Maize Production Environments Revisited

A GIS-based Approach

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Executive Summary

To improve the targeting of germplasm by its staff and partners, in the 1980s CIMMYT defined a set of global maize production environments known as "mega-environments" (MEs). Center staff interviewed research partners in approximately 70 maize producing countries of the developing world. Based on the results, the major, non-temperate maize production ecologies were subdivided into 30 large, not necessarily contiguous areas according to such factors as maturity, preferred grain color and texture, and important production constraints (drought, low N conditions, diseases, insect pests). These ME definitions are very useful for targeting and priority setting, but also have shortcomings. They are based on expert knowledge and are therefore subjective. Crop losses due to diseases, pests and abiotic stress factors are estimated and not based on trials. The timing and severity of common stresses are not defined, thus precise aggregation of areas with similar stress ratings is difficult. Furthermore, definitions focus on regions where CIMMYT has strong contacts, leaving some areas poorly characterized. In some regions, different MEs overlap, making the system difficult to use. Finally, maize cropping locations, circumstances, and systems have changed considerably since the original ME study, but updating of MEs has been sketchy for lack of resources to do a complete, methodical revision.

This publication presents a revision of the maize MEs that draws on geographic information systems (GISs). A cluster analysis was performed on climate data, representing a four-month growing season, for key maize producing locations. The onset of the growing season was determined based on the month when the ratio of precipitation over potential evapotranspiration exceeds 0.5, assuming rainfed production conditions. Diagnostic criteria for mapping MEs were based on cluster analysis results and expert knowledge, and resulted in divisions based on daylength, mean temperature, and precipitation. The resulting maps and classifications can be used to select appropriate target environments for maize germplasm and trials at the regional level, as well as in priority setting and site selection for global maize breeding programs. The full ME classification and map (Table 5 and Appendix H) is more detailed than many users will want to deal with, so a simplified map **(Centerfold)** and table of criteria (Table 1) were prepared that eliminate the subdivisions based on precipitation. In any case, the creation of surfaces for precipitation is more problematic than for temperature. Variation in precipitation often shows no relation to elevation, and precipitation amounts may change rapidly over relatively short distances (e.g., in rain shadows). We expect that users of the map will usually have a good understanding of such local variation.

The ME definitions need further refinement using actual maize production[1] and distribution data; long-term trial results that represent genotype-by-environment interaction and the incidence and severity of stresses; improved data on soils; information on consumer preferences; and the identification of irrigated maize areas in developing countries, to name a few important factors.

[1] Including planting dates for main and secondary seasons.

Table 1. Descriptions, regions, countries, and key sites associated with global maize mega-environments.

ME	Name	Daylength (h)	Mean temperature (ºC)	Description *
1	Tropical lowland	11-12.5	>=24	Equatorial Central and South America and Southeast Asia, as well as coastal regions of Africa. Largely high humidity, rainfed systems. Includes some winter season regions at higher latitudes. Key sites: Suwan (W), Thailand; Bangalore (W), India; Tarapoto, Peru; Mvuazi, DRC; Kwadoso, Ghana.
2	Tropical midaltitude	11-12.5	>= 18 < 24	Much of inland equatorial sub-Saharan Africa, Central and South America. Key sites: Sete Lagos, Brazil; Palmira, Colombia; Turrialba, Costa Rica; Nazareth, Ethiopia; Embu, Kenya; Poza Rica (W), Mexico.
3	Tropical highland	11-12.5	< 18	Equatorial highlands, typically over 2,000 masl. Key sites: Rio Negro, Colombia; Ambo, Ethiopia; Cajamarca, Peru.
4	Non-equatorial Tropical - Subtropical lowland	12.5-13.4	>=24	Major environment of Central and South America, sub-Saharan and West Africa and Asia. Key sites: Ludhiana, India; Chiredzi, Zimbabwe; Santa Cruz, Bolivia; La Ceiba, Honduras; Poza Rica (S), Mexico; Tlaltizapan (S), Mexico; Suwan (S), Thailand.
5	Non-equatorial Tropical - Subtropical midaltitude	12.5-13.4	>= 18 < 24	Major environment of sub-Saharan Africa and the Mexican highlands. Typically less than 1,800 masl. Usually rainfed but with large variation in rainfall. Key sites: Harare, Zimbabwe; Celaya, Mexico.
6	Non-equatorial Tropical - Subtropical highland	12.5-13.4	< 18	Many scattered highland regions of Central and South America and Africa. Typically over 1,800 masl. Key sites: El Batan, Mexico; Thaba Seka, Lesotho.
7	Subtropical winter hot	< 11	>=24	No regions fit these criteria. The category is included only for completeness. Key sites: None.
8	Subtropical winter warm	< 11	>= 18 < 24	Typically irrigated regions at lower elevations. Key sites: Los Mochis (W), Mexico; Joydebpur (W), Bangladesh.
9	Subtropical winter cold	<11	< 18	Very limited area with cool, subtropical climate, but no frost in winter season. Key sites: Good Hope, Botswana.
10	Subtropical -Temperate hot	>= 13.4	>=24	Ranges from very dry irrigated to humid rainfed environments. Key sites: Sakha, Egypt; Chokwe, Mozambique; Rampur (S), Nepal; Islamabad, Pakistan; Temple, Texas.
11	Subtropical -Temperate warm	>= 13.4	>=18 <24	Major temperate maize production regions of USA and China. Key sites: Kunming, China; Lumle, Nepal; Potchefstroom, South Africa; Toulouse, France; Ferrara, Italy; Pyongyang, North Korea; Ames, Iowa, USA; Davis, California, USA.
12	Subtropical -Temperate cold	>= 13.4	< 18	Highest latitude regions where maize production is possible. Key sites: La Platina, Chile; Guelph, Ontario; Orleans, France.

* For key sites, S = summer season and W = winter season.

Maize Production Environments Revisited: A GIS-based Approach

Introduction

In agricultural research and development, priorities are often set and promising technologies targeted within particular crop production settings, taking into account spatial variation in biophysical and socioeconomic factors. Agricultural production environments vary by climate (a function of latitude, altitude, and other factors), soil and related aspects, consumer and producer preferences, accessibility, and input use, among other things. The effectiveness of agricultural interventions – improved cultivars, agronomic management practices, decision support systems – depends on these factors. Thus, researchers often define the limits of an environment within which a given technology is applicable.

When the CIMMYT Maize Program began developing germplasm for maize production environments in the developing world 35 years ago, it adopted a strategy for efficiently applying resources to a range of needs and problems. That strategy involved grouping the world's maize production regions into major ecologies: the lowland tropics, the subtropics, midaltitude regions, and the highlands. By the late 1980s, the Program had subdivided these ecologies into 30 areas called mega-environments (MEs) in 70 countries. MEs were defined as the largest subunits of a crop's growing or target environment within which a particular variety or related practice was useful (Pham and Edmeades 1987; CIMMYT 1989b; Delacy et al. 1994). For the Maize Program at that time, it involved such factors as maturity, preferred grain color and texture, and production constraints (e.g., drought, low N conditions, diseases, insect pests) to which the germplasm must be resistant or tolerant. The typical ME encompassed large (in excess of 1 million ha), not necessarily contiguous areas in several countries (CIMMYT 1989a).

Use of the ME concept at CIMMYT

Mega-environments were originally intended to help crop breeders manage genotype-by-environment interaction and extrapolate successful varieties and results from one site or region to other locations where they might have potential use. The relative size of each ME — together with considerations such as impact on the poor, likeliness of success, and the presence of alternative suppliers — was a key criterion in strategic planning and the subsequent allocation of resources during the late 1980s and early 1990s (CIMMYT 1989a). Since then, the concept has also been applied in designing and testing new crop management practices (Sayre and Moreno Ramos 1997; CIMMYT Annual Report 1999) and other products of research by CIMMYT and its partners. The ME concept has proven useful for setting priorities, planning strategy, and collaborating with researchers worldwide (CIMMYT 1990).

Refining ME definitions

CIMMYT initially characterized maize and wheat production environments through consultation with regional staff and scientists in national programs (CIMMYT Maize Program 1988;

CIMMYT 1989b). The criteria used were semi-quantitative, and there was frequent discussion about whether the classification of environments could be revised using more objective and easily reproducible measures. The development of geographic information systems (GIS), as well as improved coverage and reliability in data for factors such as climate, soils, and topography, offered a way to achieve this, as demonstrated in preliminary work by Pollak and Corbett (1993).

This paper describes a GIS-based approach for refining the definition of maize MEs. It reviews the origin of the ME concept in more detail, summarizes various iterations of maize MEs, and concludes with a version that uses daylength, temperature, and season rainfall as classification criteria.

Previous ME Classification Methods

The first global ME study: 1985-1988

The first initiatives at CIMMYT to assemble ME information started in 1977 for wheat. Regional and national program staff were asked to identify major production regions by country, setting a lower limit of harvested area of 100,000 ha annually. These regions were described in terms of area; crop type; moisture conditions; incidence of heat, cold, and drought; maturity requirements; and the average annual loss to specific diseases and insects. By 1985, after several iterations of data collection and analysis, rough maps of national production regions were available and a computerized database was produced (CIMMYT 1989b).

Tropical maize is grown over a wider range of environments than wheat and interacts more closely with its environment, making the ME approach potentially more useful for maize. When CIMMYT began to define global maize MEs in 1985, it used the same approach as for wheat, except that losses from pests and diseases were considered and greater attention paid to preferences for grain texture and color. The main criteria were elevation and climate zones (Appendix A). The information was computerized and rough maps of 30 MEs, as drawn by the numerous contributors, were published in 1988. This reference, often referred to as "The Yellow Book" (CIMMYT Maize Program 1988), has since been an important tool for CIMMYT and its partners. A summary table was developed (CIMMYT 1989c) in which not only area but yield level and grain production were estimated (Appendix A). Production data could be weighted by factors such as utilization (food vs feed), per capita income, relative strength of a national program, or emphasis on a particular region (e.g., sub-Saharan Africa).

Updating the global ME 1985-88 survey results

The construction of a database from expert knowledge was very expensive, making it impracticable to update the ME definitions comprehensively on a regular basis. Because biannual updates of maize area, production, and yield were needed, the 1985-88 estimates were increased with correction factors derived from FAO country level statistics. The areas of all MEs in a given country were automatically increased at the same ratio as the increase for the country's entire maize area.

Table 2. Agroclimatic criteria used for the maize environment classification by Dowswell et al. (1996).

Environment	Mean growing season temperature (°C) Min.	Max.	Mean	Altitude (masl)	Latitude
Tropical	22	32	28	<1,000	33° or lower
Subtropical	17	32	25	<1,600	23-33°
“	17	32	25	1,000-1,800	23° or lower
Temperate	14	24	20	<500	34° or higher
Highland	7	24	16	>1,800	23° or lower
“	9	25	18	>1,600	23-34°

In publications on the impact of international maize breeding (Lopez-Pereira and Morris 1994; Morris 1998), the 1985-1988 ME classification was updated with information from the FAO AGROSTAT (FAO 1990) database (see Appendix B; Tables B.1 and B.2). Dowswell et al. (1996) suggested a more expanded table with agroclimatic criteria (Table 2). Using information from the 1985-1988 study, they produced an area table by region (Appendix B; Table B.3).

Classification of testing sites with point based meteorological data

In 1989, an attempt was made to classify maize testing sites in sub-Saharan Africa (Pollak and Pham 1989). Forty-two sites from sub-Saharan Africa were used to create seven clusters. Fifty-two monthly agroclimatic variables from ten years of meteorological data from those sites were used. The classification used Ward's method of cluster analysis and canonical discriminant analysis. They identified four lowland regions, two midaltitude regions, and one highland region. Lowland regions were separated into 1) high rainfall, 2) warm temperatures and high rainfall, 3) low minimum temperature, and 4) very high temperature.

The 1991 classification attempt

In 1991, an interdisciplinary group was formed at CIMMYT to redefine maize MEs using more objective criteria. An initial effort resulted in the criteria shown in Table 3. These classification criteria were to be sent to CIMMYT outreach staff and collaborating national programs, as was done in 1985, but with the hope of obtaining more objective and reproducible area estimates. The effort never went further, due to funding constraints.

Limitations to previous classification approaches

The 1985-88 study is still widely used in international maize research, including the private sector (McCarter 1998, personal communication). This testifies to the overall utility of the ME concept and the robustness of the maize MEs defined largely on expert knowledge. However, several limitations of this approach are apparent.

The definition of environments is subjective. For example, terms such as “midaltitude” and “subtropical” are sometimes used interchangeably where germplasm requirements are similar, so

Table 3. Maize Mega-Environment Update Committee classification, 1991.

Ecology	Mean growing season temperature (°C)	Elevation (masl)	Latitude
Lowland tropics	>24	0-1,000	30°N-30°S
Midaltitude tropical	20-24	800-1,800	30°N-30°S
Subtropical	20-24	-	>20°N & >20°S
Tropical highland transition	17-20	1,500-1,800	30°N-30°S
Tropical highland	12.5-17	>2,000	30°N-30°S
Temperate	20-22	-	>30°N & >30°S
Highland temperate	15-20	-	>30°N & >30°S

results are not easily reproducible, and the two types of ME are not separated well enough. (The 1985-88 classification created many overlapping subdivisions in certain regions.) Crop losses due to diseases, pests and abiotic stress factors are estimated, rather than being based on trial results. The timing and severity of common stresses are not defined, even though they may strongly affect the extent of crop losses. As a result, an assessment of one stress factor in a given region may not really be comparable to the same level of stress identified in another region. This makes the aggregation of areas with similar ratings for various stress factors imprecise. The same applies for the use of elevation: perceptions of "lowland," "midaltitude," and "highland" can vary among maize researches, especially across regions and where countries have established their own classifications. Moreover, the ME definitions described above focus on regions where CIMMYT has strong contacts, leaving certain areas in Asia, for example, poorly characterized. Finally, maize cropping locations, circumstances, and systems have changed considerably since the original ME study, but updating of the definitions has been sketchy for lack of resources to do a more complete, methodical revision.

GIS-based Approaches

To avoid confusion in terminology, update area and production data, identify non-overlapping MEs, and introduce more useful, diagnostic variables, CIMMYT proposed in 1996 to redefine global maize MEs using geographic information systems (GIS). Use of a GIS can ensure that criteria are applied consistently across regions. Furthermore, a GIS can combine or link many types of data (climate and soils, pests and diseases, socioeconomic factors) by overlaying and merging them.

The availability of environmental data has improved greatly with the development of GIS. Elevation data on a 1-km grid are available for the entire globe (USGS 1997). Climate data, including long-term monthly means for maximum and minimum temperature and totals for precipitation and potential evapotranspiration, are available as interpolated surfaces with a grid cell size typically of 5 to 10 km^2 (Corbett and O'Brien 1997). The interpolation procedures used can allow for elevation effects and normally offer more accurate results than simple estimations of climate based on reference to the nearest station (Hartkamp et al. 1999). Obtaining detailed and reliable soil and crop distribution data is still problematic. The best global soil database is the FAO digital soil map of the world (FAO 1996) at a 1:5,000,000 scale. Crop distribution data are available for Latin America (Hyman et al. 1998) and efforts to obtain similar data for Africa are under way (P. Thornton, personal communication). [2]

A first attempt to define maize ecologies using GIS-based approaches was made by Pollak and Corbett (1993) for Central America and Mexico. They clustered grid cells based on elevation and mean monthly precipitation and temperature data during the growing season (April through October). Ten ecologies were identified: three lowland, three highland, two subtropical, and two transitional from subtropical to highland.

