

An aerial photograph of a lush green coffee plantation in East Africa. The landscape is characterized by terraced fields and small houses, with a dense forest in the background. The text "Why does this coffee taste so good?" is overlaid in yellow.

Why does this coffee taste so good?

Discoveries from East Africa

The Norman Borlaug Institute for International Agriculture

Presentation Flow

- **Coffee Production Research**
- **Coffee Quality Research**
- **Importance of Collaborative Research**
 - U.S. Specialty Coffee Industry
 - Origin Research Institutions and stakeholders
 - U.S. Research Institutions
- **Preliminary attempt to organize this type research**
- **A good example of Collaborative Research**
- **Results from several preliminary collaborative experiments**
- **Brief note on East African appellation development**

Coffee Research and Development

Traditional agricultural research

- **Past research has largely focused on coffee production constraints**
 - Genetics
 - Cultural practices
 - Insects and diseases
- **Led to high yielding, disease resistant varieties for origin producing countries**
- **Very little research conducted on factors affecting coffee quality**
 - Consuming market in non-producing countries
 - No standardized measures of quality until recently
 - Price determined largely by C market until recently

21st Century perspective

- Increasingly, price determined by quality
- Provides a new way that producers can increase their income through quality interventions
- This increases producer wealth at origin and increased sales and profits at market place
- But what interventions to focus on to get there?
- How to increase coffee quality through research?



Quality variability

- In order to increase quality, we must have variability in quality.
- Overwhelming proportion of quality variability is at origin
 - Genetic effect on quality (bourbon, typica, land race genes,...
 - Effect of production variables on quality (fertilizer, shade, spacing...
 - Effect of processing variables on quality (fermentation, agricultural engineering, machines...
 - Effect of geographic position on quality (altitude, slope, exposition, etc.

Pushing the Quality Envelope

Collaborative Research on Coffee Quality

Working with Intelligentsia Coffee, Counter Culture Coffee, Volcafe Specialty, and Songer Coffee, SPREAD decided to include a Coffee Quality Research and Development program in the project to 'pilot' the idea of collaborative research

Assumption: neither origin nor consuming segments of the chain can increase coffee quality in isolation from each other.

Objective: To work with origin and consuming segments of the specialty value chain to increase the quality of coffee and therefore the price paid to the farmer.

- **Origin tends to miss the nuances of high-end specialty market in consuming countries**
- **Consuming segment does not understand the breadth and possibilities of variability in quality at origin (green is green is final)**
 - Like a telescope; a mm at 'origin' can radically miss the point at consumption

Synthesis of Collaborative Program

In 2006, the USAID/SPREAD project worked with both consuming and origin partners to design and execute research experiments to evaluate the effect of production and processing variables on the cup quality of green exportable coffee.

Partners:

- Origin: Agronomy department at the National University of Rwanda, USAID/SPREAD, Rwanda Institute of Ag Research, Technoserve, and local cooperatives and CWS operations
- Consuming end: Intelligentsia Coffee, Counter Culture Coffee, and Volcafe Specialty coffee
- US Research end: The Norman Borlaug Institute, the Texas A&M Horticulture Department
- Other: Pinhalense Machines Company in Brazil, Penagos Machine Company in Colombia, AgPro Company in Philippines

Synthesis of Hypotheses

Different ideas on preliminary research themes came from brain-storming sessions among partners, but especially the US coffee industry:

- What is the effect of fermentation of coffee quality?
- What is the effect of different pulping methods on coffee quality?
- Does soaking wet parchment for 24 hours after fermentation is complete add quality? Increased green shelf life?
- What is the effect of transport time from farm to factory on coffee quality?
- What are the environmental or physical elements that positively correlate with high coffee quality?
- Can appellations be developed by geo-spatial correlations?

Development of experiments to test proposed 'themes' or hypothesis

Design experiments that answer the questions posed by Industry

- Experimental design choice
- Appropriate number of replications and locations
- Number of years
- Choice of Statistical analyses
- Dependent variable is QUALITY but how to measure?
- Use of industry cuppers in determining the absolute quality parameters of experimental treatments
- Eventual need to 'zen' into the components of coffee quality.
 - Use of descriptive cupping

A good example

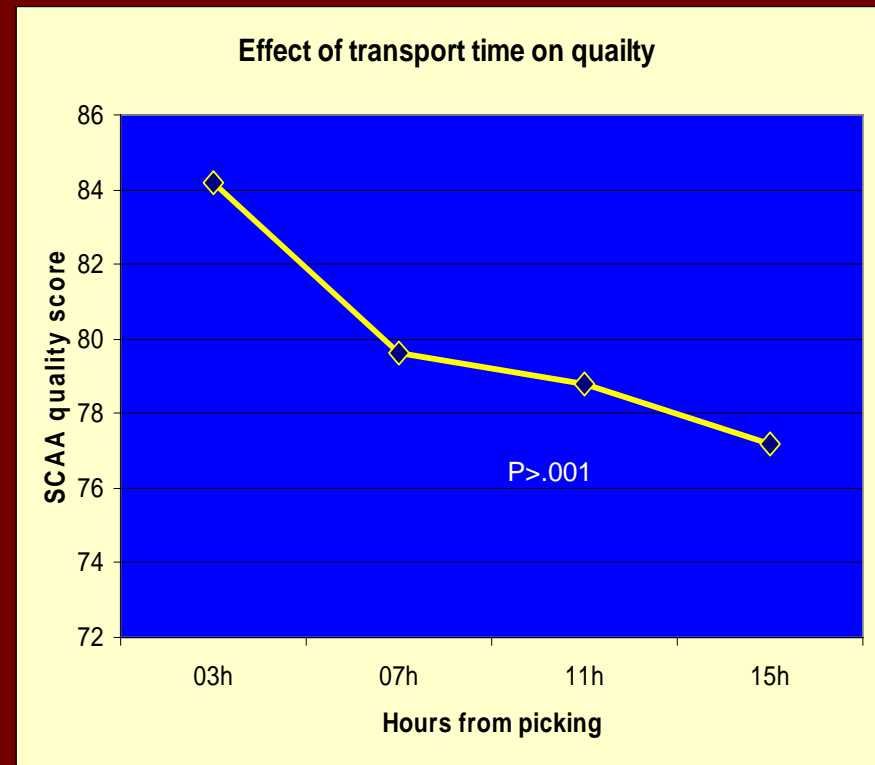
The development of the 'coffee bike'

- Origin visits by Intelligentsia, Counter Culture and Volcafe reveal that mediocre quality of many Rwandan coffees likely due to the long time it takes to bring in the coffee from farms to the CWS...
- Borlaug, Texas and NUR take this and turn it into an experiment to determine the effect of cherry transport time from farm to factory, on coffee quality
- Under SPREAD linkages with NUR, 2006, a student completes a preliminary 'laboratory' experiment that shows that the effect of transport time is VERY important on coffee quality.



