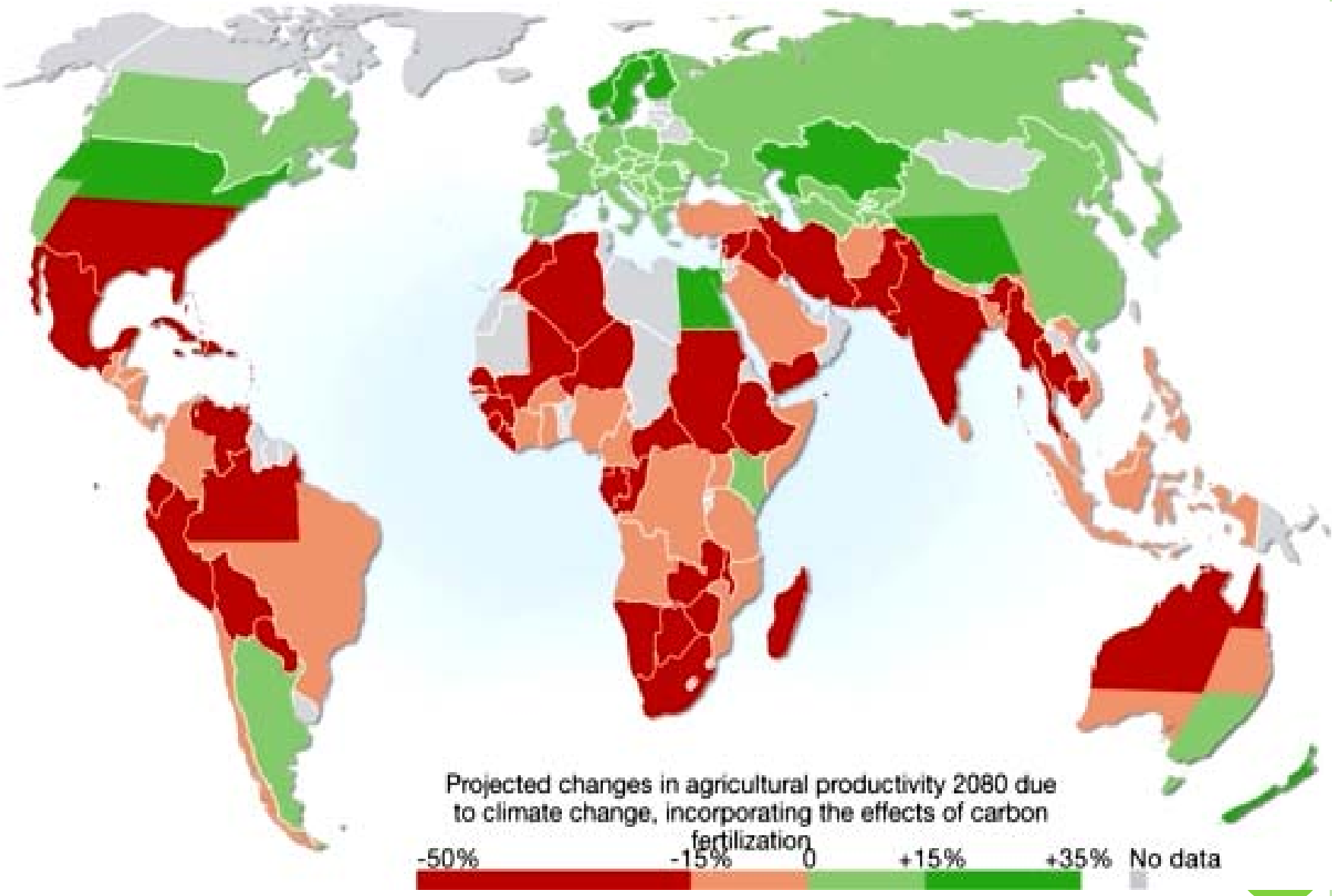
- Rainfall is likely to decrease in much of Mediterranean Africa and northern Sahara
- In Southern Africa rainfall is likely to decrease in much of the winter rainfall region and on western margins.
- There is likely to be an increase in annual mean rainfall in East Africa

MAIN PROJECTED IMPACTS OF CLIMATE CHANGE IN AFRICA

- **Climate change will impact all natural ecosystems/resources and socio-economic systems:**
  - ***Forests, wetlands, biodiversity, rivers, grasslands***
  - ***Agriculture, fisheries, coastal settlements***
- **Natural resources (forests, grassland, wildlife, water bodies) are currently subjected to stresses and getting degraded**
- **Ecosystems and Rural communities**
  - ***Vulnerable to even current stresses***
  - ***Characterized by Low adaptive capacity***
- **Climate change will exacerbate the vulnerability of Natural ecosystems, fresh water supply, food production etc.**
- **Small farmers, subsistence farmers, pastoralists, forest dwellers and fisher folk; face risk of climate impacts**