Gebrekidan et al. (1992) and Corbett (1998) proposed a geographic approach to define maize production environments for Kenya. The ecologies (lowland, midaltitude, transitional, and highland) are based on altitude and a cutoff between moist (> 550 mm) and dry (< 550 mm) for the growing

[2] Crop distribution data are critical sources of information on area and production, essential to the definition of maize production environments.

season (March to August). The moist transitional zone (1,200 to 2,000 masl, > 550 mm) accounts for the largest portion (41%) of the total maize area.

Criteria from the aborted 1991 study were later used at CIMMYT to create global maps representing maize production zones. An example is given for South America in Appendix C. The growing season was determined using the Spatial Characterization Tool (SCT) "optimal season" climate model (Corbett and O'Brien 1997). The optimal season is defined as the five-month period with the largest ratio of precipitation over potential evapotranspiration. Mean growing season temperatures were replaced by minimum and maximum temperature ranges (-6ºC and +6ºC from the mean temperature). This approach is only approximate, because diurnal temperature ranges in lowland tropical areas are typically smaller than in the highlands. Data on the start and length of the onset of the growing season were estimated by assuming that the ratio of precipitation to potential evapotranspiration exceeds 0.5 during the season ("trigger season" climate model). This approach has proven useful in targeting different maturity classes of maize in sub-Saharan Africa, although the 0.5 limit appears to be too high for most drier areas where maize is sown at low densities (Hodson et al. 1999).

In a regional refinement to this global classification, maize areas were assigned to ME climatology zones in Latin America, based on maize production data. A crop distribution database for Latin America was developed by the GIS group at the Centro Internacional de Agricultura Tropical (CIAT; Hyman et al. 1998). Disaggregated, municipality-level maize production information was reclassified to identify municipalities where at least 10,000 ha of maize was grown, applying a probability model that included infrastructure, transportation access, and location of populated areas. The crop distribution information for maize was then overlaid on the ME zonal maps for Latin America by country (Appendix D).

Methodology for this Study

About 150 representative sites were selected from records for international maize trials, and approximately 70 sites were added to cover regions where trials had not been conducted (Appendix E).[3] Information on planting dates was compiled from international trial reports and in consultation with maize researchers. A separate set of planting dates was obtained using the climate models for the trigger and optimal seasons, as defined in the SCT environmental database (Corbett and O'Brien 1997). Monthly climate data for the selected sites were obtained using the climate surfaces. For Africa and Latin America, gridded climate surfaces were derived from Corbett and O'Brien (1997). For Asia, gridded climate surfaces were derived from Jones (1998). Starting with the reported month of planting, variables from the first four consecutive months were taken. This interval was chosen to represent a 120-day maize crop cycle.

Daylength (d) was estimated using the algorithm of Goudriaan and Van Laar, (1994):

$$d=12 * [1+ (2/pi) * asin(a/b)]$$

$$a = sin(lat)*sin(om) \quad b = cos(lat)*cos(om)$$

$$sin(om) = - sin (pi * 23.45/180) * cos (2 * pi * (td + 10)/365),$$

where :

lat = latitude

td = day of year.

[3] The geographical coordinates of these sites were carefully checked.

To represent the daylength that affects floral initiation, three values for *td* were used: 15 days, 30 days, and 45 days after planting date.[4]

For the hierarchical cluster analysis, Ward's clustering procedure (Ward 1963) within SAS 6.12 (SAS Institute 1998) was used. All variables (daylength, temperature difference, mean temperature, precipitation and evapotranspiration) were standardized by subtracting the mean and dividing by the standard deviation. Cluster distance was not stable enough to determine an optimal number of clusters, so a maximum of 15 clusters was allowed, since this was considered to provide a manageable number of MEs. Clusters were estimated based on daylength and the first four monthly mean climate variables derived from:

- Planting dates as reported in the CIMMYT Maize International Testing Unit database or compiled through consultation with maize scientists.
- Planting dates as estimated based on start of the trigger season.
- Planting dates as estimated based on the start of the optimal season.

Criteria were derived from evaluating the values of the environmental variables of members within each cluster. Maize production environments were mapped and feedback from experts was sought. After several iterations this resulted in a revised set of criteria for defining maize MEs.

[4] The 15th day of the planting month was considered the planting date.

Results and Discussion

Planting date and clusters

Each approach to define planting date and growing season (reported, trigger season model, optimum season model) resulted in different cluster compositions. Site clusters using planting date from trigger season resembled site clusters from reported planting date more than site clusters from optimal season (data not shown). A set of "best bet" planting dates was compiled from the reported planting dates, trigger planting dates, and expert knowledge. These climate data were clustered again, giving the clusters shown in Appendix F. Mean cluster values are shown in Table 4.

Determining criteria

Classification criteria were determined from the range of values for environmental variables of the individual sites within the clusters. This was done iteratively; e.g., assuming a daylength of 13.5 h for high latitude to temperate areas and checking the sites that segregate at this criterion. This proved to segregate better at a daylength of 13.4 h. This process resulted in the use of three classification criteria: daylength, mean temperature, and seasonal rainfall over the four-month growing season (Table 5). After this process of determining the criteria based on membership of the selected sites to specific clusters, another application of the criteria involving maize scientists took place. For instance, analysis of the clusters suggested a different temperature criterion for distinguishing non-equatorial subtropical lowlands from non-equatorial subtropical midaltitude environments (22ºC) than for distinguishing equatorial tropical lowlands from equatorial tropical midaltitude environments (24ºC). Upon mapping, however (see next paragraph), this did not provide a

Table 4. Cluster mean values for variables: daylength, temperature difference, mean temperature, precipitation and evapotranspiration. M1, M2...refers to month of growing season.

	Fre-	Daylength (h)			Tdifference (ºC)				Tmean (ºC)				Precipitation (mm)				Evapotranspiration (mm)			
Cluster	quency	M1	M2	M3	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4	M1	M2	M3	M4
1	5	12.2	12.0	11.8	7.3	7.7	8.2	8.7	27.4	27.0	25.6	23.9	243	125	66	41	170	172	166	156
2	28	12.5	12.6	12.7	10.0	9.1	8.3	8.1	28.0	27.7	27.4	27.1	116	161	196	233	190	181	169	165
3	7	10.7	10.5	10.5	14.5	15.4	15.8	16.4	21.1	18.1	17.7	20.0	16	10	12	13	142	126	126	152
4	19	12.1	12.2	12.1	7.8	7.6	7.7	8.2	25.7	25.7	25.8	26.0	182	196	177	166	109	105	107	114
5	25	12.0	12.0	12.0	11.8	10.8	10.6	11.0	21.8	21.2	20.9	20.9	95	135	119	89	117	108	104	107
6	15	12.6	12.6	12.6	9.9	9.3	9.4	9.5	26.8	26.3	26.1	26.3	279	352	364	322	131	122	120	119
7	9	12.1	12.1	12.1	9.4	8.8	8.9	9.5	15.3	15.2	15.2	15.1	172	233	190	124	89	86	82	86
8	23	12.7	12.8	12.9	11.2	9.6	9.5	9.7	22.7	22.0	21.9	21.9	145	251	244	210	137	121	117	112
9	39	13.0	13.0	13.0	12.5	11.6	11.4	11.6	24.1	23.9	24.0	24.3	129	171	163	138	144	140	135	130
10	12	13.3	13.1	12.9	14.3	13.6	14.0	14.8	21.3	20.6	20.4	20.6	97	113	97	73	149	139	125	108
11	17	12.7	12.9	13.1	14.0	13.0	12.8	13.0	14.3	14.9	15.5	16.0	81	110	119	115	112	114	118	120
12	11	13.7	13.7	13.5	9.1	7.2	7.3	7.7	26.8	26.4	26.2	25.2	218	359	348	240	228	209	210	197
13	2	13.5	13.7	13.8	9.1	6.9	5.8	6.1	23.1	24.0	24.0	23.9	327	735	1133	1061	215	200	195	200
14	5	13.5	13.5	13.4	14.1	13.3	13.2	12.8	25.4	26.8	27.2	25.8	1	3	10	22	196	204	195	171
15	4	14.1	13.9	13.7	13.9	10.4	10.5	13.7	32.5	31.0	29.8	27.8	74	139	144	53	355	295	280	280

satisfactory distinction between lowland and midaltitude environments, so we reverted to a uniform temperature criterion of 24ºC to distinguish between lowland and midaltitude environments in both the equatorial tropics and non-equatorial subtropics.

Finally, locations were classified according to the new criteria. To compare classification methods, the sites were also classified using the previous classification criteria. This is depicted in the first columns of Appendix G.

Mapping maize MEs

Because the actual planting date for each map cell was not available, we used the planting date surface as defined by the trigger season model of the SCT (Corbett and O'Brien 1997) for mapping maize MEs. Moreover, planting dates as reported by collaborators conducting international maize trials may not necessarily follow the actual growing season, because they may plant late due to late arrival of seed shipments or use irrigation (which allows them to plant outside the normal season). Farmers in contrast are more dependent on the actual start of the growing season.[5] Daylength maps were calculated from latitude grids and the trigger season planting date (averaging values for +15, +30 and +45 days after trigger season planting date). Zonal maps were made using criteria from Table 5 (Appendix H). A simplified map (centerfold) was created by eliminating the precipitation criteria.

Use of maize mega-environment maps and information

The maize MEs provide a global characterization of the target environments for tropical maize germplasm. Potential users and applications include:

- For research managers to set priorities and allocate resources.
- For scientists to focus efforts on relevant products; i.e., those most urgently needed for the most important MEs. (Thus, if early-maturing, drought

[5] The start of the trigger growing season commonly coincides with the main (summer-autumn) growing season. The secondary season is thus not represented here.

Table 5. Cluster criteria for revised maize mega-environments, including subdivisions based on precipitation, for a 4-month growing season.

No.	Name	Daylength (h)	Mean temperature (°C)	Precipitation (mm)
1a	Too dry lowland tropical	11 to 12.5	≥ 24	< 200
1b	Lowland tropical mesic	11 to 12.5	≥ 24	≥ 200 and <600
1c	Lowland tropical wet	11 to 12.5	≥ 24	≥ 600 and <2,000
1d	Lowland tropical excess	11 to 12.5	≥ 24	≥ 2,000
2a	Too dry tropical midaltitude	11 to 12.5	> 18 and < 24	< 200
2b	Tropical midaltitude mesic	11 to 12.5	> 18 and < 24	≥ 200 and < 600
2c	Tropical midaltitude wet	11 to 12.5	> 18 and < 24	≥ 600 and < 2,000
2d	Tropical midaltitude excess	11 to 12.5	> 18 and < 24	≥ 2,000
3a	Too dry tropical highland	11 to 12.5	≤ 18	< 200
3b	Tropical highland mesic	11 to 12.5	≤ 18	≥ 200 and < 600
3c	Tropical highland wet	11 to 12.5	≤ 18	≥ 600 and < 2,000
3d	Tropical highland excess	11 to 12.5	≤ 18	≥ 2,000
4a	Too dry non-equatorial tropical/subtropical lowland	12.5 to 13.4	≥ 24	< 200
4b	Non-equatorial tropical/subtropical lowland mesic	12.5 to 13.4	≥ 24	≥ 200 and < 600
4c	Non-equatorial tropical/subtropical lowland wet	12.5 to 13.4	≥ 24	≥ 600 and < 2,000
4d	Non-equatorial tropical/subtropical lowland excess	12.5 to 13.4	≥ 24	≥ 2000
5a	Too dry non-equatorial tropical/subtropical midaltitude	12.5 to 13.4	> 18 and < 24	< 200
5b	Non-equatorial tropical/subtropical midaltitude mesic	12.5 to 13.4	> 18 and < 24	≥ 200 and < 600
5c	Non-equatorial tropical/subtropical midaltitude wet	12.5 to 13.4	> 18 and < 24	≥ 600 and < 2000
5d	Non-equatorial tropical/subtropical midaltitude excess	12.5 to 13.4	> 18 and < 24	≥ 2,000
6a	Too dry non-equatorial tropical/subtropical highland	12.5 to 13.4	≤ 18	< 200
6b	Non-equatorial tropical/subtropical highland mesic	12.5 to 13.4	≤ 18	≥ 200 and < 600
6c	Non-equatorial tropical/subtropical highland wet	12.5 to 13.4	≤ 18	≥ 600 and < 2,000
6d	Non-equatorial tropical/subtropical highland excess	12.5 to 13.4	≤ 18	≥ 2,000
7a	Subtropical winter hot dry	≤ 11	≥ 24	< 200
7b	Subtropical winter hot mesic	≤ 11	≥ 24	≥ 200 and < 600
7c	Subtropical winter hot wet	≤ 11	≥ 24	≥ 600 and < 2,000
7d	Subtropical winter hot excess	≤ 11	≥ 24	≥ 2,000
8a	Too dry subtropical winter warm	≤11	> 18 and < 24	< 200
8b	Subtropical winter warm mesic	≤11	> 18 and < 24	≥ 200 and < 600
8c	Subtropical winter warm wet	≤11	> 18 and < 24	≥ 600 and < 2,000
8d	Subtropical winter warm excess	≤11	> 18 and < 24	≥ 2,000
9a	Too dry subtropical winter cold	≤ 11	≤ 18	< 200
9b	Subtropical winter cold mesic	≤ 11	≤ 18	≥ 200 and < 600
9c	Subtropical winter cold wet	≤ 11	≤ 18	≥ 600 and < 2,000
9d	Subtropical winter cold excess	≤ 11	≤ 18	≥ 2,000
10a	Too dry temperate/subtropical lowland dry	≥ 13.4	≥ 24	< 200
10b	Temperate/subtropical hot mesic	≥ 13.4	≥ 24	≥ 200 and < 600
10c	Temperate/subtropical hot wet	≥ 13.4	≥ 24	≥ 600 and < 2,000
10d	Temperate/subtropical hot excess	≥ 13.4	≥ 24	≥ 2,000
11a	Too dry temperate/subtropical warm dry	≥ 13.4	> 18 and < 24	< 200
11b	Temperate/subtropical warm mesic	≥ 13.4	> 18 and < 24	≥ 200 and < 600
11c	Temperate/subtropical warm wet	≥ 13.4	> 18 and < 24	≥ 600 and < 2,000
11d	Temperate/subtropical warm excess	≥ 13.4	> 18 and < 24	≥ 2,000
12a	Too dry temperate/subtropical cold dry	≥ 13.4	≤ 18	< 200
12b	Temperate/subtropical cold mesic	≥ 13.4	≤ 18	≥ 200 and < 600
12c	Temperate/subtropical cold wet	≥ 13.4	≤ 18	≥ 600 and < 2,000
12d	Temperate/subtropical cold excess	≥ 13.4	≤ 18	≥ 2,000

stressed maize turns out to occupy substantially more area than currently estimated, it may deserve increased attention.)
- For scientists to test the right type of germplasm in the appropriate environments. This should also allow a reduction in the number of testing sites.
- For national program researchers and other partners to decide which type of germplasm and trials most suit their needs.

Challenges

The ME definitions provided here need to be refined through one or several of the following:

- Development of a global database of actual maize planting dates for main and secondary seasons.
- Identification of irrigated maize production areas.
- Integration of improved data on soils.
- Integration of data on consumer preferences.
- Integration of data on the incidence and severity of diseases and insect pests.
- Linkage to crop distribution data to obtain maize production information.

For validation purposes there is a need to link the proposed maize environment definitions to data on genotype-by-environment interactions from trials across MEs; this could also improve the efficiency of international testing. The work of Crossa et al. (1993) exemplifies an effective study of genotype-by-environment interaction. They analyzed eight years of historical maize data from multi-environment trials using pattern analysis on performance data. In this way, they were able to 1) tease out long-term relationships among international maize testing environments for which breeding strategies ought to be defined and 2) assess the long-term precision of trials at the specific testing locations.