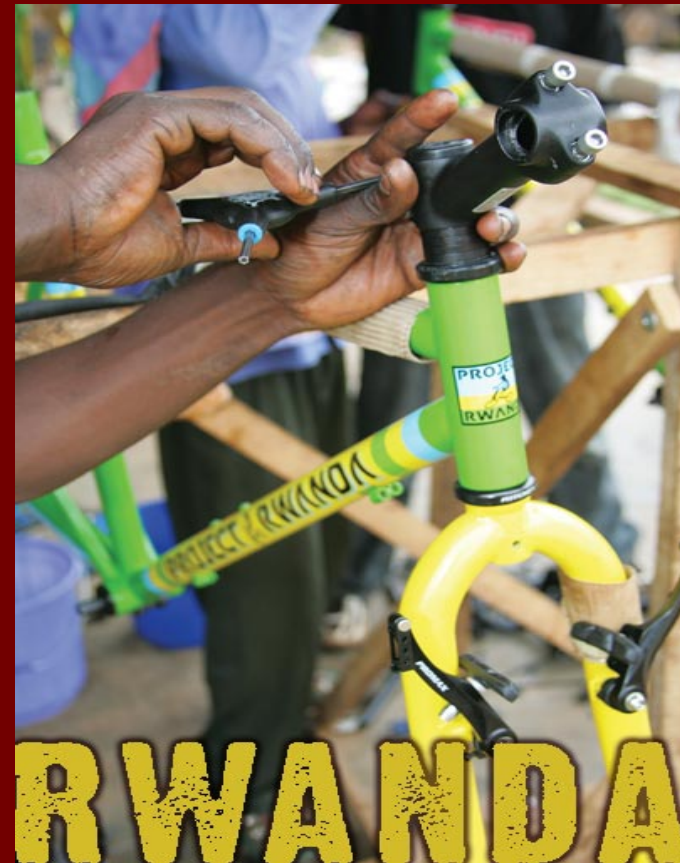
Experimental Results

- An experiment was designed to determine the actual effect of transport time on the final quality of green coffee using real cherry volumes, real farmers, in a real production environment
- This experiment confirmed preliminary lab experiment and shows that a reduction in transport time from farm to CWS can increase quality
- For every hour in transport, the coffee will lose almost 1 full quality point



Extrapolation of results into action to raise quality

- Further interest and partnership produce a US bike designer who will design special mountain bike to bring the coffee in from farm to factory faster
- Everything set to capitalize on research results showing strong negative correlation between time of transport and coffee quality



The Coffee Bike

- Low reasonable cost (\$200 each)
- Well designed: solid, simple, efficacious
- Capable of carrying 200 kg load through smart engineering
- Can assist family increase income in ways other than just coffee
- Increases mobility and openness of farm families
- Encourages youth to maintain and grow the family coffee business



Further evolution of actions to insure the 'auto-continuation' of program

Extension and Outreach

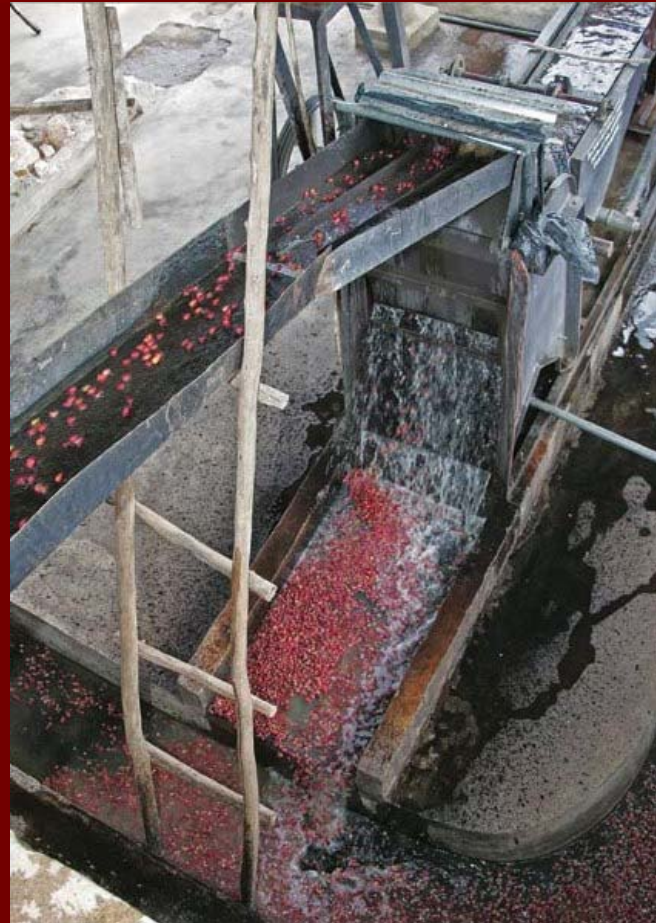
- Develop incentives for farmers to get cherries to CWS before 5PM in order to maximize quality and therefore total factory revenue
- Expand partnership to micro-credit companies who extend credit to farmers to purchase a coffee bike and finance over a 3 year period
- Bike plant created to import 'coffee bikes' to Rwanda, assemble, sell and distribute. Provide parts.



Testing validity of an old industry 'quality wife's tale'

For example:

"Mechanical de-mucilage of cherries degrades the cup quality of green coffee compared to classic fermentation of pulped cherries..."



The effect of pulping machinery and methods on coffee quality, cost of production and environment

Partners

- **U.S. Coffee Industry: Counter Culture, Intelligentsia, and Volcafe Specialty**
- **Origin: Agronomy Department of National University of Rwanda, Technoserve, SPREAD, Cooperatives, CWS owners**
- **Science side: Borlaug Institute, Texas A&M Horticulture department**
- **Machinery Industry: Pihalense/Brasil, Penagos/Colombia, Naicof/Kenya**

The effect of pulping machinery and methods on coffee quality, cost of production and environment

determination of treatments ...

Discussions with machine manufacturers, cooperative users, U.S. industry coffee buyers, project specialists, local University scientists and U.S. based Universities determine most appropriate treatments and the best and most logical processing standard for each process.