CLIMATE CHANGE IMPACT ON AFRICA

Systems	Impacts
Land degradation	➢ **Arid & semi-arid areas are likely to increase in Mediterranean, Northern Sahara & Southern Africa** **- By 5 to 8 % or 60 to 90 Mha** ➢**Arid and semi-arid areas, likely to increase in East Africa**
Crop yield	➢**By 2020; yield of rain-fed agriculture could reduce up to 50%**
Water	➢**Increase in runoff and flooding** ➢**Increase drought risk** ➢**Impacts enhanced by poor water management** ➢**By 2020; 75 to 250 million people will face increased water stress**
Others	✓**Forest Ecosystems; species loss, extinction, dramatic shift or changes in species range & increased fire occurance** ✓**Forest NPP – to decline in the longterm** ✓**Pasture and livestock productivity; decline**



Source: Biopact, 2007

Bioenergy

Options and potentials

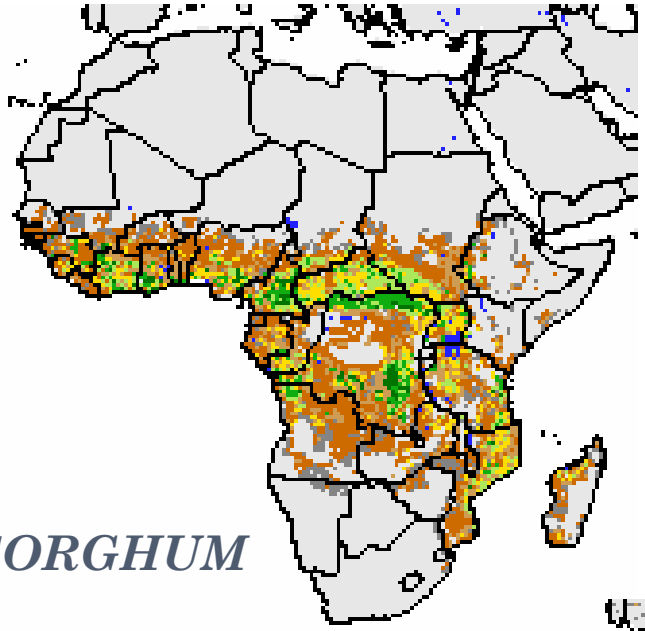
BIOENERGY OPTIONS - Africa

Biomass Source	Conversion	End Use
Lignocellulosic biomass -wood -crop residue	Combustion and Gasification	-Electricity -Heat (process) -Cooking
Sugar (Sugar cane) or Starches (e.g. Maize)	Fermentation	Ethanol for transportation.
Vegetable oils - Shrubs (Jatropha) -Trees (Pongamia, Oil Palm)	Esterification	Biodiesel for transportation.
Cattle dung, leaf litter, wet organic matter	Anaerobic digestion	Biogas for cooking , power