Conclusions

The ME concept has proven a useful tool for setting priorities, allocating resources, and fostering international collaboration in agricultural research and development. Use of a GIS can allow scientists to 1) define environments according to more quantitative criteria and 2) visualize how these criteria affect the location of the environments. To be fully useful, the ME definitions provided here need to be refined using actual maize distribution and production data, as well as information on major production constraints, by country. A GIS-based approach can help researchers establish a framework within which other spatial data can be consulted. The ultimate goal is for researchers and other users to be able to formulate task-specific versions of the MEs or “query” a ME definition for information of interest.

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Appendix A. **Estimated area and production percentages for maize mega-environments, derived from the 1987-1988 mega-environment survey. (Classification criteria used in the 1987-1988 maize MEs are listed below.)**

Mega-environment	Estimated area (%)	Estimated production (%)	Weighted production (%)
Highland			
Tropical highlands	6.0	4.4	1.0
Tropical transitional	4.1	6.4	12.0
Temperate highlands	1.0	0.9	0.7
Subtotal	**11.0**	**11.7**	**13.7**
Subtropical			
Early white flint/dent	1.2	0.9	1.6
Early yellow flint	1.8	1.1	1.2
Intermediate white dent	7.5	9.5	8.6
Intermediate yellow flint	1.9	1.3	1.5
Late white flint	3.9	3.3	11.2
Late white dent	5.1	6.1	12.4
Late yellow dent/flint	7.8	9.5	2.6
Other	0.8	1.0	1.3
Subtotal	**30.3**	**32.6**	**40.4**
Lowland tropical			
Early white flint	4.0	2.2	3.7
Early white dent	1.2	0.7	1.0
Early yellow flint	7.1	4.3	3.5
Early yellow dent	2.5	1.3	0.5
Intermediate white flint	2.1	1.5	3.2
Intermediate white dent	5.3	6.2	3.6
Intermediate yellow flint	9.6	9.7	6.1
Late white flint	4.4	3.6	4.4
Late white dent	6.9	7.3	5.0
Late yellow flint	8.4	9.7	9.4
Late yellow dent	1.7	2.3	2.6
Others	5.8	7.0	2.9
Subtotal	**59.0**	**55.7**	**45.9**
Total	**100.0**	**100.0**	**100.0**

Classification criteria used in the 1987-1988 maize mega-environments study.

Ecology:
- LT: Lowland tropical
- TE: Temperate
- HT: Highland tropical
- ST: Subtropical
- TZ: Transitional zone
- SH: Temperate highland

Grain type:
- WD: White dent
- WF: White flint
- WFD: White (flint or dent)
- YD: Yellow dent
- YF: Yellow flint
- YFD: Yellow (flint or dent)
- MD: Mixed colors dent
- MD: Mixed colors flint
- MIX: Mixed colors (flint or dent)
- GF: Gray flint
- BF: Black flint
- WO: White floury
- YO: Yellow floury
- GO: Gray floury
- BO: Black floury
- WM: White morocho
- YM: Yellow morocho
- BM: Black morocho
- M: Morocho (yellow and white)

Growing season:
- MA: Major season
- MI: Minor season

Maturity:
- XE: Extra early
- E: Early
- I: Intermediate
- L: Late
- XL: Extra late

Moisture:
- A: Rarely stressed
- B: Sometimes stressed
- C: Frequently stressed
- D: Usually stressed

Soil type:
- 1: Normal
- 2: Acid

Disease and insects: A relative importance rating of 0-5, where 0 means no presence, and 5 means that maize cannot be grown unless a resistant variety is grown or chemical control is applied.

Appendix B. **Maize mega-environment updates using FAO information, 1990 and 1996.**

Table B.1. Maize production ecologies in developing and industrialized countries in 1990 (López-Pereira and Morris 1994).

	Developing countries			Industrialized countries	
Ecology	**Total maize area (million ha)**	**Percent of total**	**Percent of non-temperate**	**Total maize area (million ha)**	**Percent of total**
Lowland tropical	34.5	43	57	0	-
Subtropical	13	16	21	42	9
Tropical midaltitude	7.6	9	12	0	-
Tropical highland	6	8	10	0	-
Temperate regions	19.6	24	-	44.3	91
Total	**80.7**	**100**	**100**	**86.3**	**100**

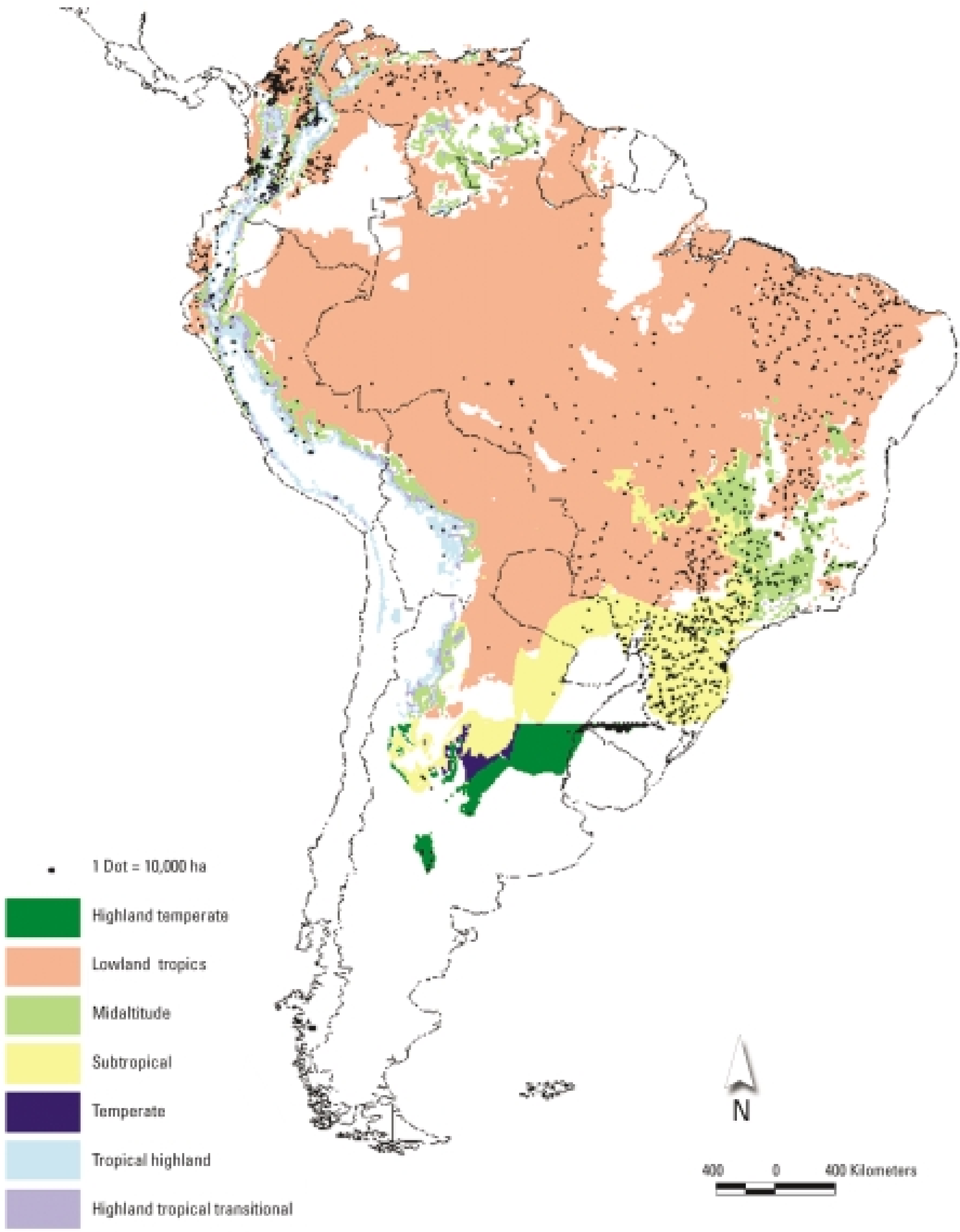
Table B.2Distribution of non-temperate maize in 1990, from Lopez-Pereira and Morris (1994).

Region	**Lowland tropics**	**Subtropics**	**Tropical midaltitude**	**Tropical highland**	**All**	**Total maize area (million ha)**
Sub-Saharan Africa	49	2	38	11	100	14.4
West Asia & North Africa	0	99	0	1	100	1.2
Asia	71	21	3	5	100	19
Latin America	59	23	3	14	100	23.1
Total	**59**	**19**	**12**	**10**	**100**	**57.7**

Table B.3 Maize environments in the developing world (million ha), from Dowswell et al. (1996).

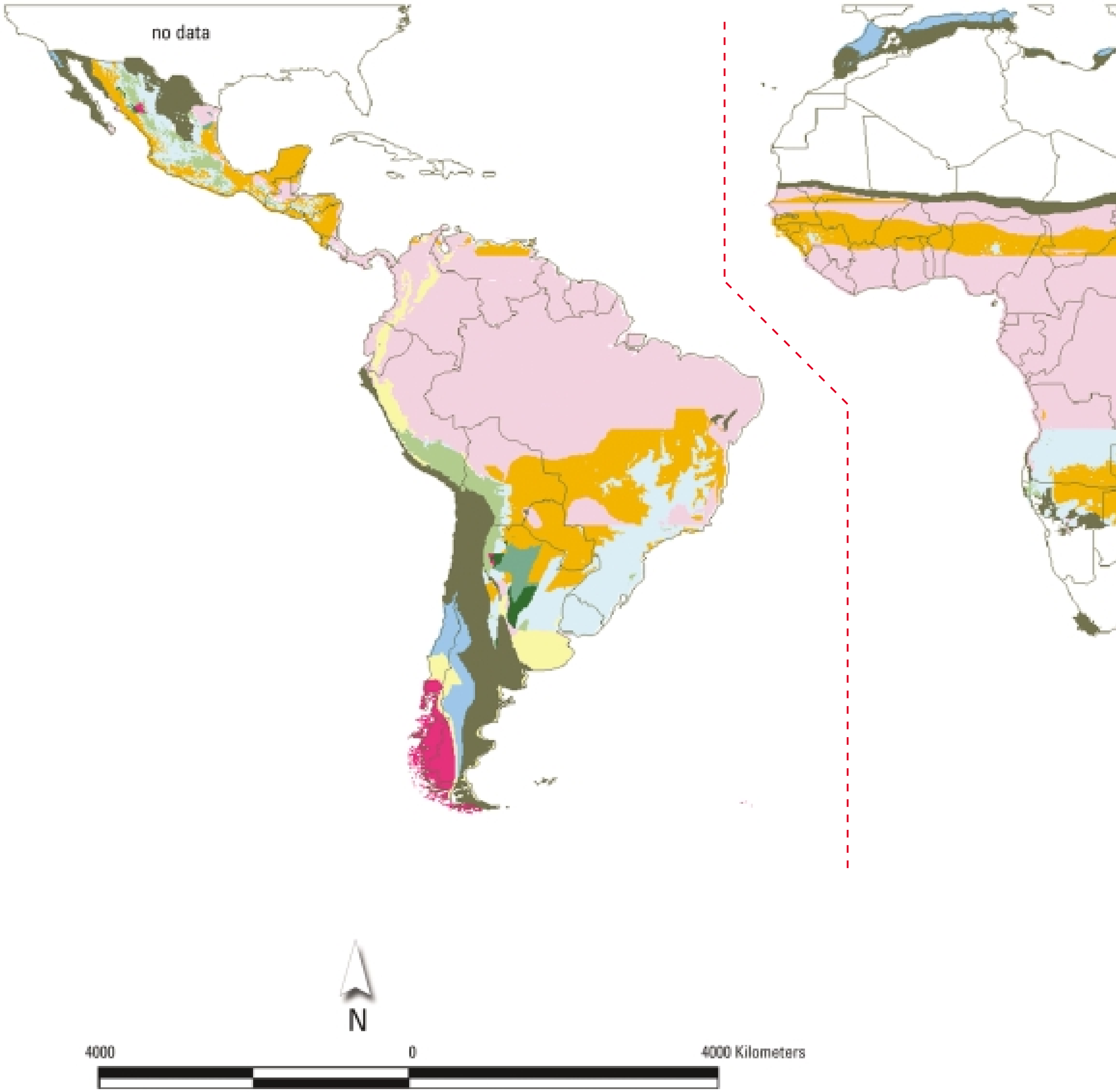
Region	**Tropical**	**Subtropical**	**Temperate**	**Highland**
Southern Cone, South America	8.7	4	1.8	0
Andean Region, South America	1.6	0.3	0	0.5
Mexico and Central America	4.3	1.6	0	3
West and Central Africa	5.2	0.3	0	0.05
West and Southern Africa	2.1	7	0	1.5
North Africa and the Mideast	0	1	1.1	0
South Asia	5.6	1.4	0	0.6
Southeast Asia	8.7	0.2	0	0
East Asia	0.5	1.3	19.3	0.55
Total	**36.7**	**17.1**	**22.2**	**6.2**

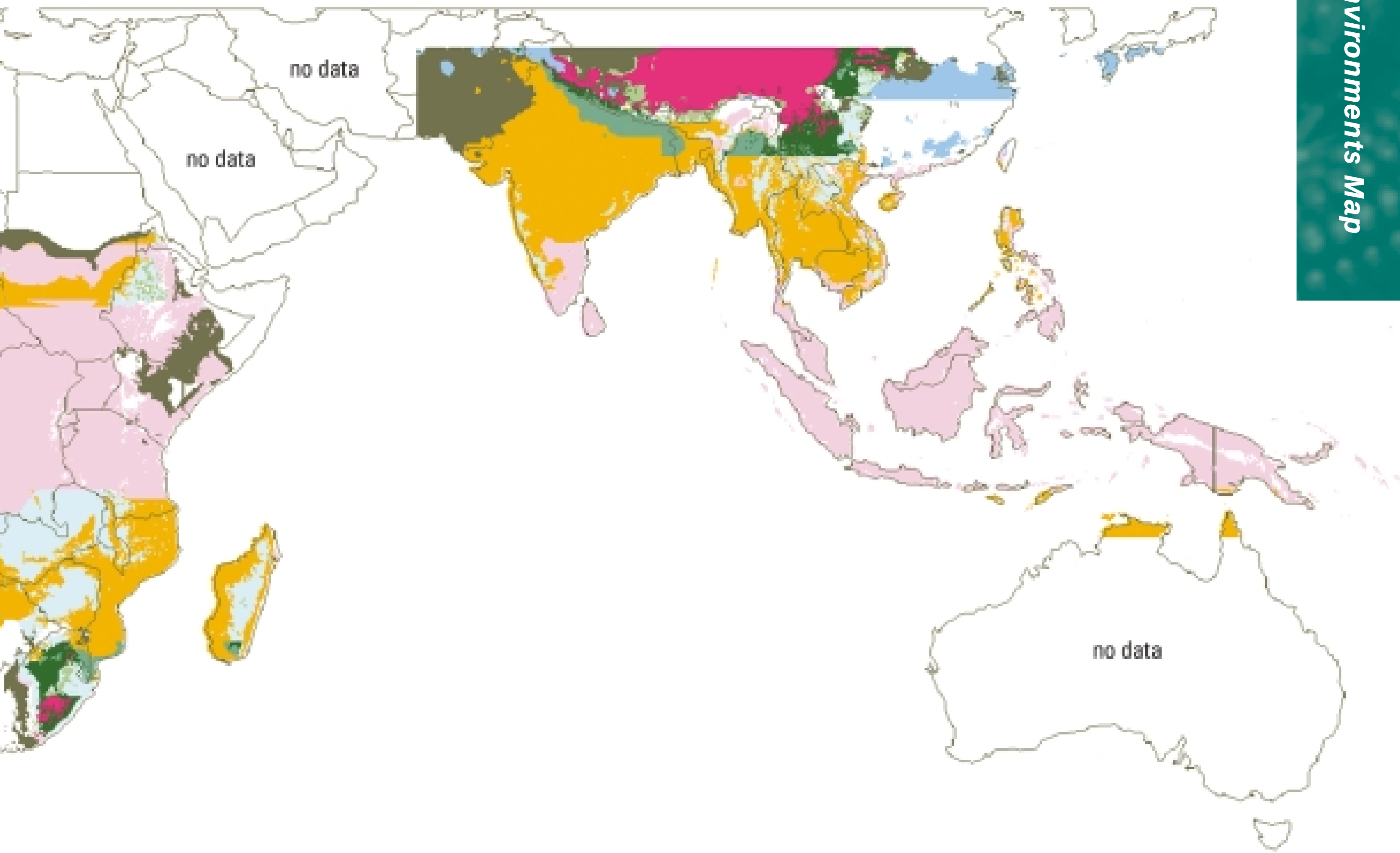
Appendix C. **Maize mega-environments in South America using the 1991 classification criteria. (Crop distribution from Hyman et al., 1998, is overlayed as dots.)**



A simplified map of maize mega-environments created by removing precipitation criteria

(see Table 1 for descriptions, regions, countries, and key sites associated with global maize mega-environments).
Source of climate data: Latin America, Africa: Corbett and O'Brien (1997); Asia: Jones (1998).





