Threats of Climate Change on Arabica Coffee (*Coffea arabica*) in its Center of Origin Ethiopia

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Outline

1. Introduction
   - Climate change (broader perspective)
   - Coffee & climate change (objective)
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2. Impacts of climate change on *C. arabica*
   - Growth and development (shift in flower pattern)
   - Yield & quality
   - Genetic resources (on survival of the crop)
3. Conclusion

1. Introduction

Climate change

– widespread impacts on human and natural systems including agriculture.
- Many terrestrial, freshwater and marine species have shifted their geographic ranges, seasonal activities, migration patterns, abundances and species interactions in response to ongoing climate change (high confidence)
- Many assessment indicating
  – negative impacts of climate change on crop yields more common than positive impacts (high confidence).

With Arabica coffee
- productivity (yield) is tightly linked to climatic variability
  – optimum mean annual temp = 18 – 24 C.
  – > 25 C
    - accelerated berry development and ripening of fruits
      – leading to the loss of quality.
- continuous exposure to as high as 30 C leads to stress, depressed growth and abnormalities,
  – yellowing and defoliation
- favorable to emergence and/or resurgence of
  – diseases and insect pests

- Arabica coffee is a remarkably climate-sensitive species
  – as it evolved in the moist evergreen afromontane rain forests
  – climate variables
    - scarce rainfall, increased drought, and increasing temperatures cause major detrimental effects
      – production/yield and quality, and ultimately threaten existence in Ethiopia, the major reservoir of genetic diversity for the species.

2. Direct impact

2.1 Growth and development

Intense sun scorch effect on coffee seedlings (growth shock, wilt)

Impact of moisture stress (lack of rainfall) on grown mature coffee trees in (SW Ethiopia, 2014-2015)

Severe & prolonged drought leading to irreversible wilt & finally death of coffee trees (SW Ethiopia, 2014-2015)

2.2 Yield and quality

Coffee yield, quality and irrigation water use efficiency influenced by different deficit irrigation methods at Jimma, Ethiopia

Irrigation Treatment	Yield (Fresh cherry, kg/ha)	IWUE (g/kg)	Quality (%)		
			Raw	Liquor	Overall
Optimum watering	8588.9 a	8.9 c	25.4 b	38.1 b	63.6 b
Partial root zone drying	7375.6 ab	15.2 a	29.3 a	42.8 a	72.1 a
Normal deficient irrigation	5919.3 b	12.2 b	29.5 a	42.5 a	72.0 a

Tesfaye Shimber and M.R. Ismail, 2008.

Coffee yield and quality influenced by different supplemental irrigation methods at Jimma, Ethiopia

Supplemental Irrigation	Yield (Fresh cherry, kg/ha)	Quality (%)		
		Raw	Liquor	Overall
Full irrigation	8076.3 a	26.8 b	34.4 a	61.1 b
Deficit Irrigation	6723.3 ab	29.5 a	38.1 a	67.6 a
Rain fed (control)	5288.2 b	29.3 a	36.3 a	65.5 a

Tesfaye Shimber and M.R. Ismail, 2008.

2.3 Indirect impacts

. Favoring diseases and insect pests

1.Coffee berry disease – on yield & quality

2. Coffee Leaf Rust

Severe infection leads to defoliation, yield loss on current & next crop.

Physiologic races = 49 characterized in the world (by 2012)

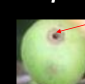
	Samples	races (gene for virulence)				
		I	II	III	X	XV
		(V2V5)	(V1V5)	(V5)	(V4V5)	(V1V4V5)
Total n	241	0	97	128	10	6
Per cent	100	0.8	39.9	52.7	4.1	2.5

- **climate change**
  - **new race appearance**
  - **tolerant HT catimore lines severely attacked (Chala 2009)**

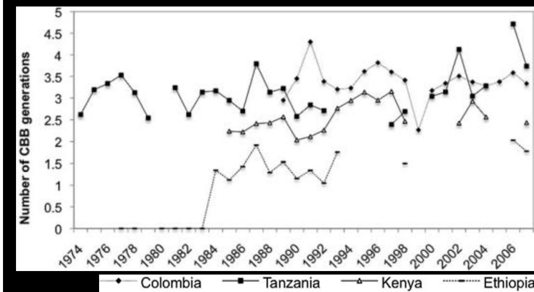
3. Bacterial blight of coffee

- new record & outbreak (2008)
- spread to many districts (2014)

4. Coffee berry borer, *Hypothenemus hampei*



- first occurrence in Ethiopia (Davidson, 1968).
- later varying incidence in some parts of the country (Million 1987, 2001; Esayas *et al*. 2003, 2004).
  - before 1984 it was too cold for *H. hampei* to complete even one generation per year but rising temperatures in the area, 1–2 generations per year/coffee season could be completed (Fig).