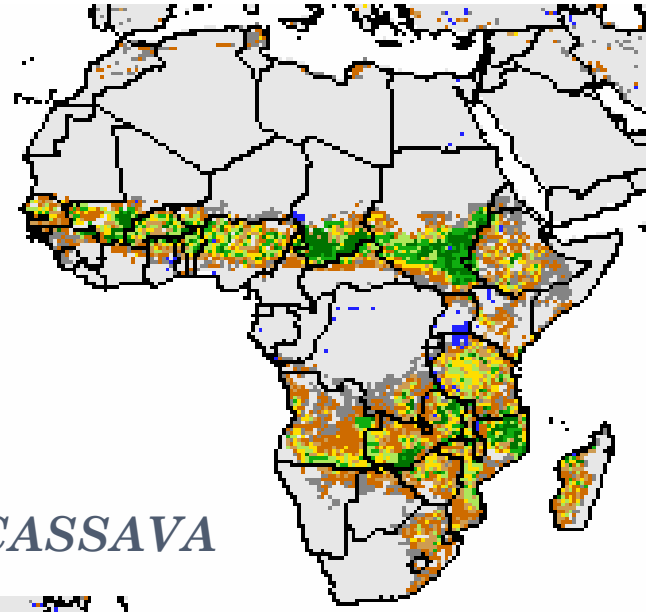
BROAD CATEGORIES OF BIOFUEL CROPS

	Rainfall (cm)	Land and Climate	Cultivation practice
Sugarcane	**150 – 250**	**-Tropical and Sub-tropical** **-Good quality land**	**-Intensive** **-Irrigation + fertilization**
Oil palm	**180-500**	**- Moderate-high quality land** **- Humid tropical**	**-No irrigation in Humid** **-Fertilize for high yields**
Maize (Grain) **Sweet Sorghum (Stalk)** **Cassava (Root)**	**70-150**	**-Semi-arid** **-Moderate to high quality land** **-Cassava: Low quality-land : drought resistant**	**-Intensive practices for high yields** **-Irrigation and Fertilization for high yields**
Jatropha (Seeds)	**60-120**	**-Tropical, sub-tropical and semi-arid** **-Poor to moderate land** **-Not irrigated - drought resistant**	**-Not intensive** **-No irrigation and fertilizer application**
Woody Biomass (lignious biomass)	**50-500**	**-Arid, semi-arid, humid** **-Tropical to temperature** **-Poor quality land - OK** **- Drought resistant**	**-No irrigation, fertilization, fertilizer application** **-Low intensification**

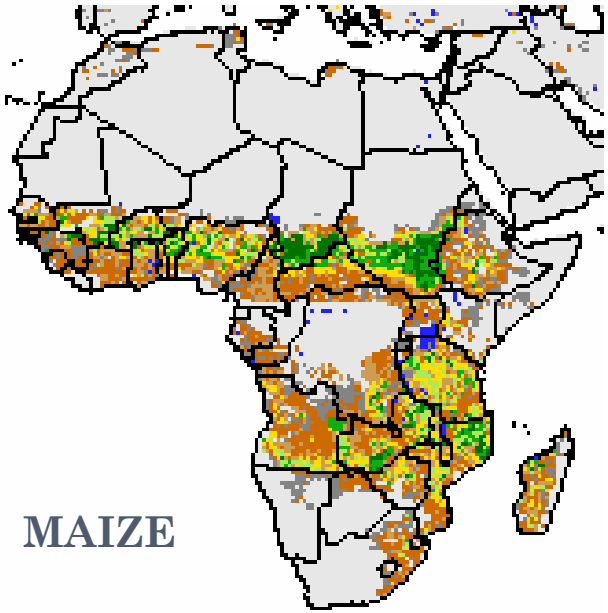
Suitability for rain-fed cultivation of various bio-fuels