Logic UCBE 500M



Naicof single 1000



Pinhalense ECO-1SV

Materials and Methods

- Approximately 1 ton of red-ripe cherries were delivered early to Sovu CWS by foot or bike before 3PM.
- Storage of cherries in flotation tank of cool water until time of process when low-density cherries are removed by flotation sort.
- STANDARD process at Sovu CWS includes McKinnon-type Naicof single disc pulping into A1 and A2 density graded wet parchment, complete dry fermentation (typically 14-16hr), washing, and a 24hr soak.
- Beans then spread on raised screens under shade cover and undergo hand sorting during the morning. Defective beans weighed and removed.
- Raised bed drying- Parchment is spread and monitored on drying tables until moisture meter readings show water content at 12%. Manual turnover, shade cloth, and plastic tarping is used to maintain consistency and control variables.
- Storage- Dry parchment is bagged and stored at Sovu in a small warehouse

Materials and Methods

...the experimental design

Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9
<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>
<i>T2</i>	<i>T3</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T1</i>
<i>T3</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T1</i>	<i>T2</i>	<i>T3</i>	<i>T1</i>	<i>T2</i>

Completely Randomized design with 5 treatments and 9 replications where replications were nested within days to remove the effect of machine order. Treatments 2 and 3 were each subdivided into two lots of wet parchment. One that went to drying table directly (T2) and the other that was left to soak overnight in water(T4 for Pen and T5 for Pin).

Each machine functioned for a 30-40 minute time period for pulping and then followed standard post-pulping operations procedures as manufacture and local users pre-determined.

Variables measured

- Total quantity of cherries used during each test run, weighed from flotation tank
- Total quantity of low-density floating cherries removed before process
- Total quantity of cherries allotted for each run and time taken to complete process
- H2O Flow meters recorded at start and stop of process at every point of input
- Diesel and petrol consumed measured by refilling tanks following process
- Quantity cherries 'lost' in pulp sorted and weighed from 5min sample
- Machine-caused defects found during hand sort and quantity weighed as dry parchment
- Total time of each step of process from pulping to dry parchment storage
- Water use
- Energy use
- Labor use
- Coffee quality attributes
Using standard SCAA scoring with quantitative evaluation of quality attributes
 - Acidity
 - Body
 - Sweetness
 - Flavor
 - Finish

Cost of production results

- Classic wet processing used significantly reduced levels of fuel per unit of coffee pulped than other systems
- However, cost of labor in processing using classic system is almost 40 times higher than the new technologies
- The new technologies also used almost no water compared to the classic wet system
 - 20,000 liters to process 1 ton of parchment vs only 200 for the Penagos machine and 1,700 for the Pinhalense

Treatment	Fuel L/ton	Water L/ton	Labor Hrs./ton
Classic fermentation	0.73c	20,599a	40.7a
Penagos	1.92a	227d	1.6c
Pinhalense	1.37b	1,744bc	1.0c
Penagos w/ Soaking	1.92a	840cd	11.6b
Pinhalense w/ Soaking	1.37b	2,203b	11.0b
L.S.D.	0.4	1,290	0.7

Cup Quality Results

Treatment	Sweetness	Acidity	Flavor	Body	Finish	Average
Classic fermentation	6.6bc	6.7b	6.6b	6.7b	6.5c	79.7c
Penagos	7.3a	6.7a	7.2a	7.1a	7.1a	82.7a
Pihalense	7.1ab	7.2ab	7.0a	7.0ab	6.8c	81.6ab
Penagos w/ Soaking	7.0ab	7.0ab	7.1a	7.1a	7.0ab	82.2ab
Pihalense w/ Soaking	6.8bc	6.9b	6.9a	7.1a	6.9ab	81.4b
L.S.D.	0.3	0.3	0.3	0.3	0.3	1.3

- No significant difference in coffee quality between classic fermented/washed coffee and the same coffee mechanically de-mucilaged
 - Quality attributes tend to be enhanced
- Soaking wet parchment after full mucilage removal did not result in higher quality coffee
- Partial mucilage removal followed by overnight fermentation did not result in higher quality coffee
- Utilization of the Penagos or Pihalense mechanical demucilaging pulpers will not degrade the quality of coffee compared to the classic fully washed wet system and in some cases can enhance the quality

Bottom line

Although this research will be repeated again this year, we feel confident in recommending the new pulping technologies for all three parameters measured:

- **As good or better coffee quality than classic fully washed system and taste attributes stay same**
- **Much cheaper labor costs resulting in higher earnings**
- **Amazing economy of water resulting in a 'greener' system with significant savings on total cost of production**

The only variable where the classic system appears to have an advantage is in the fuel costs to run the motors of the pulpers where the classic system used half the fuel of the eco-pulpers.

The effect of fermentation time on cup quality of coffee

■ Partners:

- NUR, SPREAD, Intelligentsia, Counter Culture, Volcafe Specialty, Borlaug Institute, Maraba cooperative, Texas A&M Horticulture

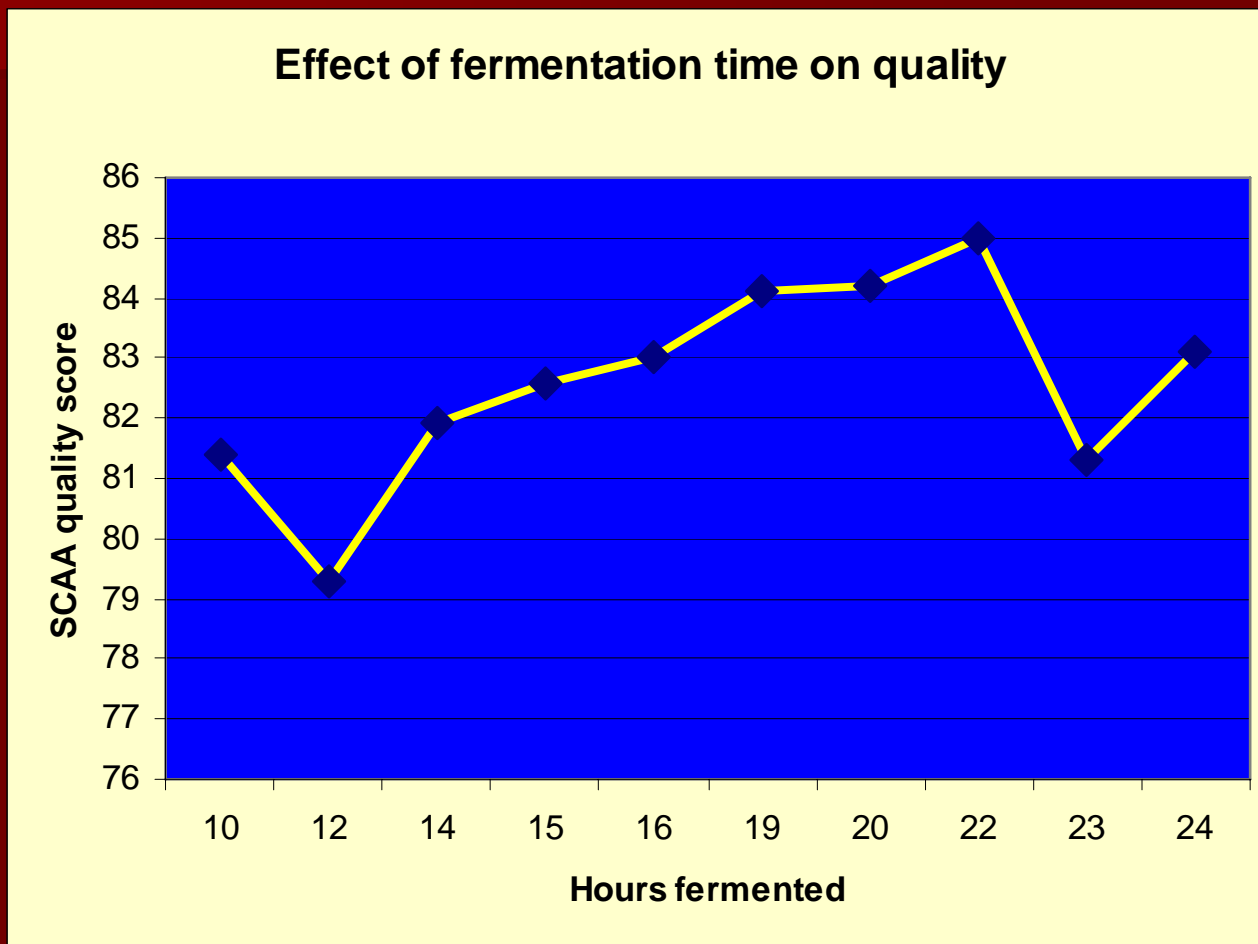
■ Experimental design:

- Completely Randomized Design with 10 fermentation times and 4 replications in time

■ Analysis:

- Simple Linear Regression
- Means tables

Results



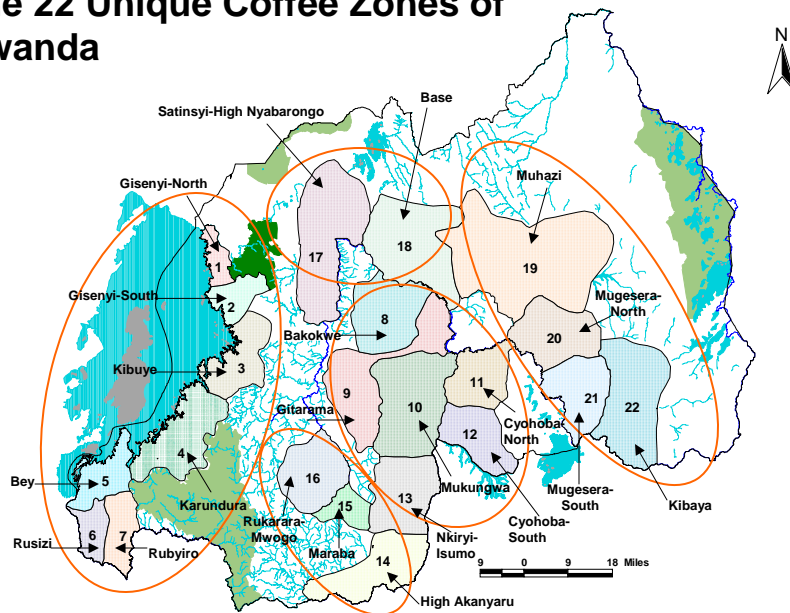
Implications

- Generally fermentation requires approximately 14-16 hours in Rwanda
- If wet parchment is left in the fermentation tank for an additional 4 hours, a significant quality enhancement can be obtained
- Fermentation time threshold (22 hours) critical
- Recommendations are being made this year to increase fermentation time by 4 hours

Adding value at origin through branding

The development of Rwanda's Coffee Appellation *Preliminary Results*

The 22 Unique Coffee Zones of Rwanda



- To benefit farmers from premiums paid for consistent quality flavor profiles originating from a unique and specific geographic 'appellation'.
- Highest level of traceability back to origin of the coffee
- Guarantees consistent quality to consumer

Coffee Appellation Development Partners

- OCIR-Café
- Center for GIS and Remote sensing at NUR
- USAID/SPREAD
- Songer Coffee Inc.
- Intelligentsia Coffee
- Green Mountain Coffee
- Terroir Coffee
- Stumptown Coffee
- Allegro Coffee
- Counter Culture Coffee
- Texas A&M University Mapping Sciences department

Coffee Appellation Development

Specific Objectives

- To determine if Rwanda possesses unique taste profiles that can be linked to geographic areas and eventually into commercial appellations
- To analyze the factors affecting the taste of these coffees through Zen-like 'descriptive cupping'
- To conduct spatial correlation analyses capable of delineating 'appellation boundaries' or 'terroirs' based on the relation of the coffee's taste profile and the physical environment that produced it