		Mega-environment	DL	Tmean
	Tropical lowland	1	11-12.5	>=24
	Tropical midaltitude	2	11-12.5	>=18-<24
	Tropical highland	3	11-12.5	<18
	Non-Eq tropical / Subtropical lowland	4	12.5-13.4	>=24
	Non-Eq tropical / Subtropical midaltitude	5	12.5-13.4	>=18-<24
	Non-Eq tropical / Subtropical highland	6	12.5-13.4	<18
	Subtropical winter hot	7	<11	>=24
	Subtropical winter warm	8	<11	>=18-<24
	Subtropical winter cold	9	<11	<18
	Temp / Subtropical hot	10	>=13.4	>=24
	Temp / Subtropical warm	11	>=13.4	>=18-<24
	Temp / Subtropical cold	12	>=13.4	<18
	No growing season			
	Too dry			

Appendix D. **Latin America maize mega-environment production breakdown created by overlaying crop distribution (Hyman et al. 1998) and 1991 mega-environment area maps.**

Table A assings maize area within a district according to the percentages of environment areas per district.
Table B assigns all maize area within a district to the environment area that is largest in that district.

A MA priority over ST

	Maize area by ME (000 ha)							
Region/country	**Lowland tropics**	**Midaltitude**	**Highland tropical transitional**	**Tropical highland**	**Subtropical**	**Temperate**	**Highland temperate**	**Total area**
Central America	6,946	2,529	927	1,061	-	-	117	11,580
Belize	11	-	-	-	-	-	-	11
Costa Rica	28	6	3	2	-	-	-	38
El Salvador	387	13	-	-	-	-	-	399
Guatemala	182	37	34	24	-	-	-	300
Honduras	167	125	14	-	-	-	-	306
Mexico	5,782	2,276	856	1,035	-	-	117	10,066
Nicaragua	213	14	-	-	-	-	-	227
Panama	177	59	20	-	-	-	-	256
South America	15,241	1,369	343	496	845	27	178	18,499
Argentina	159	43	13	14	209	27	153	618
Bolivia	252	16	5	15	-	-	-	288
Brazil	10,826	627	2	-	588	-	23	12,067
Chile	-	-	-	-	-	-	-	-
Colombia	2,691	410	225	276	-	-	-	3,603
Ecuador	209	99	60	127	-	-	-	495
Guyana	7	0	-	-	-	-	-	7
Paraguay	95	-	-	-	48	-	-	143
Peru	426	62	24	56	-	-	-	568
Surinam	0	0	-	-	-	-	-	0
Uruguay	-	-	-	-	-	-	1	1
Venezuela	576	111	14	8	-	-	-	709
Latin America	22,187	3,897	1,270	1,557	845	27	295	30,079
	73.8%	13.0%	4.2%	5.2%	2.8%	0.1%	1.0%	100.0%

B MA priority over ST

	Maize area by ME (000 ha)							
Region/country	**Lowland tropics**	**Midaltitude**	**Highland tropical transitional**	**Tropical highland**	**Subtropical**	**Temperate**	**Highland temperate**	**Total area**
Central America	7,035	457	1,376	1,947	865	-	-	11,680
Belize	11	-	-	-	-	-	-	11
Costa Rica	38	38	-	0	-	-	-	-
El Salvador	399	-	-	-	-	-	-	399
Guatemala	132	101	39	66	-	-	-	338
Honduras	126	167	12	-	-	-	-	306
Mexico	5,948	48	1,324	1,880	865	-	-	10,066
Nicaragua	137	89	-	-	-	-	-	227
Panama	243	13	-	-	-	-	-	256
	-	-	-	-	-	-	-	-
South America	8,269	2,608	46	2,287	5,213	0	87	18,511
Argentina	96	12	-	-	422	0	87	618
Bolivia	198	-	-	89	-	-	-	288
Brazil	4,270	1,626	-	1,523	4,647	-	-	12,067
Chile	-	-	-	-	-	-	-	-
Colombia	2,705	809	-	88	-	-	-	3,603
Ecuador	197	22	2	274	-	-	-	495
Guyana	7	-	-	-	-	-	-	7
Paraguay	0	-	-	-	143	-	-	143
Peru	111	105	44	307	-	-	-	568
Surinam	0	-	-	-	-	-	-	0
Uruguay	-	-	-	-	1	-	-	-
Venezuela	683	33	-	5	-	-	-	721
	-					-	-	-
Latin America	15,304	3,065	1,422	4,234	6,079	0	87	30,190
	50.7%	10.2%	4.7%	14.0%	20.1%	0.0%	0.3%	100.0%

Appendix E. **Locations selected for GIS-based cluster analysis.**

Number	Season*	Longitude†	Latitude†	Planting month	Country	Location
1	a	13.72	-9.10	3	Angola	Catete-Mazozo
2	a	15.12	-11.42	10	Angola	Cela
3	a	15.83	-12.73	10	Angola	Chianga
4	a	13.43	-15.03	11	Angola	Humpata
5	a	14.73	-8.91	10	Angola	Kilombo
6	a	16.32	-9.52	10	Angola	Poligno-Florestal
7	a	12.20	-5.57	11	Angola	St. Vincente
8	a	-60.57	-33.93	9	Argentina	Pergamino
9	a	-65.25	-25.83	12	Argentina	Leales
10	a	90.42	24.00	4	Bangladesh	Joydebpur
11	b	90.42	24.00	11	Bangladesh	Joydebpur
12	a	89.08	24.12	4	Bangladesh	Ishurdi
13	b	89.08	24.12	11	Bangladesh	Ishurdi
14	a	89.23	25.73	4	Bangladesh	Rangpur
15	b	89.23	25.73	11	Bangladesh	Rangpur
16	a	-89.00	17.00	6	Belize	Central Farm
17	a	-63.13	-17.70	10	Bolivia	Santa Cruz
18	a	-66.32	-17.35	12	Bolivia	Parirumani
19	a	-66.17	-17.43	12	Bolivia	Cochabamba
20	a	-63.77	-19.87	11	Bolivia	Iboperanda
21	a	-63.95	-18.12	11	Bolivia	Mairana
22	a	-63.65	-21.45	11	Bolivia	Algarrobal
23	a	25.47	-25.48	6	Botswana	Good-Hope
24	a	21.75	-23.97	2	Botswana	Hukunsi
25	a	25.65	-18.55	12	Botswana	Pandamatenga
26	a	25.95	-24.57	2	Botswana	Sebele
27	a	-44.25	-19.47	10	Brazil	Sete Lagoas
28	a	-47.80	-20.98	10	Brazil	Jardinopolis
29	a	-49.57	-18.68	10	Brazil	Capinopolis
30	a	-36.00	-6.22	11	Brazil	Sta. Cruz Palmeira
31	a	-4.33	11.10	5	Burkina Faso	Farako-Ba
32	a	105.00	12.00	5	Cambodia	Banteay-Dek
33	a	-70.63	-33.57	10	Chile	La Platina
34	a	102.72	25.12	6	China	Kunming
35	a	108.17	22.60	4	China	Nanning
36	a	106.65	26.48	6	China	Gui-Yang
37	a	-75.60	4.93	4	Colombia	Chinchina
38	b	-75.60	4.93	9	Colombia	Chinchina
39	a	-75.58	6.26	4	Colombia	Medellin
40	b	-75.58	6.26	9	Colombia	Medellin
41	a	-76.60	2.45	9	Colombia	Popayan
42	a	-76.35	3.55	9	Colombia	Palmira
43	a	-75.97	8.65	4	Colombia	Turipana
44	b	-75.97	8.65	9	Colombia	Turipana
45	a	-75.78	8.83	4	Colombia	Monteria
46	b	-75.78	8.83	9	Colombia	Monteria
47	a	-76.37	3.50	9	Colombia	Cali
48	a	-74.20	4.70	4	Colombia	Tibaitata
49	b	-74.20	4.70	9	Colombia	Tibaitata

* Season a = main season; season b= second season.
† Digital degree format.

Appendix E. **Locations selected for GIS-based cluster analysis (cont'd).**

Number	Season*	Longitude†	Latitude†	Planting month	Country	Location
50	a	-75.43	6.18	4	Colombia	Rionegro
51	b	-75.43	6.18	9	Colombia	Rionegro
52	a	-76.80	7.70	5	Colombia	Antioquia
53	a	-85.13	10.35	7	Costa Rica	Guanacaste
54	a	-83.77	10.22	5	Costa Rica	Los Diamantes
55	b	-83.77	10.22	10	Costa Rica	Los Diamantes
56	a	-83.65	9.88	5	Costa Rica	Turrialba
57	b	-83.65	9.88	10	Costa Rica	Turrialba
58	a	-5.23	9.58	4	Cote d'Ivoire	Ferkessedougou
59	a	-5.03	7.68	7	Cote d'Ivoire	Bouake
60	a	-3.07	9.62	4	Cote d'Ivoire	Sinematiali
61	a	-82.52	23.83	6	Cuba	Alquizar
62	a	-82.52	23.85	6	Cuba	Tomeguin
63	a	-70.83	18.38	6	Dominican Republic	Ciaza
64	a	-79.48	-1.10	6	Ecuador	Pichilingue
65	a	-80.43	-1.07	7	Ecuador	Porto Viejo
66	a	-78.52	-0.38	11	Ecuador	Sta.Catalina
67	a	30.98	28.93	6	Egypt	Sids
68	a	31.12	30.72	6	Egypt	Gemmeiza
69	a	30.95	31.12	6	Egypt	Sakha
70	a	30.50	31.00	6	Egypt	Nubaria
71	a	-89.42	13.80	5	El Salvador	San Andrés
72	a	37.82	9.05	5	Ethiopia	Ambo
73	a	41.08	9.40	7	Ethiopia	Alemaya
74	a	38.48	7.08	5	Ethiopia	Awassa
75	a	37.08	5.85	5	Ethiopia	Bako
76	a	39.50	8.50	6	Ethiopia	Nazareth
77	a	-1.58	6.75	6	Ghana	Kwadaso
78	a	23.00	40.55	5	Greece	Thessaloniki
79	a	-61.67	16.33	6	Guadeloupe	Godet
80	a	-90.00	14.25	5	Guatemala	Cuyuta
81	a	-91.57	14.30	6	Guatemala	La Máquina
82	a	-91.52	14.87	5	Guatemala	Quetzaltenango
83	a	-90.23	15.08	5	Guatemala	San Jeronimo
84	a	-89.92	14.25	5	Guatemala	Jutiapa
85	a	-89.75	15.31	5	Guatemala	Polochic
86	b	-89.75	15.31	10	Guatemala	Polochic
87	a	-14.55	12.35	6	Guinea-Bissau	Cenmac
88	a	-88.20	14.25	5	Honduras	La Esperanza
89	b	-88.20	14.25	12	Honduras	La Esperanza
90	a	-87.67	14.40	5	Honduras	Omonita
91	b	-87.67	14.40	12	Honduras	Omonita
92	a	-85.90	14.91	5	Honduras	Catacamas
93	a	-86.87	15.75	6	Honduras	La Ceiba
94	b	-86.87	15.75	12	Honduras	La Ceiba
95	a	75.80	30.90	7	India	Ludhiana
96	a	78.50	17.33	7	India	Hyderabad
97	a	79.45	29.00	6	India	Pantnagar
99	a	94.27	26.77	6	India	Jorhat

* Season a = main season; season b= second season.

† Digital degree format.

Appendix E. **Locations selected for GIS-based cluster analysis (cont'd).**

Number	Season*	Longitude†	Latitude†	Planting month	Country	Location
98	a	86.25	25.98	6	India	Dholi
100	a	75.88	19.85	6	India	Jalna
101	a	81.60	27.72	6	India	Bahraich
102	b	81.60	27.72	12	India	Bahraich
103	a	74.90	16.20	6	India	Arabhavi
104	a	77.58	12.97	2	India	Bangalore
105	a	105.10	-5.30	9	Indonesia	Lampung
106	a	106.73	-6.62	9	Indonesia	Bogor
107	a	113.28	-8.27	4	Indonesia	Muneng
108	b	113.28	-8.27	9	Indonesia	Muneng
109	a	119.60	-5.00	4	Indonesia	Maros
110	b	119.60	-5.00	9	Indonesia	Maros
111	a	50.00	35.78	4	Iran	Karaj
112	a	54.00	36.00	4	Iran	Gorgan
113	a	35.00	-1.01	4	Kenya	Kitale
114	a	37.45	-0.50	3	Kenya	Embu
115	a	37.23	-1.58	3	Kenya	Katumani
116	a	28.05	-28.88	10	Lesotho	Leribe
117	a	27.50	-29.28	11	Lesotho	Maseru
118	a	29.08	-29.28	10	Lesotho	Mokotlong
119	a	28.62	-29.50	10	Lesotho	Thaba-Tseka
120	a	34.43	-14.17	12	Malawi	Bembeke
121	a	33.63	-13.98	12	Malawi	Chitedze
122	a	34.92	-16.47	12	Malawi	Ngabu
123	a	35.07	-15.92	11	Malawi	Bvumbwe
124	a	34.07	-13.13	12	Malawi	Chitala
125	a	-100.82	20.52	6	Mexico	Celaya (INIFAP)
126	a	-109.00	25.77	11	Mexico	Los Mochis
127	a	-97.43	20.53	6	Mexico	Poza Rica
128	a	-109.42	26.67	10	Mexico	Cd. Obregón
129	a	-99.13	18.68	6	Mexico	Tlaltizapán
130	a	-98.87	19.52	5	Mexico	El Batán
131	a	-99.65	19.28	5	Mexico	Toluca
132	a	-96.12	19.15	6	Mexico	Veracruz
133	a	-105.20	21.51	6	Mexico	Nayarit (INIFAP)
134	a	-104.80	21.43	6	Mexico	Xalisco
135	a	-107.75	29.33	7	Mexico	Gomez Farías
136	a	-107.40	24.80	7	Mexico	Culiacán
137	a	-103.77	20.47	6	Mexico	Tlajomulco
138	a	-103.50	20.50	6	Mexico	S.M. Cuyutlán
139	a	-103.38	20.70	6	Mexico	Zapopan
140	a	-100.67	20.52	6	Mexico	Queretaro
141	a	-101.32	20.73	6	Mexico	Irapuato
142	a	-99.63	19.30	5	Mexico	Metepec
143	a	-102.30	22.18	6	Mexico	Pabellón
144	a	-104.05	20.55	6	Mexico	Ameca
145	a	-98.77	19.13	5	Mexico	Amecameca
146	a	-102.65	22.90	7	Mexico	Calera
147	a	-99.18	19.68	6	Mexico	Cuautitlán

* Season a = main season; season b= second season.
† Digital degree format.