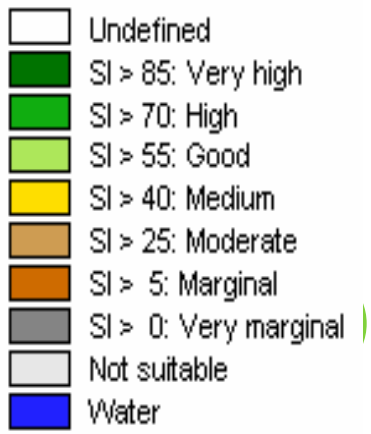
SORGHUM



CASSAVA

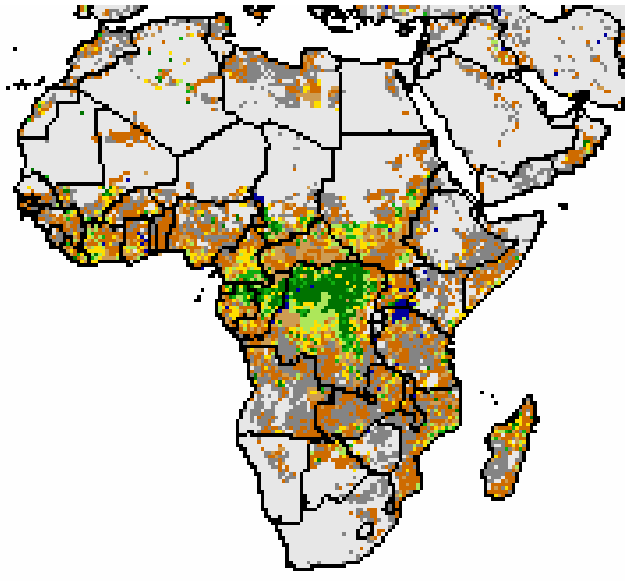


MAIZE

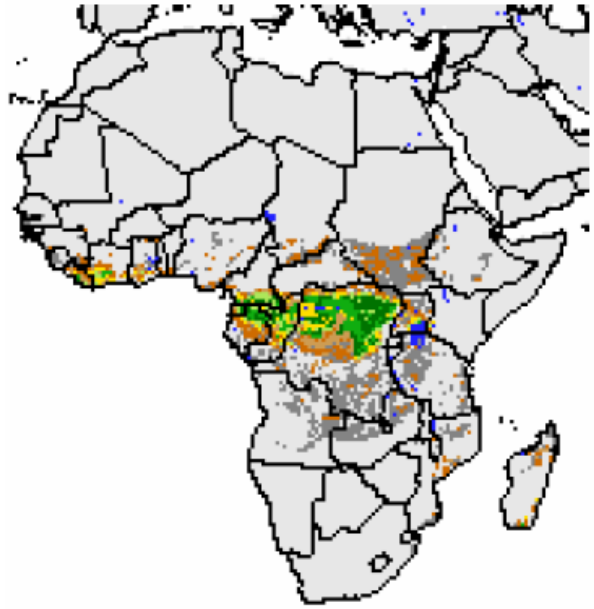


source: IIASA/FAI (2002)

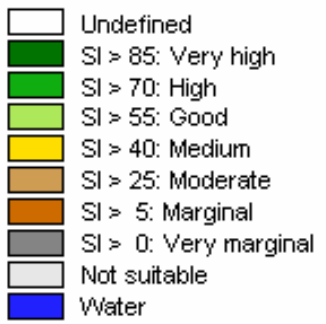
SUITABILITY FOR RAIN-FED CULTIVATION OF VARIOUS BIO-FUELS



SUGARCANE



OIL PALM



Source: IIASA/FAI (2002)

YIELD OF BIOFUEL CROPS

ETHANOL		BIODIESEL	
Crop	*Yield (litres/ha)*	*Crop*	*Yield (litres/ha)*
1. Sugarcane	4000-8000	1. Oil Palm	2500-6000
2. Maize	700-3000	2. Jatropha	400-2200
3. Sweet Sorghum	3000-6000		
4. Cassava	1750-5400		