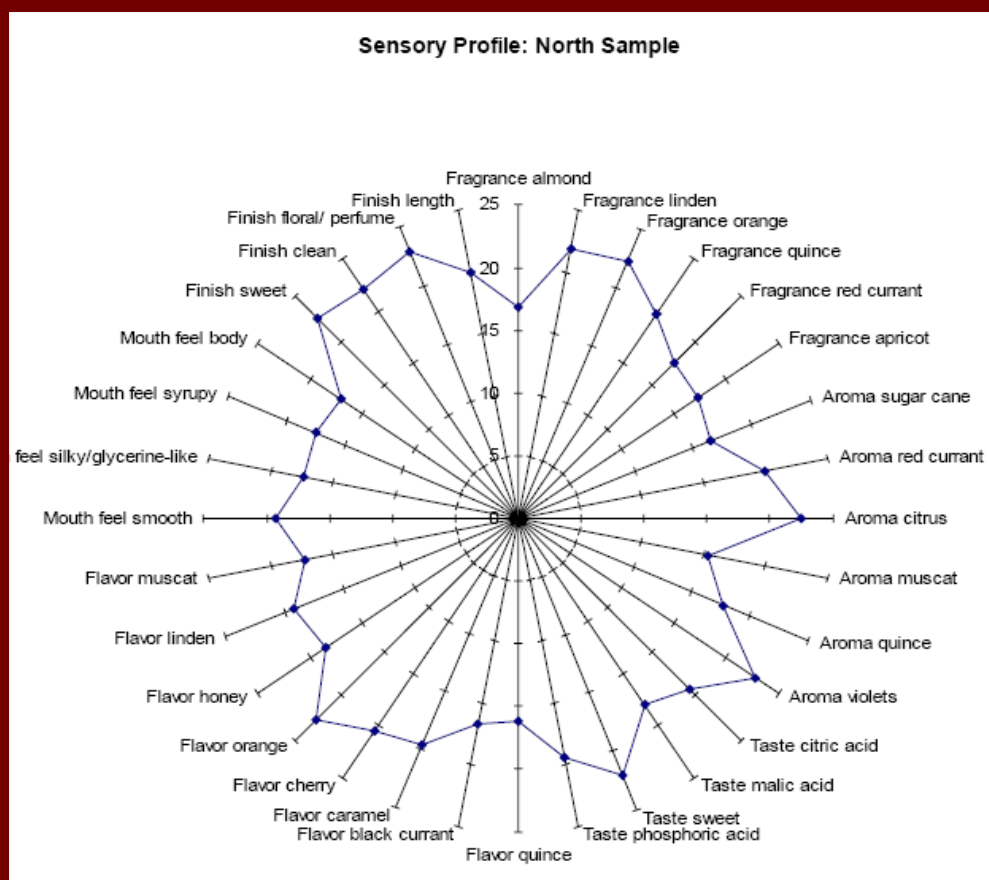
Materials and Methods

- **Winning coffees from the 2007 Rwandan Golden cup competition were used since they represent the highest standards of quality for Rwanda**
- **3 samples from each of 8 main production regions were evaluated for their taste attributes**
- **1 of 3 samples were selected as being the most representative of the zone based on unique, repeatable taste attributes from descriptive cupping**
- **Each of the 8 selected coffees were then rigorously evaluated by a international descriptive panel and results were tested for conformity with their two zonal 'sisters'**
- **Statistical and geo-spatial analyses were then performed to determine if the taste attributes associated with the 8 exemplary coffees could be correlated to discrete geographic variables from the zones in which they were produced**



Descriptive Profiling

A critical step of the methodology to investigate which flavor attributes are unique and would distinguish the coffees from others currently on the market and show the greatest probability of appearance in coffees from the same region.



Taste attributes
evaluated

Fragrance

Aroma

Taste

Flavor

Mouth feel

Finish

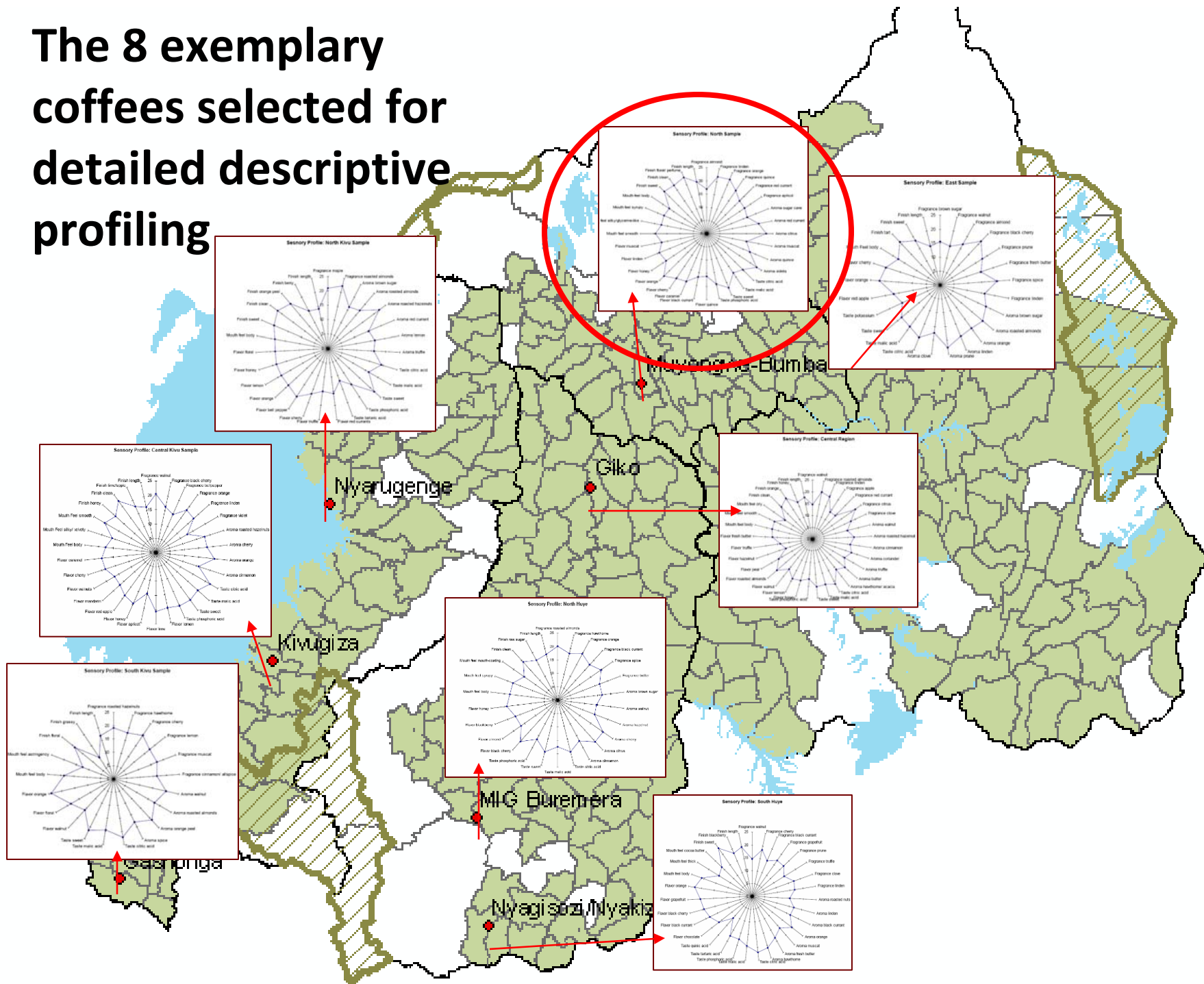
Descriptive Cupping

The Zen of cupping

- Not concerned with 'scores'
- Each coffee is evaluated by a panel of experts
- Taste attributes are referenced back to LNDV and LNDC
- Panel consensus is made on attribute presence and intensity



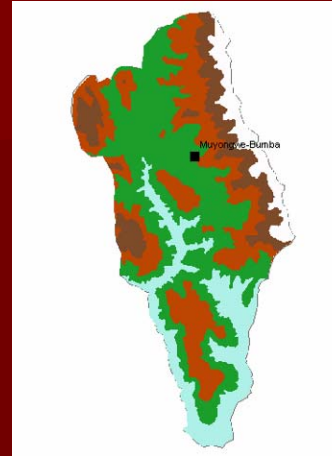
The 8 exemplary coffees selected for detailed descriptive profiling