Appendix E. **Locations selected for GIS-based cluster analysis (cont'd).**

Number	Season*	Longitude†	Latitude†	Planting month	Country	Location
148	a	33.22	-19.33	11	Mozambique	Sussundenga
149	a	32.38	-26.58	11	Mozambique	Umbeluzzi
150	a	35.23	-13.30	11	Mozambique	Lichinga
151	a	39.28	-15.10	12	Mozambique	Nampula
152	a	33.00	-24.53	12	Mozambique	Chokwe
153	a	86.07	27.68	5	Nepal	Kabre-Dolakha
154	a	87.33	27.08	6	Nepal	Pakhribas
155	a	84.00	28.22	5	Nepal	Pokhara
156	a	83.80	28.30	5	Nepal	Lumle
157	a	81.72	28.85	6	Nepal	Dailekh
158	a	84.42	27.62	6	Nepal	Rampur
159	a	81.60	28.60	6	Nepal	Surkhet
160	a	-86.18	12.13	5	Nicaragua	Santa Rosa
161	a	71.58	34.02	6	Pakistan	Peshawar
162	a	72.83	34.00	6	Pakistan	Pirsabak
163	a	74.00	31.00	6	Pakistan	Yousafwala
164	a	72.75	33.50	6	Pakistan	Islamabad
165	a	-79.37	9.05	5	Panama	Tocumen
166	a	-80.33	7.83	6	Panama	Guarare
167	a	-82.33	8.38	5	Panama	Chiriqui
168	a	-80.38	7.93	6	Panama	El Ejido
169	a	-80.00	8.00	9	Panama	La Honda
170	a	-57.10	-25.40	9	Paraguay	Caacupe
171	a	-55.82	-27.28	9	Paraguay	Capitán Miranda
172	a	-80.63	-5.18	6	Peru	Piura
173	a	-76.95	-12.08	6	Peru	La Molina
174	a	-76.42	-6.52	2	Peru	Tarapoto
175	a	-78.07	-7.10	10	Peru	Cajamarca
176	a	-76.35	-6.52	2	Peru	El Porvenir
177	a	-73.25	-3.75	2	Peru	Iquitos
178	a	-78.05	-7.62	10	Peru	Cajabamba
179	a	124.38	8.29	5	Philipinnes	Cagayan
180	a	121.25	14.17	5	Philippines	U.P. Los Baños
181	a	125.00	7.00	5	Philippines	Karaan
182	a	121.15	16.50	4	Philippines	Ilagan
183	b	121.15	16.50	9	Philippines	Ilagan
184	a	125.18	6.12	5	Philippines	Gral. Santos
185	a	124.82	7.23	6	Philippines	Mindanao
186	a	30.60	-29.02	10	RSA	Greytown
187	a	27.07	-26.67	12	RSA	Potchefstroom
188	a	26.92	-27.17	1	RSA	Viljienskroon
189	a	31.15	-26.55	10	Swaziland	Malkerns
190	a	31.92	-26.78	11	Swaziland	Big-bend
191	a	36.52	33.18	6	Syria	Aleppo
192	a	120.23	23.50	8	Taiwan	Po-tzu-chia-i
193	a	120.68	24.02	8	Taiwan	Taichung
194	a	35.17	-4.50	12	Tanzania	Selian
195	a	33.37	-8.92	11	Tanzania	Uyole
196	a	37.03	-6.77	12	Tanzania	Ilonga

* Season a = main season; season b= second season.

† Digital degree format.

Appendix E. **Locations selected for GIS-based cluster analysis (cont'd).**

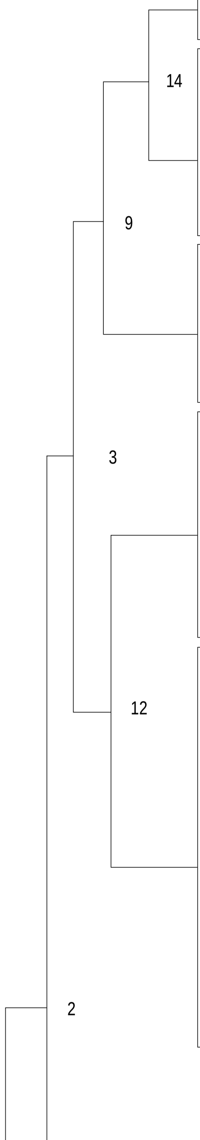
Number	Season*	Longitude†	Latitude†	Planting month	Country	Location
197	a	33.02	-2.70	11	Tanzania	Ukiriguru
198	a	37.23	-3.28	3	Tanzania	Lambo
199	a	101.00	14.08	6	Thailand	Suwan
200	a	100.50	15.35	6	Thailand	Nakhon Sawan R.
201	a	100.60	14.73	6	Thailand	Phraphutthabat
202	a	102.83	16.43	6	Thailand	Khonkaen
203	a	26.75	36.70	5	Turkey	Adapazari
204	a	30.83	37.00	5	Turkey	Antalya
205	a	32.58	0.53	3	Uganda	Namulonge
206	a	-57.68	-34.33	9	Uruguay	La Estanzuela
207	a	168.30	-17.75	9	Vanuatu	Tagabe
208	a	-77.05	12.10	9	Venezuela	Maracay
209	a	-67.78	10.26	6	Venezuela	San Joaquín
210	a	-68.65	10.35	7	Venezuela	San Javier
211	a	105.78	20.48	6	Vietnam	Song Boi
212	a	107.23	10.95	4	Vietnam	Hung Loc
213	a	108.38	11.13	5	Vietnam	Doc Trong Farm
214	a	105.80	21.03	2	Vietnam	Dan Phuong
215	a	23.95	-6.75	9	Zaire	Gandajika
216	a	27.42	-11.73	11	Zaire	Kaniamesh
217	a	14.90	-5.45	10	Zaire	Mvuazi
218	a	28.47	-14.45	11	Zambia	Kabwe
219	a	31.13	-10.22	11	Zambia	Kasama
220	a	27.75	-15.85	11	Zambia	Masabuka
221	a	28.25	-15.53	11	Zambia	Mount Makulu
222	a	28.85	-11.10	11	Zambia	Mansa
223	a	28.37	-14.17	11	Zambia	Golden Valley
224	a	27.92	-15.77	12	Zambia	Kaoma
225	a	32.62	-20.20	11	Zimbabwe	Chipinge
226	a	31.58	-21.02	12	Zimbabwe	Chiredzi
227	a	30.78	-19.83	11	Zimbabwe	Makoholi
228	a	28.50	-20.38	11	Zimbabwe	Matopos
229	a	32.33	-20.35	12	Zimbabwe	Save-Valley
230	a	31.17	-17.67	11	Zimbabwe	Rattray-Arnold
231	a	31.05	-17.80	11	Zimbabwe	Harare
232	a	30.90	-18.32	11	Zimbabwe	Kadoma
233	a	31.02	-16.37	12	Zimbabwe	Mzarabani
234	a	32.23	-20.80	12	Zimbabwe	Chisumbanji
235	a	31.03	-17.08	11	Zimbabwe	Glendale
Extra: for post-classification only						
240	b	-44.25	-19.47	10	Brazil	Sete Lagoas
242	b	108.17	22.60	10	China	Nanning
243	b	-90.00	14.25	10	Guatemala	Cuyuta
238	b	-97.43	20.53	10	Mexico	Poza Rica
237	b	100.50	15.35	10	Thailand	Nakhon Sawan R.
236	b	101.00	14.08	10	Thailand	Suwan
241	b	105.78	20.48	10	Vietnam	Song Boi
239	b	28.37	-14.17	4	Zambia	Golden Valley

* Season a = main season; season b= second season.

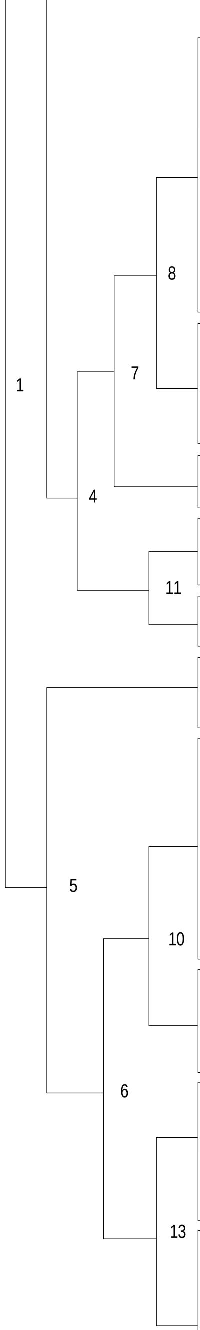
† Digital degree format.

Annex F. Clusters for 220 unique maize international testing sites using four consecutive monthly environmental variables starting from the ‘best bet’ planting date.

Several sites have two seasons : ID =1 main season; ID = 2 second season.



Diagnostic / Characteristic	CID	ID	Country	Location	PLANT	LAT	LONG	Z	DL	TMEAN	TDIF	TOTP	ETP	CID	ID	Country	Location	PLANT	LAT	LONG	Z	DL	TMEAN	TDIF	TOTP	ETP
lDL-hTMEAN-vlTDIF-aTOTP	90507	1	Indonesia	Muneng	4	-8.3	113.3	13	11.7	25.6	7.6	338	145	91301	1	Taiwan	Po-Tzu-Chia-I	8	23.5	120.2	4	12.4	26.2	8.6	510	175
Tropical lowland average rainfall humid	90512	1	Indonesia	Maros	4	-5.0	119.6	52	11.8	27.3	8.1	348	160	91302	1	Taiwan	Taichung	8	24.0	120.7	82	12.4	25.5	8.1	483	175
	91609	2	Philippines	Ilagan	9	16.5	121.2	278	11.8	25.4	7.5	699	175													
lDL-hTMEAN-vlTDIF-aTOTP	4	1	Angola	Catete-Mazozo	3	-9.1	13.7	50	11.9	25.5	7.0	341	116	20518	2	Guatemala	Polochic	10	15.3	-89.8	40	11.4	25.4	8.5	549	102
Tropical lowland average rainfall	8	1	Angola	Kilombo	10	-8.9	14.7	432	12.3	24.4	8.7	493	120	20615	2	Honduras	La Ceiba	12	15.8	-86.9	22	11.1	24.2	7.4	739	106
	10	1	Angola	St.Vincente	11	-5.6	12.2	0	12.3	27.0	7.2	422	112	20615	1	Honduras	La Ceiba	6	15.8	-86.9	22	12.9	27.5	7.5	648	121
	10502	2	Colombia	Turipana	9	8.7	-76.0	50	11.9	26.8	8.0	986	105	20902	1	Panama	Tocumen	5	9.1	-79.4	6	12.5	26.9	6.1	990	103
	10502	1	Colombia	Turipana	4	8.7	-76.0	50	12.3	27.1	8.2	942	117	20907	1	Panama	Guarare	6	7.8	-80.3	33	12.4	26.2	7.6	714	103
	10504	2	Colombia	Monteria	9	8.8	-75.8	70	11.9	26.9	8.2	973	106	20911	1	Panama	El Ejido	6	7.9	-80.4	22	12.4	26.5	7.6	695	103
	10504	1	Colombia	Monteria	4	8.8	-75.8	70	12.3	27.1	8.3	905	118	11029	1	Peru	Iquitos	2	-3.8	-73.3	91	12.1	26.5	9.4	1088	96
	10516	1	Colombia	Antioquia	5	7.7	-76.8	168	12.4	25.7	8.0	1109	111	91517	1	Vietnam	Dan Phuong	2	21.0	105.8	16	11.7	22.8	6.1	274	123
	60702	1	Cote D'Ivoire	Bouake	7	7.7	-5.0	360	12.3	24.9	9.0	530	104	72408	1	Zaire	Mvuazi	10	-5.5	14.9	538	12.2	24.5	8.9	701	108
	61103	1	Ghana	Kwadasco	6	6.8	-1.6	287	12.4	24.5	6.8	592	96													
aDL-hTMEAN-alTDIF-vhTOTP	20102	1	Belize	Central Farm	6	17.0	-89.0	353	13.0	26.0	7.3	1520	120	61302	1	G. Bissau	Cenmac	6	12.4	-14.6	23	12.7	26.8	8.6	1265	128
Tropical lowland wet	20302	1	Costa Rica	Guanacaste	7	10.4	-85.1	25	12.4	27.0	10.4	1428	119	80422	1	India	Arabhavil	6	16.2	74.9	531	12.9	24.6	7.1	1053	160
	20304	2	Costa Rica	Los Diamantes	10	10.2	-83.8	245	11.6	25.2	10.0	1567	103	90503	1	Indonesia	Bogor	9	-6.6	106.7	341	12.1	25.4	7.7	1448	150
	20304	1	Costa Rica	Los Diamantes	5	10.2	-83.8	245	12.6	26.0	9.9	1400	111	20710	1	Mexico	Poza Rica	6	20.5	-97.4	87	13.2	27.5	10.7	999	129
	20311	2	Costa Rica	Turrialba	10	9.9	-83.7	595	11.6	23.9	10.8	1134	99	20716	1	Mexico	Veracruz	6	19.2	-96.1	3	13.1	27.4	9.9	968	124
	20311	1	Costa Rica	Turrialba	5	9.9	-83.7	595	12.5	24.7	10.7	1225	106	20717	1	Mexico	Natarit	6	21.5	-105.2	7	13.2	28.6	10.1	1300	138
	20502	1	Guatemala	La Maquina	6	14.3	-91.6	55	12.8	27.4	10.2	1642	121	20909	1	Panama	Chiriqui	5	8.4	-82.3	16	12.5	27.0	9.9	1476	107
	20518	1	Guatemala	Polochic	5	15.3	-89.8	40	12.8	28.2	9.6	1326	134													
ahDL-aTMEAN-aTDIF-hTOTP	5	1	Angola	Cela	10	-11.4	15.1	1328	12.4	20.5	9.8	680	116	71203	1	Mozambique	Lichinga	11	-13.3	35.2	1305	12.7	21.1	9.9	815	124
NONEQ Tropical midlands wet	10302	1	Brazil	Sete Lagoas	10	-19.5	-44.3	823	12.8	22.5	11.1	954	115	72406	1	Zaire	Kaniamesh	11	-11.7	27.4	1295	12.6	22.1	11.5	952	110
	20501	1	Guatemala	Cuyuta	5	14.3	-90.0	950	12.8	23.9	9.6	1040	125	25	1	Zambia	Kabwe	11	-14.5	28.5	1200	12.8	22.4	10.2	780	124
	20506	1	Guatemala	San Jeronimo	5	15.1	-90.2	1420	12.8	22.4	10.2	1081	114	26	1	Zambia	Kasama	11	-10.2	31.1	1363	12.6	21.6	9.9	918	113
	20507	1	Guatemala	Jutiapa	5	14.3	-89.9	948	12.8	23.7	9.7	1032	125	72501	1	Zambia	Mount-Makulu	11	-15.5	28.3	1281	12.9	22.0	10.1	687	129
	20604	1	Honduras	La Esperanza	5	14.3	-88.2	1821	12.8	18.9	11.0	1225	113	72502	1	Zambia	Mansa	11	-11.1	28.9	1267	12.6	21.8	10.3	842	112
	20606	1	Honduras	Omonita	5	14.4	-87.7	560	12.8	25.2	9.9	990	132	72503	1	Zambia	Golden Valley	11	-14.2	28.4	1170	12.8	22.5	10.3	818	123
	20612	1	Honduras	Catacamas	5	14.9	-85.9	819	12.8	22.8	8.9	687	120	28	1	Zimbabwe	Chipinge	11	-20.2	32.6	1102	13.1	21.0	9.6	751	132
	21	1	Malawi	Bembeke	12	-14.2	34.4	1170	12.8	21.5	8.8	802	117	72601	1	Zimbabwe	Rattray-Arnold	11	-17.7	31.2	1452	13.0	20.8	10.5	683	128
	71001	1	Malawi	Chitedze	12	-14.0	33.6	1097	12.8	22.1	9.6	724	119	72602	1	Zimbabwe	Harare	11	-17.8	31.1	1489	13.0	20.7	10.5	646	129
	71005	1	Malawi	Bvumbwe	11	-15.9	35.1	889	12.9	23.1	9.3	788	128	72609	1	Zimbabwe	Glendale	11	-17.1	31.0	1250	13.0	21.7	10.5	682	131
	71006	1	Malawi	Chitala	12	-13.1	34.1	733	12.7	24.1	8.9	948	125													
ahDL-ahTDIF-ahTOTP	7	1	Angola	Humpata	11	-15.0	13.4	1468	12.8	19.8	12.1	448	127	10901	1	Paraguay	Caacupe	9	-25.4	-57.1	214	12.4	23.6	11.0	497	145
Subtropical midlands	10102	1	Argentina	Leales	12	-25.8	-65.3	1219	13.5	21.1	11.9	475	137	10902	1	Paraguay	Capitan Miranda	9	-27.3	-55.8	91	12.4	22.4	12.9	576	135
	10207	1	Bolivia	Iboperanda	11	-19.9	-63.8	1066	13.1	24.1	12.4	487	138	91602	1	Philippines	U.P. Los Bayos	5	14.2	121.3	52	12.8	24.9	12.0	949	163
	10208	1	Bolivia	Mairana	11	-18.1	-64.0	1600	13.0	21.3	11.3	417	132	72001	1	Swaziland	Malkerns	10	-26.6	31.2	763	13.1	21.7	11.6	490	148
	10224	1	Bolivia	Algarrobal	11	-21.5	-63.7	777	13.2	24.7	12.5	539	139	72005	1	Swaziland	Big-Bend	11	-26.8	31.9	109	13.6	25.0	11.6	351	149
	13	1	Botswana	Pandamatenga	12	-18.6	25.7	1097	13.1	23.8	12.3	523	144	72101	1	Tanzania	Ilonga	12	-6.8	37.0	914	12.4	24.0	11.2	549	132
	10317	1	Brazil	Jardinopolis	10	-21.0	-47.8	709	12.8	23.3	11.4	834	128	11303	1	Venezuela	San Joaquin	6	10.3	-67.8	580	12.6	24.1	10.6	602	123
	10322	1	Brazil	Capinopolis	10	-18.7	-49.6	579	12.7	24.6	12.0	816	131	11312	1	Venezuela	San Javier	7	10.4	-68.7	557	12.4	24.6	10.5	551	130
	20401	1	El Salvador	San Andres	5	13.8	-89.4	452	12.8	25.9	10.9	1083	135	27	1	Zambia	Masabuka	11	-15.9	27.8	1000	12.9	23.7	10.6	658	135
	70601	1	Ethiopia	Alemaya	7	9.4	41.1	1524	12.4	22.3	12.6	415	139	72504	1	Zambia	Kaoma	12	-15.8	27.9	668	12.9	25.1	10.3	618	134
	71004	1	Malawi	Ngabu	12	-16.5	34.9	108	12.9	27.5	11.3	584	141	29	1	Zimbabwe	Chiredzi	12	-21.0	31.6	433	13.2	25.5	11.9	424	150
	20712	1	Mexico	Tlaltizapan	6	18.7	-99.1	945	13.1	26.5	13.5	819	119	30	1	Zimbabwe	Makoholi	11	-19.8	30.8	1111	13.1	22.5	11.2	489	146
	20725	1	Mexico	Xalisco	6	21.4	-104.8	987	13.2	25.0	12.1	1094	124	31	1	Zimbabwe	Matopos	11	-20.4	28.5	1457	13.2	21.0	11.6	458	147
	20764	1	Mexico	Culiacan	7	24.8	-107.4	48	13.1	29.0	12.0	560	143	32	1	Zimbabwe	Save-Valley	12	-20.4	32.3	446	13.2	25.4	11.9	326	142
	20794	1	Mexico	Tlajomulco	6	20.5	-103.8	1513	13.2	22.8	13.0	742	121	72604	1	Zimbabwe	Kadoma	11	-18.3	30.9	1309	13.0	21.8	11.3	585	136
	20798	1	Mexico	S.M. Cuyutlan	6	20.5	-103.5	1616	13.2	22.3	12.6	754	121	72607	1	Zimbabwe	Mzarabani	12	-16.4	31.0	429	12.9	26.5	11.1	584	139
	21101	1	Mexico	Zapopan	6	20.7	-103.4	1566	13.2	22.9	12.8	743	123	72608	1	Zimbabwe	Chisumbanji	12	-20.8	32.2	412	13.2	25.4	11.6	379	145
	21143	1	Mexico	Ameca	6	20.6	-104.1	1244	13.2	24.5	13.5	702	123													
	71201	1	Mozambique	Sussundenga	11	-19.3	33.2	787	13.1	23.5	11.5	739	139													
	71202	1	Mozambique	Umbeluzzi	11	-26.6	32.4	23	13.6	24.7	10.7	371	148													
	71208	1	Mozambique	Nampula	12	-15.1	39.3	329	12.8	26.3	11.5	831	142													
	71209	1	Mozambique	Chokwe	12	-24.5	33.0	33	13.4	26.6	12.5	411	151													