	Woody Biomass	**Power Generation Potential**
Eucalyptus plantation	5-10 t/ha/year	4 to 8 Mha/ha/yr

Source: Wetland International, 2008

AREA REQUIRED FOR PRODUCING BIOFUELS

If 10% of Gasoline & 10% of Diesel - to be Substituted by 2020

I. ETHANOL

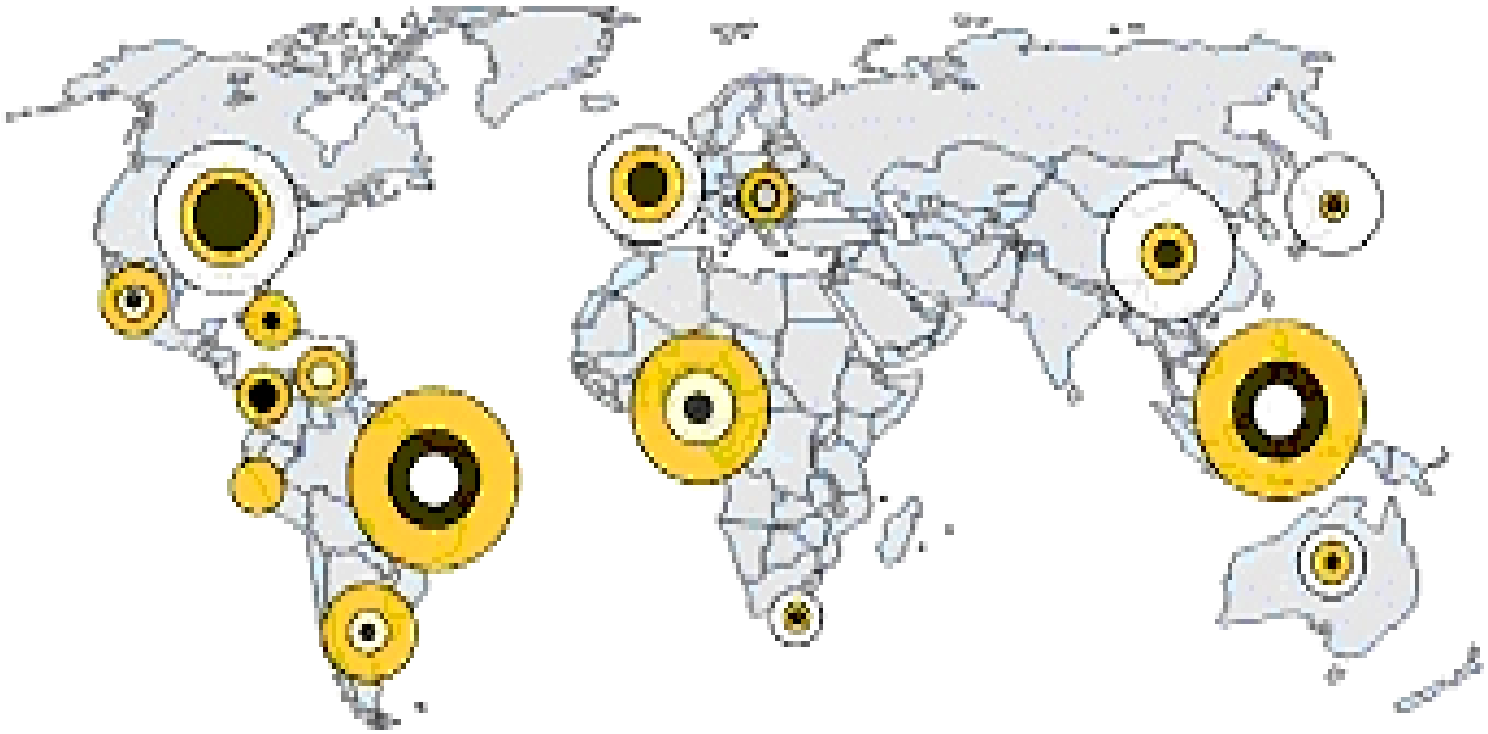
Country	2020 Ethanol demand Million litres	Area required (1000 ha) if 100% demand to be met			
		Sugarcane	*Maize*	*Sweet Sorghum*	*Cassava*
South Africa	2279	571	3,451	662	1,292
Nigeria	1754	440	2,633	510	994
Tanzania	52	13	78	15	29
Sub-Saharan Africa	5,667	1,420	8,509	1,647	3,213