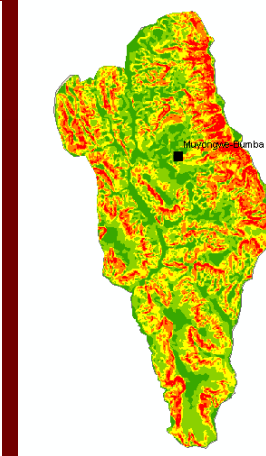
Geo-referenced GIS Database

Data available (min, mean, max, standard deviation):

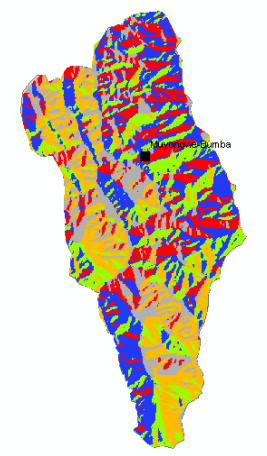
- Elevation
- Slope
- Exposition
- Climate:
 - temperature,
 - Humidity,
 - Rainfall,
 - Evaporation
- Soil characteristics:
 - soil PH,
 - C/N,
 - Mg,
 - Ca,
 - Organic material,
 - Potassium



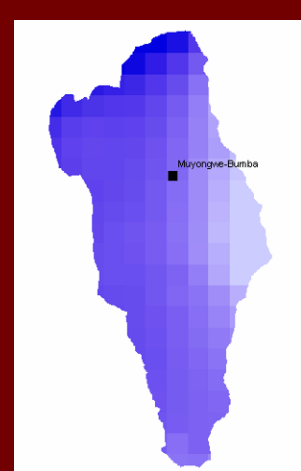
Elevation



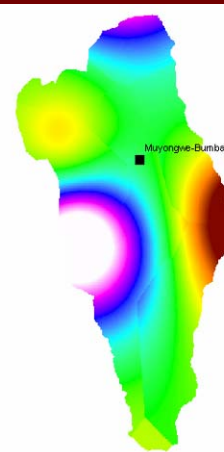
Slope



Aspect



Rainfall



Temp



Soil