aDL-vhTMEAN-lTDIF-aTOTP	80201	1	Bangladesh	Joydebpur	4	24.0	90.4	8	13.0	29.2	7.9	912	198	20805	1	Nicaragua	Santa Rosa	5	12.1	-86.2	77	12.7	27.4	9.2	617	146
Tropical lowland, hot, average rainfall	80202	1	Bangladesh	Ishurdi	4	24.1	89.1	31	13.0	29.5	9.9	775	225	3	1	Philipinnes	Cagayan	5	8.3	124.4	290	12.5	26.9	9.0	786	178
	80209	1	Bangladesh	Rangpur	4	25.7	89.2	32	13.0	28.3	9.8	1324	213	91606	1	Philippines	Karaan	5	7.0	125.0	102	12.4	27.1	9.0	923	168
	10203	1	Bolivia	Santa Cruz	10	-17.7	-63.1	350	12.7	26.0	10.7	564	152	91609	1	Philippines	Ilagan	4	16.5	121.2	278	12.6	27.0	9.1	612	205
	10342	1	Brazil	S.c. Palmeira	11	-6.2	-36.0	182	12.3	26.5	9.4	137	146	91616	1	Philippines	Gral. Santos	5	6.1	125.2	12	12.3	26.8	8.1	396	168
	61401	1	Burkina Faso	Farako	5	11.1	-4.3	466	12.6	26.7	10.5	744	149	91620	1	Philippines	Mindanao	6	7.2	124.8	24	12.4	27.9	9.2	791	175
	90302	1	Cambodia	Banteay	5	12.0	105.0	15	12.7	28.3	8.2	680	180	91401	1	Thailand	Suwan	6	14.1	101.0	13	12.8	29.9	8.8	602	203
	90403	1	China	Nanning	4	22.6	108.2	115	12.9	26.3	6.9	680	168	91406	1	Thailand	Nakhon Sawan	6	15.4	100.5	83	12.9	28.4	9.3	705	193
	60701	1	Cote D'Ivoire	Ferkessedougou	4	9.6	-5.2	283	12.4	27.7	9.9	567	150	91407	1	Thailand	Phraphutthabat	6	14.7	100.6	6	12.8	28.6	9.1	742	190
	60706	1	Cote D'Ivoire	Sinematiali	4	9.6	-3.1	250	12.4	27.6	9.6	509	143	91414	1	Thailand	Khonkaen	6	16.4	102.8	162	12.9	28.8	8.5	795	195
	80404	1	India	Hyderabad	7	17.3	78.5	521	12.7	26.1	9.1	541	195	91501	1	Vietnam	Song Boi	6	20.5	105.8	55	13.2	29.0	6.9	1219	183
	80417	1	India	Jalna	6	19.9	75.9	485	13.1	27.0	9.5	602	208	91502	1	Vietnam	Hung Loc	4	11.0	107.2	193	12.4	26.4	8.2	972	160
	2	1	Indonesia	Lampung	9	-5.3	105.1	118	12.1	27.1	9.1	633	168	91513	1	Vietnam	Doc Trong Farm	5	11.1	108.4	173	12.6	27.4	7.6	622	163
	90507	2	Indonesia	Muneng	9	-8.3	113.3	13	12.1	26.1	8.0	548	153													
	90512	2	Indonesia	Maros	9	-5.0	119.6	52	12.1	27.5	8.3	783	163													
vhDL-ahTMEAN-lTDIF-hTOTP	90402	1	China	Kunming	6	25.1	102.7	1957	13.5	19.4	8.8	703	183	34	1	Nepal	Kabre-Dolakha	5	27.7	86.1	###	13.6	20.8	6.8	1625	193
Subtropical midlands, wet	90406	1	China	Gui-yang	6	26.5	106.7	1153	13.6	23.2	9.0	631	203	35	1	Nepal	Pakhribas	6	27.1	87.3	###	13.6	24.4	6.8	696	210
	80405	1	India	Pantnagar	6	29.0	79.5	204	13.8	29.1	8.8	993	230	38	1	Nepal	Dailekh	6	28.9	81.7	###	13.7	25.6	6.5	1302	213
	80407	1	India	Dholi	6	26.0	86.3	34	13.5	29.6	7.6	1050	208	80601	1	Nepal	Rampur	6	27.6	84.4	185	13.7	28.9	8.6	1576	228
	80413	1	India	Jorhat	6	26.8	94.3	123	13.6	28.0	7.1	1685	190	80608	1	Nepal	Surkhet	6	28.6	81.6	617	13.7	28.3	7.6	1531	238
	80420	1	India	Bahraich	6	27.7	81.6	130	13.7	30.1	8.5	1012	230													
hDL-hTMEAN-lTDIF-vvhTOTP	36	1	Nepal	Pokhara	5	28.2	84.0	944	13.7	24.7	8.8	2765	215	37	1	Nepal	Lumle Arc	5	28.3	83.8	###	13.7	22.8	5.1	3745	190
Subtropical midlands extreme wet																										
hDL-hTMEAN-lTDIF-vlTOTP	50401	1	Egypt	Sids	6	28.9	31.0	29	13.7	27.2	14.2	0	188	50404	1	Egypt	Nubaria	6	31.0	30.5	8	13.9	25.8	11.9	0	173
Subtropical-temperate, rainfall limited	50402	1	Egypt	Gemmeiza	6	30.7	31.1	9	13.9	26.0	13.6	0	178	80427	1	India	Bangalore	2	13.0	77.6	909	11.8	26.6	13.8	178	243
	50403	1	Egypt	Sakha	6	31.1	31.0	7	13.9	25.7	13.3	0	177													
hDL-vhTMEAN-aTDIF-lTOTP	80701	1	Pakistan	Pirsabak	6	34.0	72.8	474	14.1	30.2	12.1	446	323	80705	1	Pakistan	Islamabad	6	33.5	72.8	521	14.1	29.2	13.1	414	300
Subtropical-temperate lowlands	80702	1	Pakistan	Yousafwala	6	31.0	74.0	176	13.9	32.2	11.4	266	313	80403	1	India	Ludhiana	7	30.9	75.8	241	13.4	29.5	11.9	513	275
vlDL-alTMEAN-hTDIF-vlTOTP	80201	2	Bangladesh	Joydebpur	11	24.0	90.4	8	10.6	21.3	12.6	55	160	11	1	Botswana	Good-Hope	6	-25.5	25.5	###	10.5	13.8	18.1	26	104
Subtropical winter, rainfall limited	80202	2	Bangladesh	Ishurdi	11	24.1	89.1	31	10.6	20.8	14.1	50	168	80420	2	India	Bahraich	12	27.7	81.6	130	10.4	18.6	15.8	66	168
	80209	2	Bangladesh	Rangpur	11	25.7	89.2	32	10.5	19.7	14.3	34	160	20709	1	Mexico	Los Mochis	11	25.8	-109.0	10	10.5	19.9	17.3	43	94
lDL-alTMEAN-alTDIF-alTOTP	6	1	Angola	Chianga	10	-12.7	15.8	1736	12.5	19.8	11.3	784	122	70702	1	Kenya	Kitale	4	-1.0	35.0	###	12.0	18.5	12.8	488	105
Tropical midlands rainfall low-average	9	1	Angola	Poligno-Florestal	10	-9.5	16.3	1178	12.4	21.3	11.7	545	113	70703	1	Kenya	Embu	3	-0.5	37.5	###	12.0	20.1	11.3	575	135
	10501	1	Colombia	Palmira	9	3.6	-76.4	1189	12.0	22.4	10.3	555	101	70709	1	Kenya	Katumani	3	-1.6	37.2	###	12.0	20.2	11.2	314	123
	10506	1	Colombia	Cali	9	3.5	-76.4	1189	12.0	22.4	10.3	555	101	11001	1	Peru	Piura	6	-5.2	-80.6	137	11.7	22.8	11.0	9	97
	10601	1	Ecuador	Pichilingue	6	-1.1	-79.5	320	11.9	23.3	9.1	272	87	11005	1	Peru	La Molina	6	-12.1	-77.0	762	11.3	16.2	9.4	23	70
	10602	1	Ecuador	Porto Viejo	7	-1.1	-80.4	213	12.0	24.0	10.2	0	93	11008	1	Peru	Tarapoto	2	-6.5	-76.4	412	12.1	24.7	10.7	522	100
	33	1	Ethiopia	Ambo	5	9.1	37.8	2083	12.5	17.0	12.3	695	99	11018	1	Peru	El Porvenir	2	-6.5	-76.4	457	12.1	24.5	10.7	524	99
	70602	1	Ethiopia	Awassa	5	7.1	38.5	1784	12.4	18.7	12.6	478	110	23	1	Tanzania	Selian	12	-4.5	35.2	###	12.3	19.3	10.9	516	116
	70603	1	Ethiopia	Bako	5	5.9	37.1	1257	12.3	21.1	10.8	344	115	24	1	Tanzania	Uyole	11	-8.9	33.4	###	12.5	21.0	10.7	704	113
	70607	1	Ethiopia	Nazareth	6	8.5	39.5	1631	12.5	21.1	12.0	567	119	72102	1	Tanzania	Ukiriguru	11	-2.7	33.0	###	12.2	22.6	9.8	468	127
	20604	2	Honduras	La Esperanza	12	14.3	-88.2	1821	11.2	16.8	12.6	94	105	72104	1	Tanzania	Lambo	3	-3.3	37.2	###	12.0	21.4	10.1	627	108
	20606	2	Honduras	Omonita	12	14.4	-87.7	560	11.2	22.8	11.1	139	121	72302	1	Uganda	Namulonge	3	0.5	32.6	###	12.0	22.4	10.3	477	130
aDL-lTMEAN-lTDIF-aTOTP	15	2	Colombia	Chinchina	9	4.9	-75.6	2500	11.9	14.1	8.2	842	84	10507	2	Colombia	Tibaitata	9	4.7	-74.2	###	11.9	13.6	8.9	418	80
Tropical highlands, cold, low temp.diff.	15	1	Colombia	Chinchina	4	4.9	-75.6	2500	12.2	14.5	8.0	658	86	10507	1	Colombia	Tibaitata	4	4.7	-74.2	###	12.2	13.7	8.1	369	78
	16	2	Colombia	Medellin	9	6.3	-75.6	2286	11.9	15.9	9.7	870	87	10510	2	Colombia	Rionegro	9	6.2	-75.4	###	11.9	16.7	9.8	870	88
	16	1	Colombia	Medellin	4	6.3	-75.6	2286	12.2	16.4	9.8	813	91	10510	1	Colombia	Rionegro	4	6.2	-75.4	###	12.2	17.1	9.8	825	92
	17	1	Colombia	Popayan	9	2.5	-76.6	2362	12.0	14.6	9.9	813	86													
hDL-aTMEAN-hTDIF-alTOTP	20708	1	Mexico	Celaya	6	20.5	-100.8	1765	13.2	21.7	13.8	501	129	12	1	Botswana	Hukunsi	2	-24.0	21.8	###	12.4	21.5	15.1	162	122
Subtropical highlands, warm	20763	1	Mexico	Gomez Farias	7	29.3	-107.8	2136	13.3	19.9	15.4	358	123	14	1	Botswana	Sebele	2	-24.6	26.0	972	12.4	21.1	15.2	197	124
	21117	1	Mexico	Queretaro	6	20.5	-100.7	1777	13.2	21.7	13.7	465	129	19	1	Lesotho	Maseru	11	-29.3	27.5	###	13.8	19.9	13.7	384	156
	21124	1	Mexico	Irapuato	6	20.7	-101.3	1785	13.2	21.7	13.8	570	128	71401	1	Rsa	Potchefstroom	12	-26.7	27.1	###	13.6	22.0	14.0	385	160
	21138	1	Mexico	Pabellon	6	22.2	-102.3	1952	13.3	20.7	14.2	387	129	71404	1	Rsa	Viljienskroon	1	-27.2	26.9	###	13.2	20.6	14.8	317	140
	21150	1	Mexico	Calera	7	22.9	-102.7	2213	13.0	19.1	13.3	276	114													
	21162	1	Mexico	Cuautitlan	6	19.7	-99.2	2246	13.1	18.8	12.9	552	107													
ahDL-vlTMEAN-hTDIF-alTOTP	10101	1	Argentina	Pergamino	9	-33.9	-60.6	61	12.5	17.8	13.4	337	126	20713	1	Mexico	El Batan	5	19.5	-98.9	###	13.1	17.4	14.3	492	115
Subtropical highlands, cold	10205	1	Bolivia	Parirumani	12	-17.4	-66.3	2819	13.0	16.1	12.9	500	116	20715	1	Mexico	Toluca	5	19.3	-99.7	###	13.1	14.4	13.2	576	106
	10206	1	Bolivia	Cochabamba	12	-17.4	-66.2	2895	13.0	15.6	12.8	485	115	21130	1	Mexico	Metepec	5	19.3	-99.6	###	13.1	14.4	13.3	572	107
	10402	1	Chile	La Platina	10	-33.6	-70.6	1037	13.4	15.4	15.9	44	137	21144	1	Mexico	Amecameca	5	19.1	-98.8	###	13.1	16.2	13.5	518	109
	10603	1	Ecuador	Sta. Catalina	11	-0.4	-78.5	3353	12.0	9.7	10.8	352	80	11013	1	Peru	Cajamarca	10	-7.1	-78.1	###	12.3	13.3	13.9	339	102
	20504	1	Guatemala	Quetzaltenango	5	14.9	-91.5	2388	12.8	14.2	11.8	679	104	11034	1	Peru	Cajabamba	10	-7.6	-78.1	###	12.3	11.1	14.1	352	99
	18	1	Lesotho	Leribe	10	-28.9	28.1	1699	13.2	18.4	13.5	411	151	22	1	Rsa	Greytown	10	-29.0	30.6	###	13.2	17.5	12.1	473	130
	20	1	Lesotho	Mokotlong	10	-29.3	29.1	2359	13.2	13.9	13.9	395	126	11201	1	Uruguay	La Estanzuela	9	-34.3	-57.7	30	12.5	17.5	11.5	338	122
	70801	1	Lesotho	Thaba-tseka	10	-29.5	28.6	2218	13.2	14.9	13.6	363	134													