II. BIODIESEL

Country	Biodiesel demand in 2020 Million / litre	Area required (100 ha)	
		Palm Oil	*Jatropha*
South Africa	1,243	511	829
Nigeria	403	166	269
Tanzania	116	48	77
Sub Sahara Africa	4,044	1,663	2,696

(Source: Wetland International, 2008)

Future Trends – Bio-fuel in Africa



- Feedstock potential based on land available for devotion to first generation biofuel feedstocks.
- Theoretical biofuel demand, assessed to be ~30% of liquid transport fuel consumption in 2006.
- Biofuel production capacity in place at year end 2006.

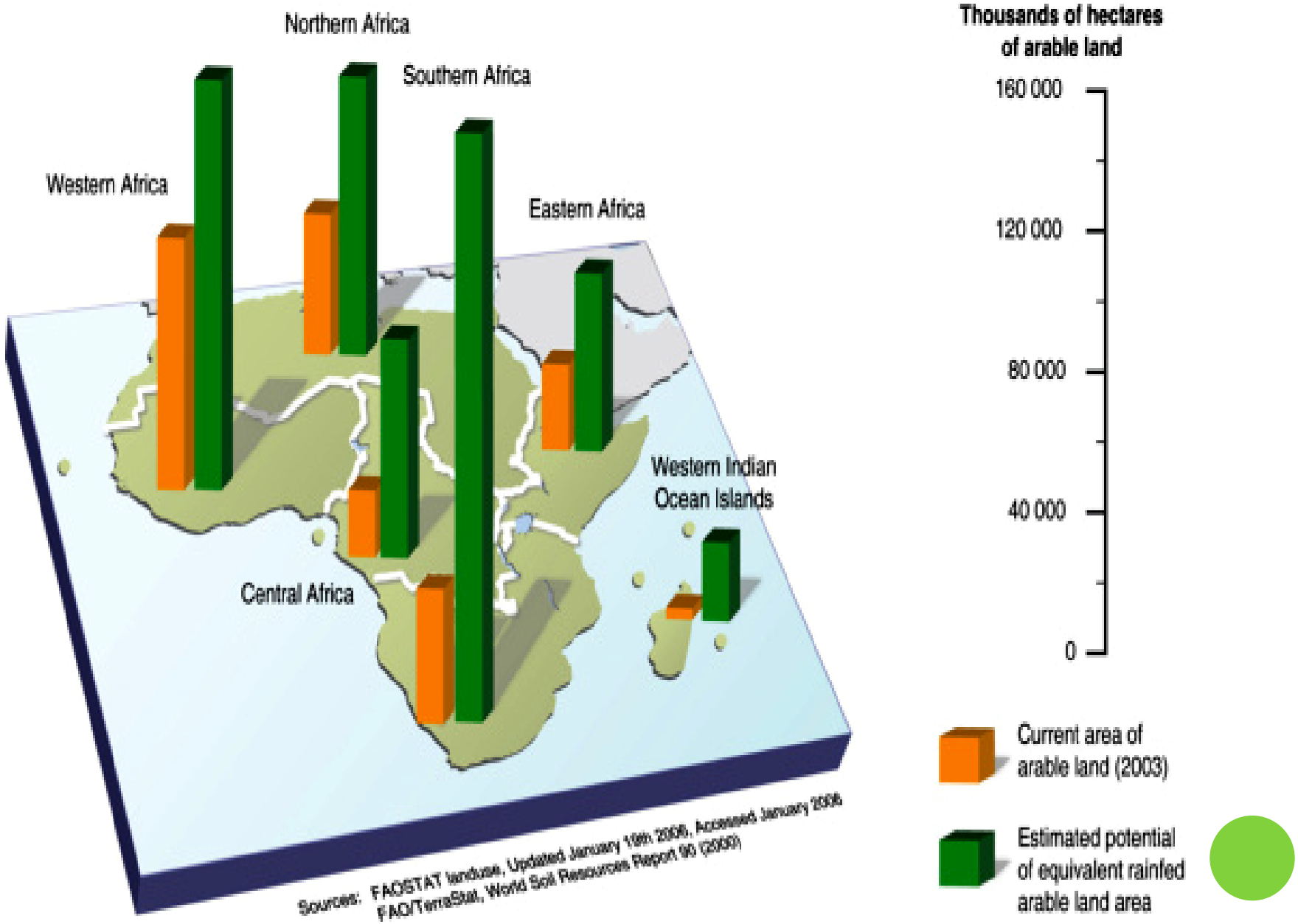
- Feedstock potential exceeds biofuel demand and surplus production capacity - so export.
- Capacity less than biofuel demand so investment in infrastructure warranted to encourage export potential.
- Feedstock constrained and capacity less than demand - so import.