Generations of *Hypothenemus hampei* in Colombia, Ethiopia (32 yrs data), Tanzania, and Kenya (Source: Jaramillo et al. 2009)

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5. Coffee berry moth, *Prophantis smaragdina*

Increasing infestation on green berries & ripe cherries

6. Blotch leaf miner (*Leucoptera* spp.)

- high Infestation in dry season
- increase with rising temperature

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7. Scale insects

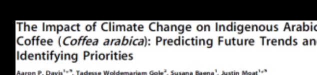
Brown scale

Green scale

8. Coffee Stem borers

unknown spp before

3. Impact on the survival of *C. arabica*


The Impact of Climate Change on Indigenous Arabica Coffee (*Coffea arabica*): Predicting Future Trends and Identifying Priorities

Aaron P. Davis, Tadesse Woldemariam Gole, Susana Baena, Justin Moat

- This study establishes a fundamental baseline for assessing the consequences of climate change on wild populations of Arabica coffee
  1. identifies and categorizes localities and areas that are predicted to be under threat from climate change now and in the short- to medium- term (2020–2050), representing assessment priorities for *ex situ* conservation;
  2. identifies 'core localities' with potential to withstand climate change until at least 2080, and serve as long-term *in situ* storehouses for coffee genetic resources
  3. provides the location and characterization of target populations for on-the-ground monitoring of climate change influence.

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- Using distribution data made bioclimatic modeling and examine future distribution with the HadCM3 climate model for three emission scenarios (A1B, A2A, B2A)
  over three time intervals (2020, 2050, 2080).

1. **locality based analysis**
   - **349** (unique) through time, within each scenario, into
     - 68% (optimal),
     - 95% (intermediate (suboptimal), and
     - 100% (marginal) including 68% and 95% thresholds.
2. **areal based analysis**

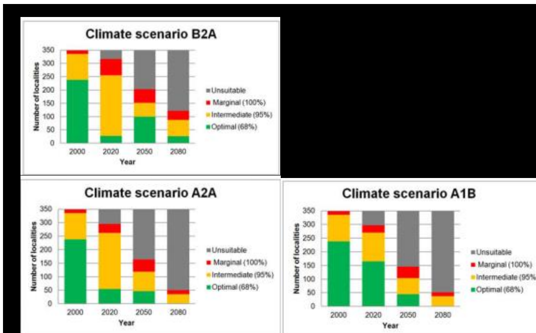
- Three time intervals
  - 2020 = an average of the years 2010–2029,
  - 2050 = for 2040–2059 and
  - 2080 = for 2070–2089.
- Three emission scenarios of the IPCC Special Report on Emissions Scenarios
  - A1B = maximum energy requirements
  - A2A =high energy requirements
  - B2A = lower energy requirements.

3.1 Climate change scenarios (2020-2080) – a locality analysis

- future modelled scenarios show
  - a dramatic and profound decrease in the number of predicted bioclimatically suitable localities for indigenous Arabica (Table; Figures).

Number of (unique) localities in each threshold class for each climate change (emission) scenario and date.

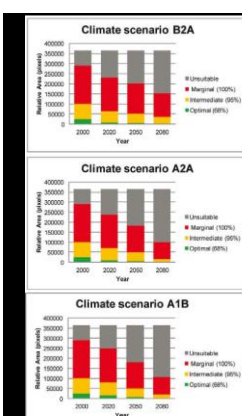
	Present day	Climate scenario B2A			Climate scenario A2A			Climate scenario A1B		
	2000	2020	2050	2080	2020	2050	2080	2020	2050	2080
Optimal (68%)	238	27	100	26	54	46	1	165	44	1
Intermediate (95%)	97	228	52	62	208	73	34	105	60	36
Marginal (100%)	14	61	51	34	33	45	15	27	42	14
Unsuitable	0	33	146	227	54	185	299	52	203	298



Predicted climate change outcomes for indigenous Arabica localities for the year interval 2000, 2020, 2050 and 2080.

3.2 Climate change scenarios (2020–2080) an area analysis

- dominated by a significant reduction in predicted occurrence for Arabica until to 2080.
- very inclusive threshold of 100%
- 38%, 56% and 55% reduction across all emission scenarios (i.e. B2A, A2A, A1B, respectively).
- Even under the 95% (intermediate) threshold the A2A and A1B and B2A scenarios show substantial reductions in the distribution area for Arabica, at 57%, 79%, and 75%, respectively (Fig.)



Area analysis overview. Predicted climate change outcomes for indigenous Arabica for the year intervals 2020, 2050 and 2080.

3.3 Anthropogenic activities

- distribution of indigenous populations is controlled almost entirely by
  - natural,
  - biotic parameters,
  - but are influenced by anthropogenic actions


Primary & secondary forest communities inhabiting enormous biodiversity including Arabica coffee



(un/intentional forest fire = burning of all biodiversity


ill-practices by indigenous people

4. Conclusion

- Indigenous Arabica coffee is rich in population diversity in Ethiopia
- Sources of 70% world coffee industry
- but much more sensitive to major impacts of climate change being inevitably threatened
  - more likely that the unique gene pool may disappear
- *In situ* and *ex situ* conservation is of immediate priority.
  - assess the genetic variation particularly in relation to their bioclimatic profiles and physiological response to climate change help to identify populations for conservation.
  - Development of advanced genomic tools to accelerate diversity characterization and their enhanced utilization for genetic improvement to generate drought/stress-tolerant, disease and insect-resistant coffee varieties are major priorities.

Acknowledgment

Coffee Genome Workshop organizers - Marcela Yepes, PhD

Thank you

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