l = low; a = average; h = high; v = very.
DL = Daylength of day 15 of each month averaged over 4 months
TMEAN = Mean of maximum and minimum temperature averaged over 4 months
TDIF = Difference in maximum and minimum temperature averaged over 4 months
TOTP = Total precipitation over 4 months
ETP = Evapotranspiration
PLANT = Planting month
LAT, LONG and Z = Latitude, longitude and altitude respectively

Appendix G. **Post classification of selected locations according to the new and 1991 classifications.**

			Classification following 1991				
Newnr	**Meclas**	**MEname**	**latitude**	**altitude**	**tmean**	**Cluster Diagnostic**	**Cluster Characteristic**
1	1a	True Tropical lowland dry	tropical	lowland	tropical	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
2		True Tropical lowland dry	tropical	lowland	tropical	na	na
3		True Tropical lowland dry	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
4		True Tropical lowland dry	tropical	lowland	tropical	hTmean-lTdif-vlP-hDL	Dry subtropical-temperate
5		True Tropical lowland dry	tropical	lowland	tropical	na	na
6	1b	True Tropical lowland mesic	tropical	midaltitude	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
7		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
8		True Tropical lowland mesic	tropical	lowland	tropical	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
9		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
10		True Tropical lowland mesic	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
11		True Tropical lowland mesic	tropical	lowland	tropical	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
12		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
13		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
14		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
15		True Tropical lowland mesic	subtropical	lowland	tropical	hTmean-vlTdif-aP-alDl	Tropical Lowland
16		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-alDl	Tropical Lowland
17		True Tropical lowland mesic	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
18		True Tropical lowland mesic	subtropical	lowland	tropical	hTmean-vlTdif-aP-alDl	Tropical Lowland
19		True Tropical lowland mesic	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
20		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
21		True Tropical lowland mesic	tropical	lowland	tropical	hTmean-vlTdif-aP-alDl	Tropical Lowland
22		True Tropical lowland mesic	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
23		True Tropical lowland mesic	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
24	1c	True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
25		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
26		True Tropical lowland wet	tropical	lowland	tropical	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
27		True Tropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
28		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-alDl	Tropical Lowland
29		True Tropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
30		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
31		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
32		True Tropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
33		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
34		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
35		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
36		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
37		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
38		True Tropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
39		True Tropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
40		True Tropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
41		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
42		True Tropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
43		True Tropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
44		True Tropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
45		True Tropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
46		True Tropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
47	2a	Tropical midaltitude dry	tropical	lowland	htroptrans	na	na
48		Tropical midaltitude dry	subtropical	lowland	st/ma	na	na
49		Tropical midaltitude dry	subtropical	midaltitude	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
50		Tropical midaltitude dry	subtropical	midaltitude	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
51		Tropical midaltitude dry	tropical	lowland	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
52		Tropical midaltitude dry	tropical	lowland	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
53	2b	Tropical midaltitude mesic	subtropical	lowland	htroptrans	na	na
54		Tropical midaltitude mesic	tropical	troptrans	htroptrans	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
55		Tropical midaltitude mesic	tropical	troptrans	htroptrans	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
56		Tropical midaltitude mesic	tropical	troptrans	htroptrans	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
57		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
58		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
59		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
60		Tropical midaltitude mesic	tropical	troptrans	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
61		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
62		Tropical midaltitude mesic	subtropical	lowland	st/ma	na	na
63		Tropical midaltitude mesic	tropical	troptrans	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
64		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
65		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
66		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
67		Tropical midaltitude mesic	subtropical	lowland	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
68		Tropical midaltitude mesic	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
69		Tropical midaltitude mesic	tropical	midaltitude	st/ma	na	na
70		Tropical midaltitude mesic	subtropical	lowland	st/ma	hTmean-vlTdif-aP-lDl	Tropical Lowland
71		Tropical midaltitude mesic	tropical	lowland	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
72		Tropical midaltitude mesic	subtropical	lowland	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
73	2c	Tropical midaltitude wet	tropical	troptrans	htroptrans	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
74		Tropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
75		Tropical midaltitude wet	tropical	troptrans	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
76		Tropical midaltitude wet	tropical	midaltitude	st/ma	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
77		Tropical midaltitude wet	tropical	lowland	st/ma	hTmean-altdif-vhP-aDl	Tropical lowland wet

Tree	CLUSTER	CLUSNAME	CID	newid	Country	Location	PLANT	LAT	LONG	Z	DL	TMEAN	TOTP	TDIF	ETP
2	5	CL17	10602	10602	Ecuador	Porto Viejo	7	-1.07	-80.43	213	11.96	24.0	0	10.2	93
na	na	na		-21	Thailand	Nakhon-S	10	15.35	100.5	83	11.41	25.7	195	10.6	183
6	2	CL15	10342	10342	Brazil	S. Cruz Palmeira	11	-6.22	-36.00	182	12.34	26.5	137	9.4	146
9	14	CL16	80427	80427	India	Bangalore	2	12.97	77.58	909	11.82	26.6	178	13.8	243
na	na	na		-20	Thailand	Suwan	10	14.08	101	13	11.46	26.8	212	12.3	205
5	9	CL22	72101	72101	Tanzania	Ilonga	12	-6.77	37.03	914	12.37	24.0	549	11.2	132
2	4	CL28	8	8	Angola	Kilombo	10	-8.91	14.73	432	12.34	24.4	493	8.7	120
12	5	CL17	11018	11018	Peru	El Porvenir	2	-6.52	-76.35	457	12.09	24.5	524	10.7	99
2	4	CL28	61103	61103	Ghana	Kwadaso	6	6.75	-1.58	287	12.37	24.5	592	6.8	96
5	9	CL22	11312	11312	Venezuela	San Javier	7	10.35	-68.65	557	12.42	24.6	551	10.5	130
12	5	CL17	11008	11008	Peru	Tarapoto	2	-6.52	-76.42	412	12.09	24.7	522	10.7	100
2	4	CL28	60702	60702	Cote D'ivoire	Bouake	7	7.68	-5.03	360	12.31	24.9	530	9.0	104
2	4	CL28	20518	-9	Guatemala	Polochic	10	15.31	-89.75	40	11.41	25.4	549	8.5	102
2	4	CL28	4	4	Angola	Catete-Mazozo	3	-9.10	13.72	50	11.89	25.5	341	7.0	116
1	1	CL47	91302	91302	Taiwan	Taichung	8	24.02	120.68	82	12.38	25.5	483	8.1	175
1	1	CL47	90507	90507	Indonesia	Muneng	4	-8.27	113.28	13	11.69	25.6	338	7.6	145
6	2	CL15	90507	-17	Indonesia	Muneng	9	-8.27	113.28	13	12.11	26.1	548	8.0	153
1	1	CL47	91301	91301	Taiwan	Po-Tzu-Chia-I	8	23.50	120.23	4	12.37	26.2	510	8.6	175
6	2	CL15	91616	91616	Philippines	Gral. Santos	5	6.12	125.18	12	12.33	26.8	396	8.1	168
2	4	CL28	10	10	Angola	St. Vincente	11	-5.57	12.20	0	12.30	27.0	422	7.2	112
1	1	CL47	90512	90512	Indonesia	Maros	4	-5.00	119.60	52	11.81	27.3	348	8.1	160
6	2	CL15	60706	60706	Cote D'Ivoire	Sinematiali	4	9.62	-3.07	250	12.36	27.6	509	9.6	143
6	2	CL15	60701	60701	Cote D'Ivoire	Ferkessedougou	4	9.58	-5.23	283	12.36	27.7	567	9.9	150
2	4	CL28	20615	-12	Honduras	La Ceiba	12	15.75	-86.87	22	11.12	24.2	739	7.4	106
2	4	CL28	72408	72408	Zaire	Mvuazi	10	-5.45	14.90	538	12.20	24.5	701	8.9	108
12	5	CL17	72401	72401	Zaire	Gandajika	9	-6.75	23.95	800	12.09	24.5	672	12.7	121
3	6	CL23	20304	-7	Costa Rica	Los Diamantes	10	10.22	-83.77	245	11.61	25.2	1567	10.0	103
1	1	CL47	91609	-19	Philippines	Ilagan	9	16.50	121.15	278	11.78	25.4	699	7.5	175
3	6	CL23	90503	90503	Indonesia	Bogor	9	-6.62	106.73	341	12.09	25.4	1448	7.7	150
2	4	CL28	10516	10516	Colombia	Antioquia	5	7.70	-76.80	168	12.41	25.7	1109	8.0	111
2	4	CL28	20907	20907	Panama	Guarare	6	7.83	-80.33	33	12.43	26.2	714	7.6	103
6	2	CL15	91502	91502	Vietnam	Hung Loc	4	10.95	107.23	193	12.41	26.4	972	8.2	160
2	4	CL28	20911	20911	Panama	El Ejido	6	7.93	-80.38	22	12.44	26.5	695	7.6	103
2	4	CL28	11029	11029	Peru	Iquitos	2	-3.75	-73.25	91	12.05	26.5	1088	9.4	96
2	4	CL28	10502	-3	Colombia	Turipana	9	8.65	-75.97	50	11.89	26.8	986	8.0	105
2	4	CL28	20902	20902	Panama	Tocumen	5	9.05	-79.37	6	12.49	26.9	990	6.1	103
2	4	CL28	10504	-4	Colombia	Monteria	9	8.83	-75.78	70	11.89	26.9	973	8.2	106
6	2	CL15	3	3	Philipinnes	Cagayan	5	8.29	124.38	290	12.45	26.9	786	9.0	178
3	6	CL23	20909	20909	Panama	Chiriqui	5	8.38	-82.33	16	12.45	27.0	1476	9.9	107
3	6	CL23	20302	20302	Costa Rica	Guanacaste	7	10.35	-85.13	25	12.42	27.0	1428	10.4	119
2	4	CL28	10502	10502	Colombia	Turipana	4	8.65	-75.97	50	12.32	27.1	942	8.2	117
2	4	CL28	10504	10504	Colombia	Monteria	4	8.83	-75.78	70	12.33	27.1	905	8.3	118
6	2	CL15	91606	91606	Philippines	Karaan	5	7.00	125.00	102	12.38	27.1	923	9.0	168
6	2	CL15	2	2	Indonesia	Lampung	9	-5.30	105.10	118	12.07	27.1	633	9.1	168
6	2	CL15	90512	-18	Indonesia	Maros	9	-5.00	119.60	52	12.06	27.5	783	8.3	163
6	2	CL15	91620	91620	Philippines	Mindanao	6	7.23	124.82	24	12.40	27.9	791	9.2	175
na	na	na		-24	Brazil	Sete Lagoas	4	-19.47	-44.25	823	11.25	18.9	133	13.5	79
na	na	na		-25	Vietnam	Song-Boin	10	20.48	105.78	55	11.2	20.9	193	6.8	120
14	10	CL25	14	14	Botswana	Sebele	2	-24.57	25.95	972	12.36	21.1	197	15.2	124
14	10	CL25	12	12	Botswana	Hukunsi	2	-23.97	21.75	1064	12.35	21.5	162	15.1	122
12	5	CL17	11001	11001	Peru	Piura	6	-5.18	-80.63	137	11.72	22.8	9	11.0	97
12	5	CL17	20606	-11	Honduras	Omonita	12	14.40	-87.67	560	11.20	22.8	139	11.1	121
na	na	na		-26	China	Nanning	10	22.6	108.17	115	11.11	18.1	206	7.9	115
12	5	CL17	70702	70702	Kenya	Kitale	4	-1.01	35.00	1694	11.96	18.5	488	12.8	105
12	5	CL17	70602	70602	Ethiopia	Awassa	5	7.08	38.48	1784	12.38	18.7	478	12.6	110
12	5	CL17	23	23	Tanzania	Selian	12	-4.50	35.17	1829	12.25	19.3	516	10.9	116
12	5	CL17	70703	70703	Kenya	Embu	3	-0.50	37.45	1380	11.99	20.1	575	11.3	135
12	5	CL17	70709	70709	Kenya	Katumani	3	-1.58	37.23	1477	11.98	20.2	314	11.2	123
12	5	CL17	70603	70603	Ethiopia	Bako	5	5.85	37.08	1257	12.31	21.1	344	10.8	115
12	5	CL17	70607	70607	Ethiopia	Nazareth	6	8.50	39.50	1631	12.47	21.1	567	12.0	119
12	5	CL17	9	9	Angola	Poligno-Florestal	10	-9.52	16.32	1178	12.36	21.3	545	11.7	113
na	na	na		-22	Mexico	Poza Rica	10	20.53	-97.43	87	11.2	21.5	534	9.3	86
5	9	CL22	70601	70601	Ethiopia	Alemaya	7	9.40	41.08	1524	12.38	22.3	415	12.6	139
12	5	CL17	72302	72302	Uganda	Namulonge	3	0.53	32.58	1112	12.01	22.4	477	10.3	130
12	5	CL17	10501	10501	Colombia	Palmira	9	3.55	-76.35	1189	11.95	22.4	555	10.3	101
12	5	CL17	10506	10506	Colombia	Cali	9	3.50	-76.37	1189	11.96	22.4	555	10.3	101
5	9	CL22	10902	10902	Paraguay	Capitan Miranda	9	-27.28	-55.82	91	12.38	22.4	576	12.9	135
12	5	CL17	72102	72102	Tanzania	Ukiriguru	11	-2.70	33.02	1239	12.15	22.6	468	9.8	127
na	na	na		-27	Guatemal	Cuyuta	10	14.25	-90	950	11.46	22.7	280	10.4	107
2	4	CL28	91517	91517	Vietnam	Dan Phuong	2	21.03	105.80	16	11.70	22.8	274	6.1	123
12	5	CL17	10601	10601	Ecuador	Pichilingue	6	-1.10	-79.48	320	11.94	23.3	272	9.1	87
5	9	CL22	10901	10901	Paraguay	Caacupe	9	-25.40	-57.10	214	12.35	23.6	497	11.0	145
12	5	CL17	6	6	Angola	Chianga	10	-12.73	15.83	1736	12.48	19.8	784	11.3	122
4	8	CL42	5	5	Angola	Cela	10	-11.42	15.12	1328	12.43	20.5	680	9.8	116
12	5	CL17	24	24	Tanzania	Uyole	11	-8.92	33.37	1524	12.49	21.0	704	10.7	113
12	5	CL17	72104	72104	Tanzania	Lambo	3	-3.28	37.23	1072	11.96	21.4	627	10.1	108
3	6	CL23	20311	-8	Costa Rica	Turrialba	10	9.88	-83.65	595	11.63	23.9	1134	10.8	99