Source: New Energy Finance www.newenergyfinance.com

BIOFUEL PRODUCTION PROJECTION -ETHANOL

Countries/Region	Production in 2008 Mean Annual (m lit)	Projection for 2017 Mean Annual (m lit)	Share in total gasoline use (%)	
			2008	*2017*
South Africa	369	683	-	1.87
Ethiopia	38	74	<1.0	<1.0
Mozambique	24	28	<1.0	1.86
Tanzania	29	43	<1.0	2.54
Global	**77,054**	**126,860**	**5.46**	**7.63**

Source: OECD - FAO, 2008

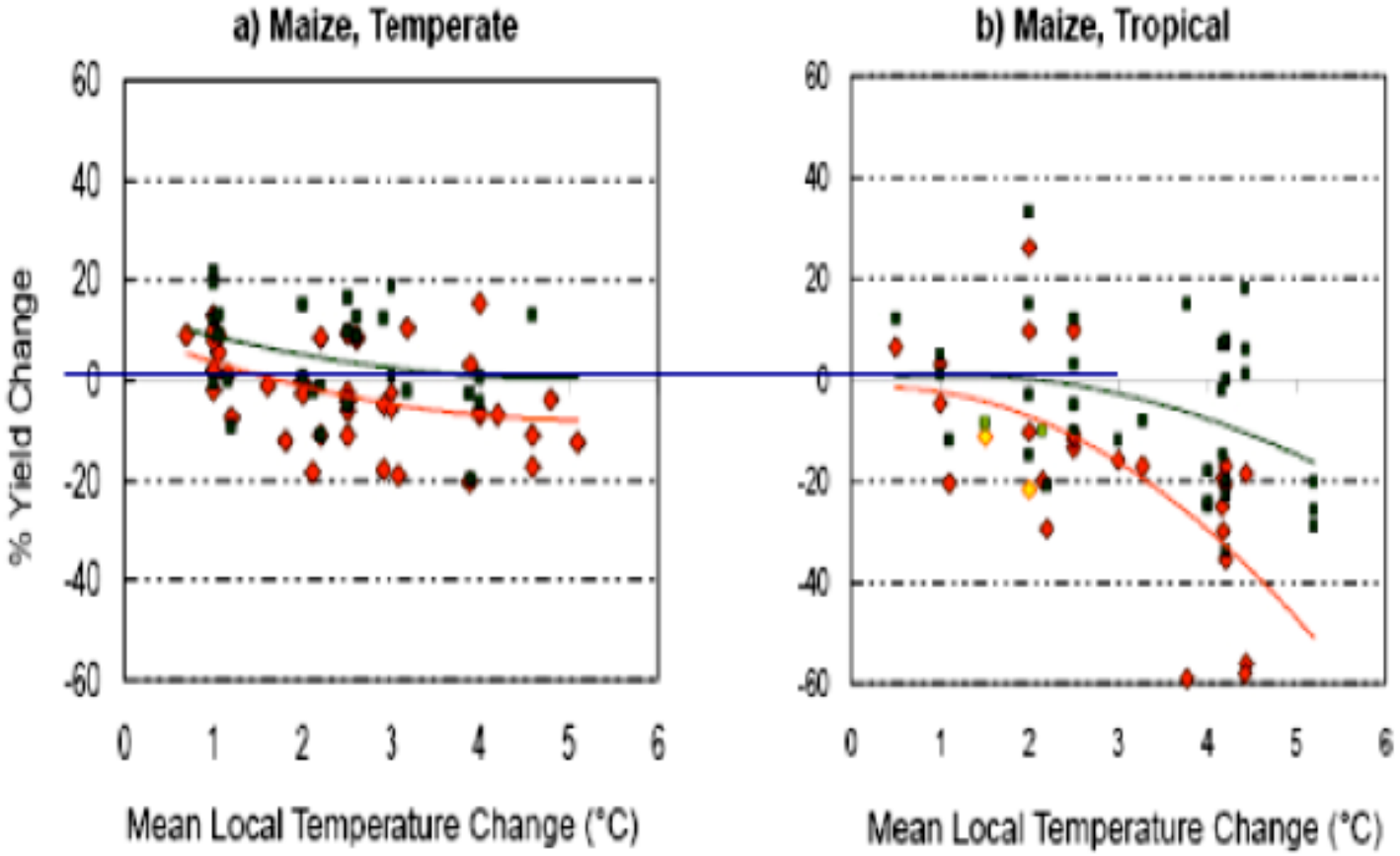

Northern Africa
Southern Africa
Western Africa
Eastern Africa
Western Indian Ocean Islands
Central Africa
Thousands of hectares of arable land
160 000
120 000
80 000
40 000
0
Current area of arable land (2003)
Estimated potential of equivalent rainfed arable land area
Sources: FAOSTAT Ventures, Updated January 19th 2006, Accessed January 2006
FAO/IIASA, World Soil Resources Report 96 (2000)

Climate Change; Impacts & Vulnerability of Biofuel crops

NO DEDICATED STUDY - addressing climate change

Biofuel	Climate Change	Impacts/Vulnerability
Maize/ Sweet sorghum	-Increase in temperature -Decrease in rainfall -Frequent droughts	- Reduce yield - Highly vulnerable
Oil Palm	-Increase in temperature -Decrease in rainfall	-Reduce yield -High vulnerability
Jatropha	-Increase in temperature -Decrease in rainfall -Frequent droughts	-Reduce yield -Low vulnerability
Sugar	If irrigated	-Minimal impact -Low vulnerability
Wood fuel for combustion and gasification	-Initial increase in NPP -Long term decline	-Minimal impact -Low vulnerability