Statistical analysis

A priori Groups

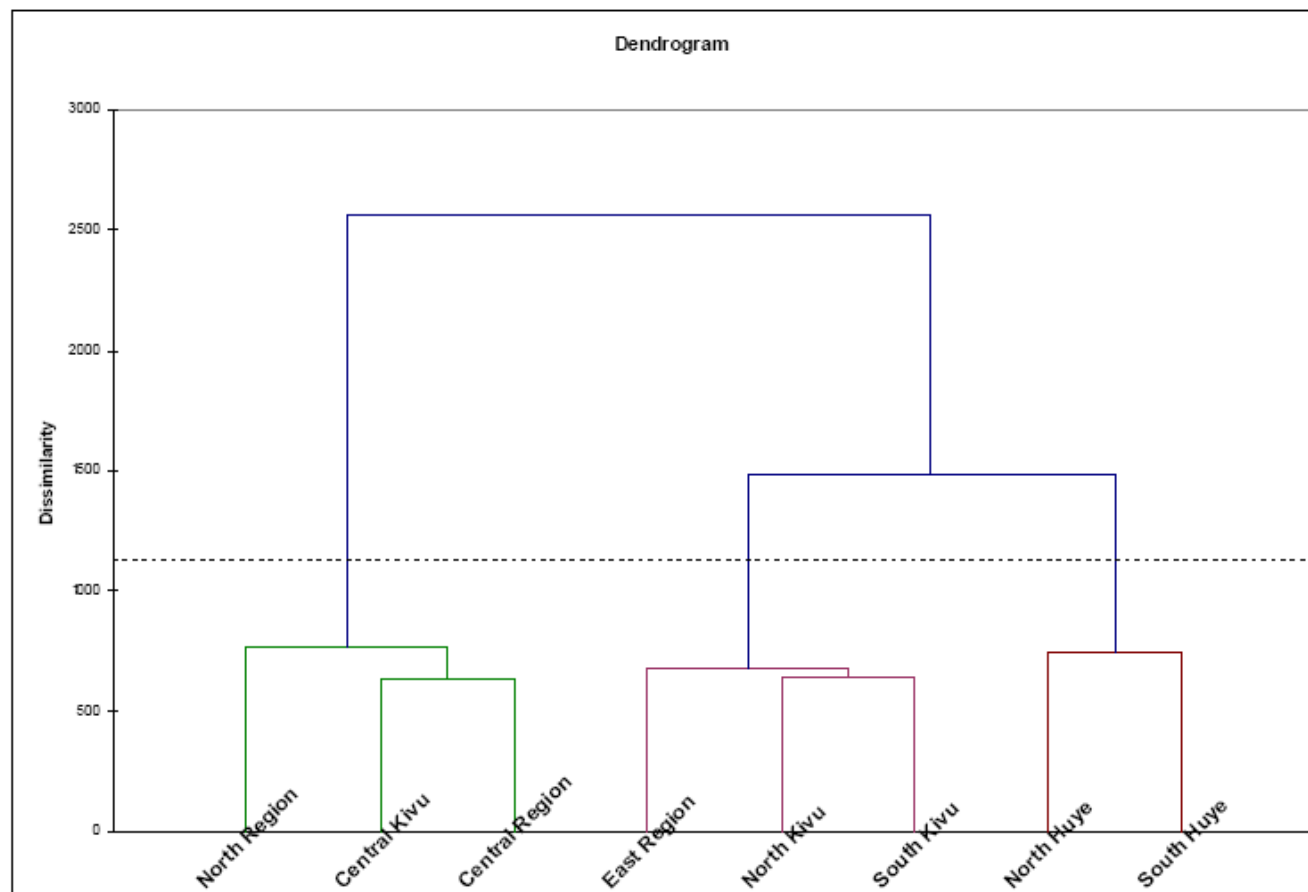


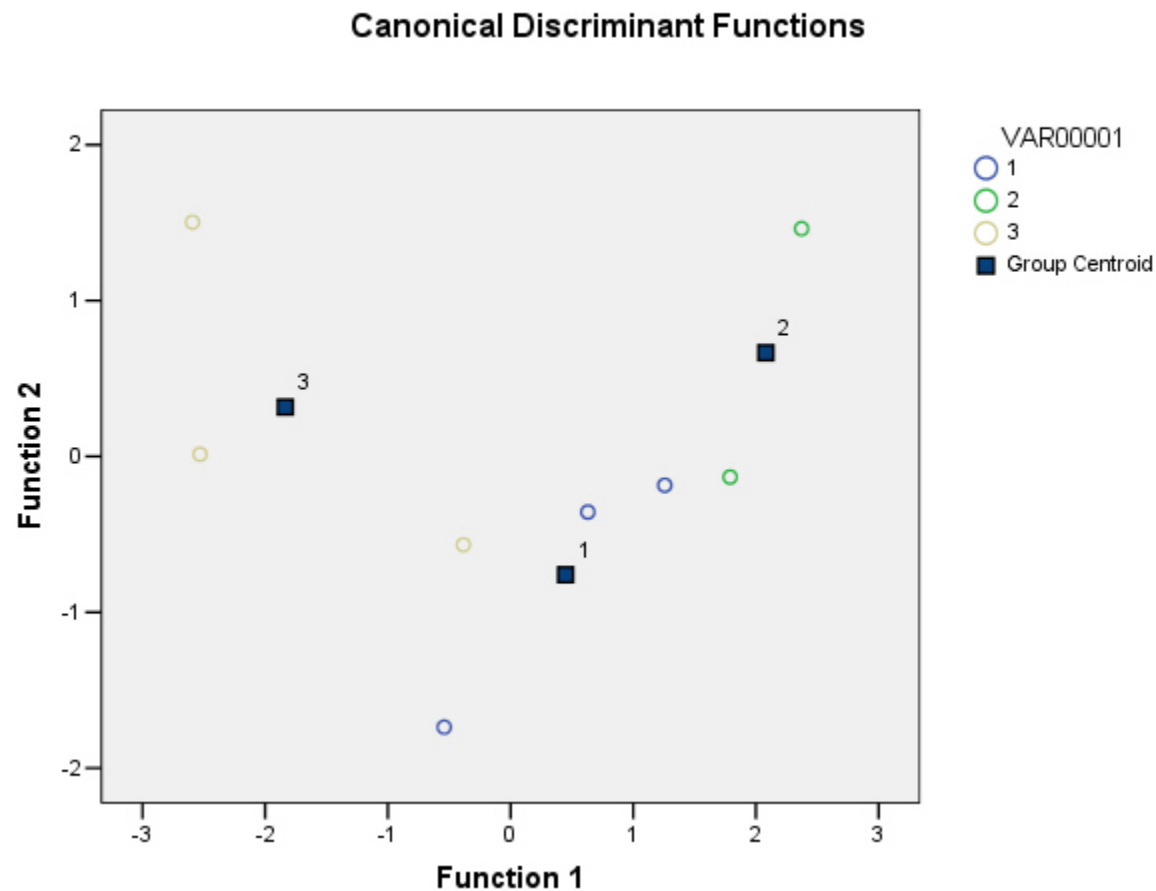
Figure 20: Dendrogram of samples.

Group 1: North region, Central Kivu, Central Region

Group 2: North Huye and South Huye

Group 3: North Kivu, South Kivu and East Region

Discriminant Analysis results confirms other statistical methods



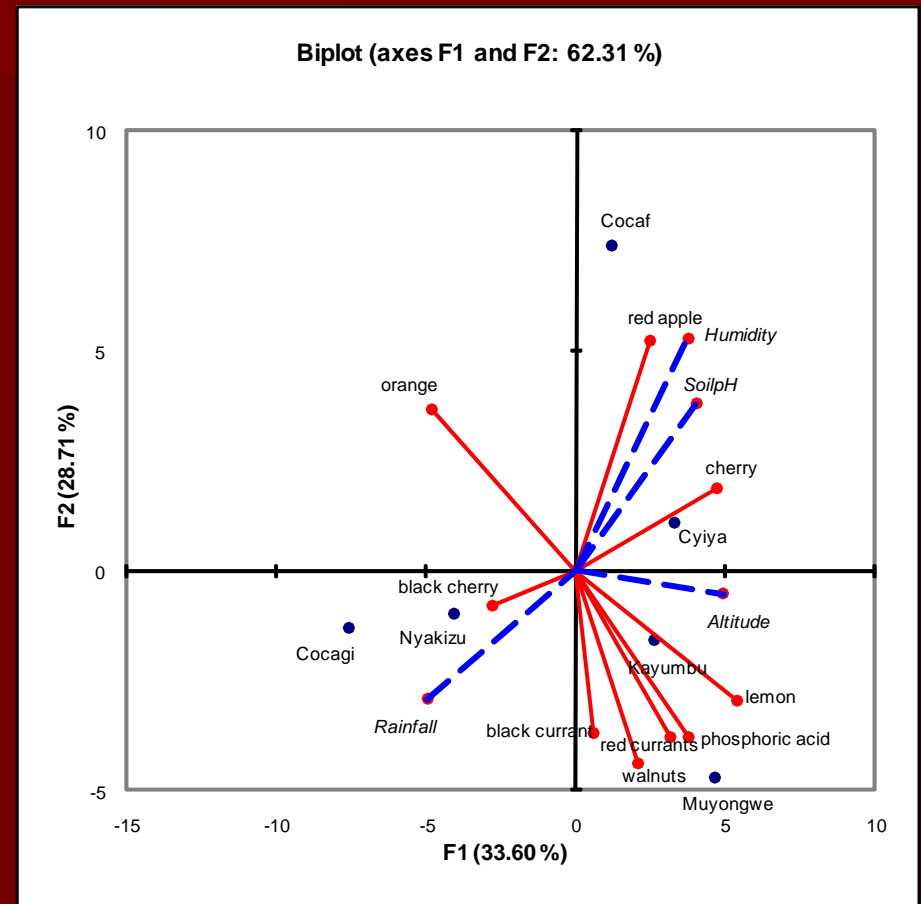
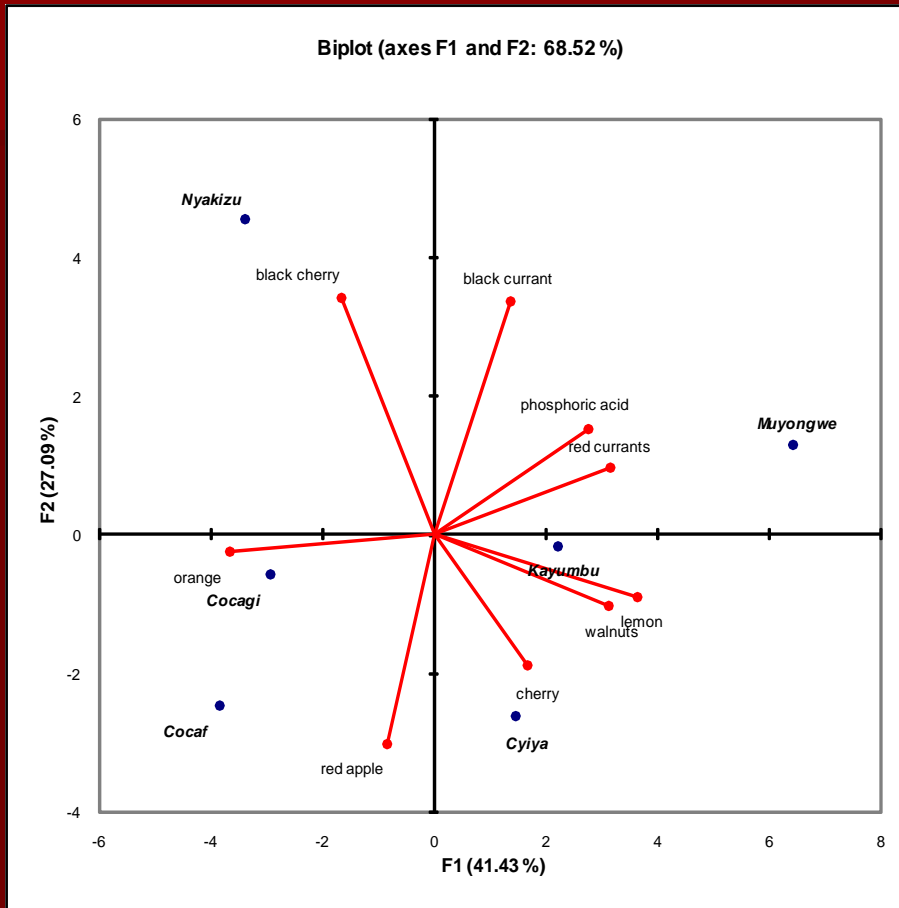
Group 1: North region, Central Kivu, Central Region