Impact and Vulnerability Scenario on Maize Production



Red = without adaptation

Green = with adaptation

——— = reference line for current yields

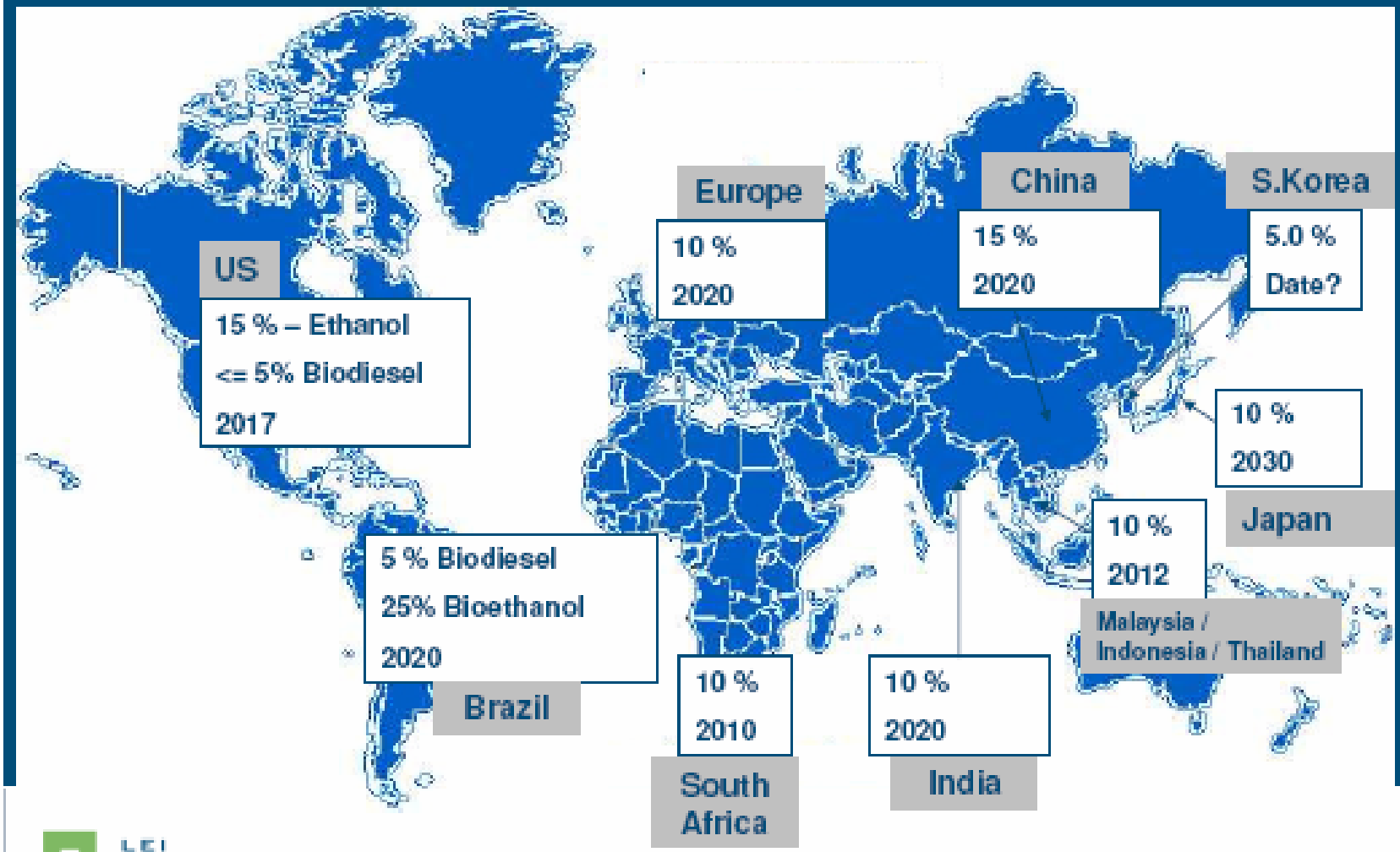
IMPACTS OF CLIMATE CHANGE ON BIOFUEL – NO DEDICATED STUDY

Biofuel crops	Likely Impact
Sugarcane	Significant Decline projected due to rise in temperature and decline in rainfall – if irrigation is affected.
Maize	Up to 25-50% decline
Sweet Sorghum	- If irrigated minimal impact – long term water crisis could decline yield
Perennials- Oil palm	Initial increase, decline beyond moderate temperature rise.
Jatropha	Significant decline in yield in absence of irrigation.

ADAPTATION OF BIOFUELS TO CLIMATE CHANGE SIMILAR TO FOOD CROPS

Crops	Adaptation practices	Adaptation policies
Sugarcane	▪ Assured irrigation ▪ Increase irrigation efficiency ▪ Efficient water management	Insurance Area regulation
Maize **Sweet Sorghum**	▪ **Soil & water conservation** ▪ **Drought resistant verities** ▪ **Irrigation ?**	**Insurance**
Jatropha	▪ Soil and water conservation ▪ Breeding for drought and pest-resistance	- Cropping only degraded lands
Wood fuel for combustion and gasification	▪ **Mixed species plantation** ▪ **Anticipatory planting of species** ▪ **Five protection and management**	**Energy plantations only in degraded lands**

Targets for Bio-fuels Worldwide



LEI WAGENINGEN UR

Sources: IEA Task 39 report May 2007, Governments of countries, Frost & Sullivan Consulting

CONCLUSION

- Africa is projected to experience significant rise in temperature and decline in rainfall.
- Climate change is likely to adversely impact water resource availability, agricultural production and forest resources.
- Africa has very large potential for Bio-fuel production; destination for oil companies
- Climate change is likely to impact Bio-fuel production in medium and long term; Maize, Sweet sorghum and Jatropha, etc will be impacted
- According to available projections, despite large potential, the spread of Bio-fuels in likely to be insignificant (<5% by 2020)
- Any large scale promotion of Bio-fuel crop must incorporate adaptation strategies to cope with projected climate change.