Group 2: North Huye and South Huye

Group 3: North Kivu, South Kivu and East Region

Taste attributes in space

Taste attributes explained



- Higher pH and relative humidity responsible for the unique 'Kivu' taste flavors of red apple and cherry
- High altitude and good rainfall responsible for the unique 'North Mountain' taste flavors of
- walnuts, currants and lemon

Preliminary results

- Rwanda possesses the potential to develop 3 appellations based on relations between their unique taste profiles and certain geographic variables
 - Northern plain region
 - Central Kivu region
 - North Huye region
- Strong indication that some taste attributes can be explained by geographic variables
- Next iteration will include higher number of samples from the above selected regions for further confirmation and development

REPUBLIC OF RWANDA

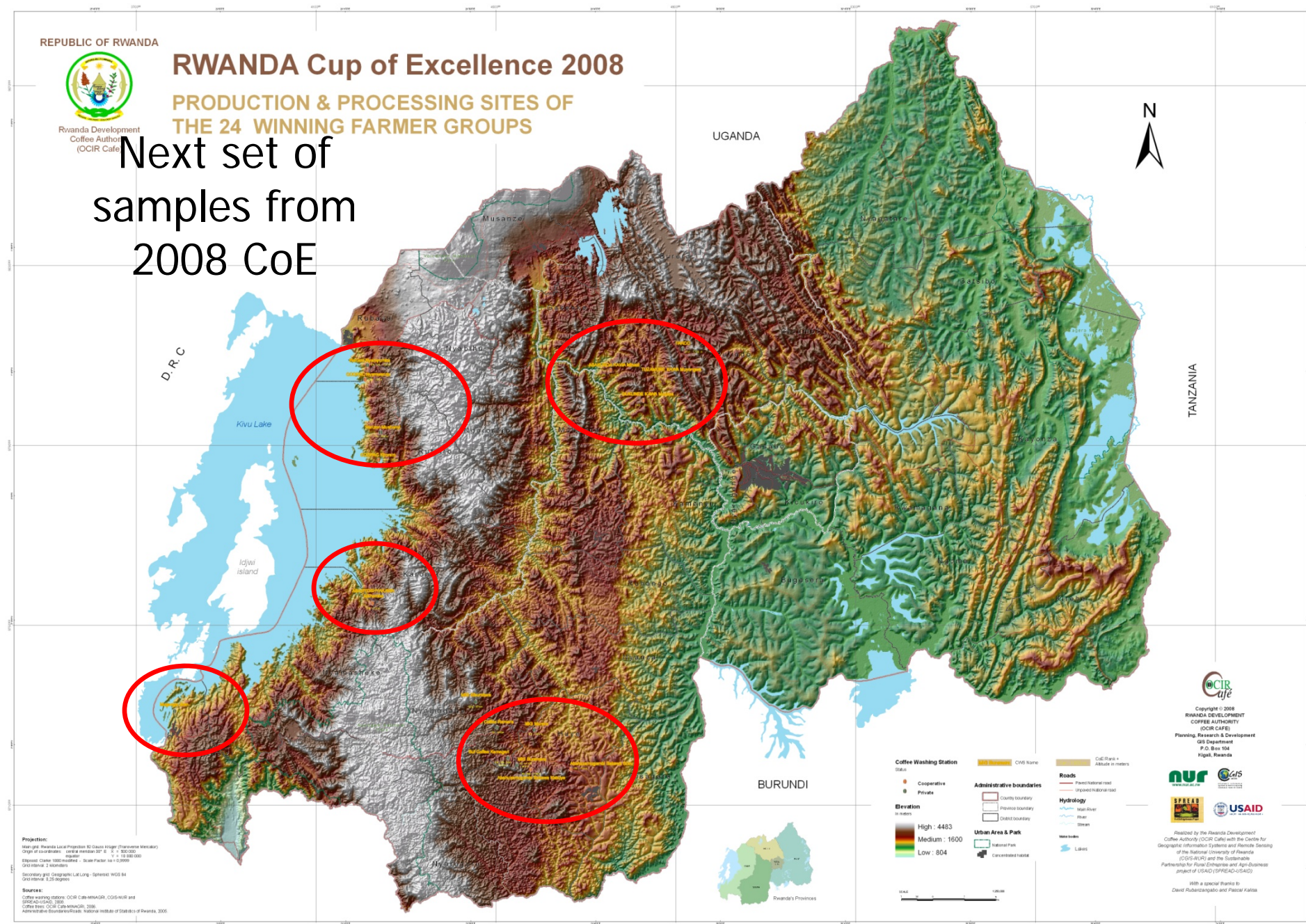


Rwanda Development
Coffee Authority
(OCIR CAFE)

RWANDA Cup of Excellence 2008

PRODUCTION & PROCESSING SITES OF
THE 24 WINNING FARMER GROUPS

Next set of
samples from
2008 CoE



General way forward

- Coffee quality can be increased through collaborative research conceived by origin and consuming market segments and executed in cooperation with U.S. and origin research institutions
- Taste attribute evaluation best done in consuming market countries with experienced coffee buyers
- If this were expanded, formalized and funded....