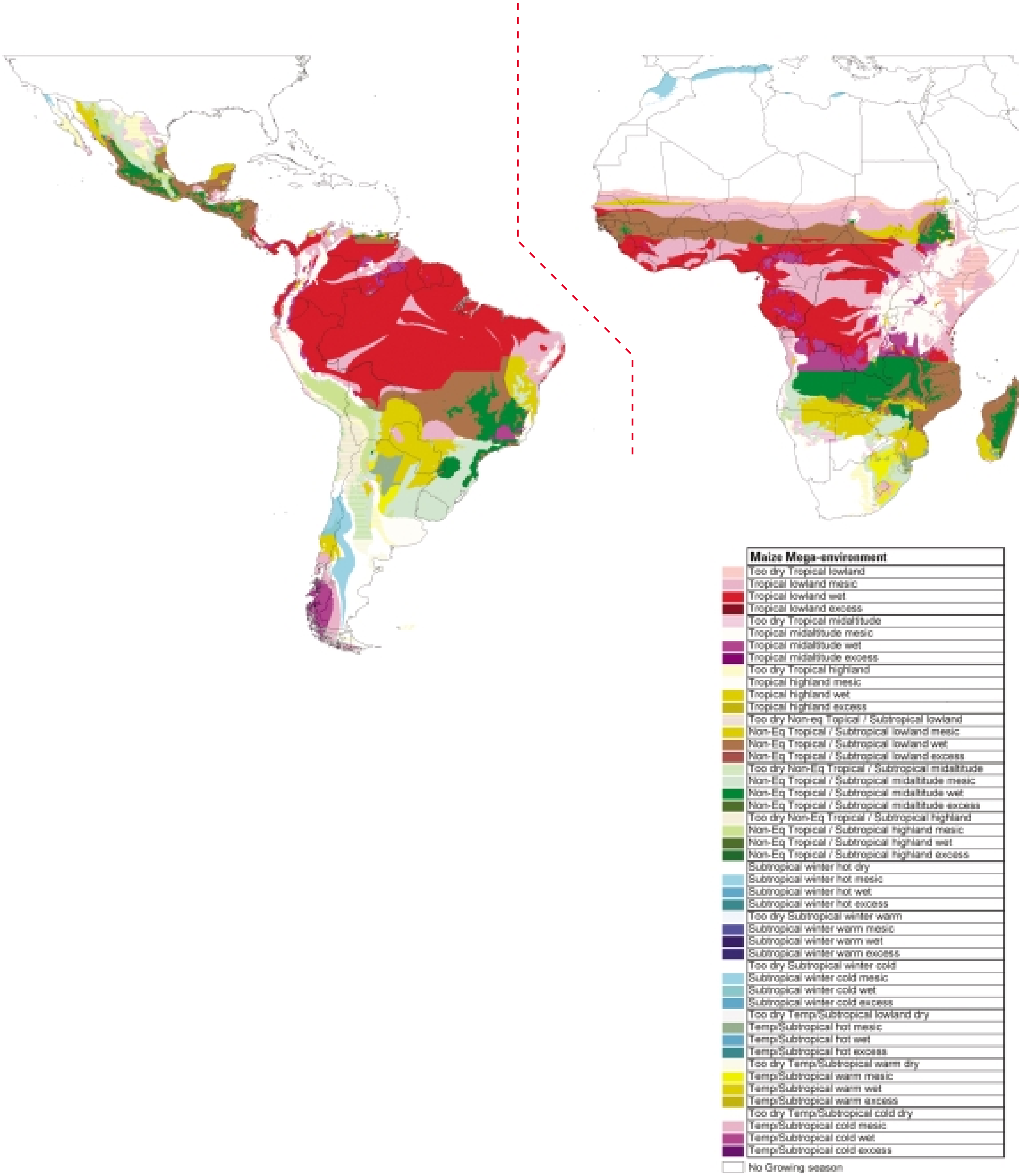
			Classification following 1991				
Newnr	**Meclas**	**MEname**	**latitude**	**altitude**	**tmean**	**Cluster Diagnostic**	**Cluster Characteristic**
78	3a	Tropical Highlands dry	tropical	lowland	trophighland	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
79		Tropical Highlands dry	tropical	troptrans	trophighland	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
80		Tropical Highlands dry	tropical	midaltitude	htroptrans	na	na
81	3b	Tropical Highlands mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
82		Tropical Highlands mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
83		Tropical Highlands mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
84		Tropical Highlands mesic	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
85		Tropical Highlands mesic	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
86		Tropical Highlands mesic	temperate	lowland	highlandtemp	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
87		Tropical Highlands mesic	temperate	lowland	highlandtemp	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
88	3c	Tropical Highlands wet	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
89		Tropical Highlands wet	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
90		Tropical Highlands wet	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
91		Tropical Highlands wet	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
92		Tropical Highlands wet	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
93		Tropical Highlands wet	tropical	highland	trophighland	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
94		Tropical Highlands wet	tropical	highland	htroptrans	alTmean-alTdif-alP-lDl	NONEQ Topics midaltitude mesic
95		Tropical Highlands wet	tropical	highland	htroptrans	lTmean-lTdif-aP-aDl	Tropical Highlands but low temperature difference
96	4b	True Subtropical lowland mesic	tropical	midaltitude	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
97		True Subtropical lowland mesic	tropical	midaltitude	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
98		True Subtropical lowland mesic	tropical	midaltitude	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
99		True Subtropical lowland mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
100		True Subtropical lowland mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
101		True Subtropical lowland mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
102		True Subtropical lowland mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
103		True Subtropical lowland mesic	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
104		True Subtropical lowland mesic	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
105		True Subtropical lowland mesic	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
106		True Subtropical lowland mesic	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
107		True Subtropical lowland mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
108		True Subtropical lowland mesic	temperate	lowland	tropical	vhTmean-aTdif-lP-hDL	Dry temperate lowlands
109	4c	True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
110		True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
111		True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
112		True Subtropical lowland wet	subtropical	troptrans	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
113		True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
114		True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
115		True Subtropical lowland wet	tropical	lowland	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
116		True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
117		True Subtropical lowland wet	tropical	lowland	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
118		True Subtropical lowland wet	subtropical	troptrans	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
119		True Subtropical lowland wet	subtropical	troptrans	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
120		True Subtropical lowland wet	tropical	lowland	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
121		True Subtropical lowland wet	subtropical	lowland	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
122		True Subtropical lowland wet	tropical	lowland	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
123		True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
124		True Subtropical lowland wet	tropical	midaltitude	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
125		True Subtropical lowland wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
126		True Subtropical lowland wet	tropical	lowland	tropical	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
127		True Subtropical lowland wet	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
128		True Subtropical lowland wet	subtropical	midaltitude	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
129		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
130		True Subtropical lowland wet	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
131		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
132		True Subtropical lowland wet	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
133		True Subtropical lowland wet	subtropical	midaltitude	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
134		True Subtropical lowland wet	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
135		True Subtropical lowland wet	tropical	lowland	tropical	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
136		True Subtropical lowland wet	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
137		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
138		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
139		True Subtropical lowland wet	tropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
140		True Subtropical lowland wet	subtropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
141		True Subtropical lowland wet	tropical	midaltitude	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
142		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
143		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
144		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
145		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
146		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
147		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
148		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
149		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
150		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-vlTdif-aP-lDl	Tropical Lowland
151		True Subtropical lowland wet	subtropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
152		True Subtropical lowland wet	tropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet
153		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
154		True Subtropical lowland wet	subtropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
155		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
156		True Subtropical lowland wet	subtropical	lowland	tropical	hTmean-altdif-vhP-aDl	Tropical lowland wet

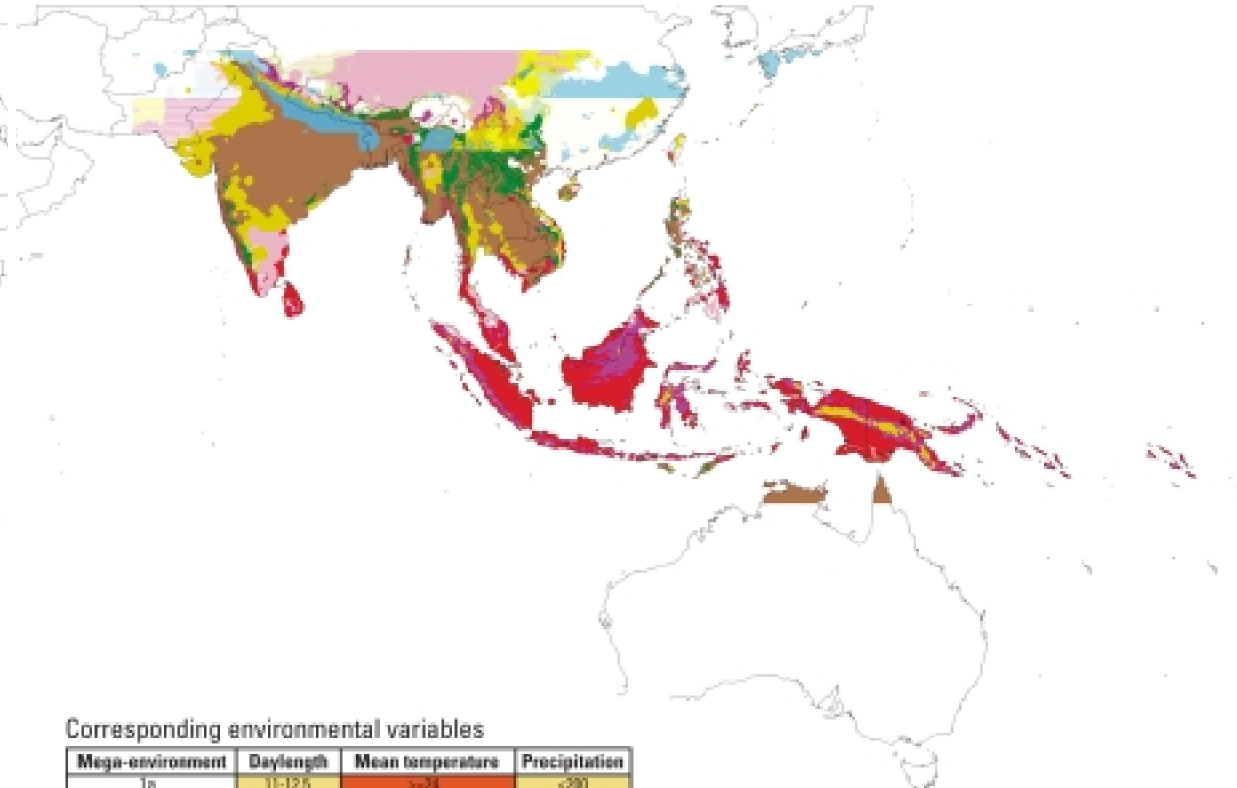
Tree	CLUSTER	CLUSNAME	CID	newid	Country	Location	PLANT	LAT	LONG	Z	DL	TMEAN	TOTP	TDIF	ETP
12	5	CL17	11005	11005	Peru	La Molina	6	-12.08	-76.95	762	11.33	16.2	23	9.4	70
12	5	CL17	20604	-10	Honduras	La Esperanza	12	14.25	-88.20	1821	11.21	16.8	94	12.6	105
na	na	na		-23	Zambia	Golden-V	4	-14.17	28.37	1170	11.46	17.9	29	15.2	110
15	11	CL19	10603	10603	Ecuador	Sta. Catalina	11	-0.38	-78.52	3353	12.02	9.7	352	10.8	80
15	11	CL19	11034	11034	Peru	Cajabamba	10	-7.62	-78.05	3353	12.29	11.1	352	14.1	99
15	11	CL19	11013	11013	Peru	Cajamarca	10	-7.10	-78.07	2896	12.27	13.3	339	13.9	102
13	7	CL51	10507	-5	Colombia	Tibaitata	9	4.70	-74.20	2545	11.94	13.6	418	8.9	80
13	7	CL51	10507	10507	Colombia	Tibaitata	4	4.70	-74.20	2545	12.17	13.7	369	8.1	78
15	11	CL19	11201	11201	Uruguay	La Estanzuela	9	-34.33	-57.68	30	12.50	17.5	338	11.5	122
15	11	CL19	10101	10101	Argentina	Pergamino	9	-33.93	-60.57	61	12.49	17.8	337	13.4	126
13	7	CL51	15	-1	Colombia	Chinchina	9	4.93	-75.60	2500	11.94	14.1	842	8.2	84
13	7	CL51	15	15	Colombia	Chinchina	4	4.93	-75.60	2500	12.18	14.5	658	8.0	86
13	7	CL51	17	17	Colombia	Popayan	9	2.45	-76.60	2362	11.97	14.6	813	9.9	86
13	7	CL51	16	-2	Colombia	Medellin	9	6.26	-75.58	2286	11.92	15.9	870	9.7	87
13	7	CL51	16	16	Colombia	Medellin	4	6.26	-75.58	2286	12.23	16.4	813	9.8	91
13	7	CL51	10510	-6	Colombia	Rionegro	9	6.18	-75.43	2156	11.92	16.7	870	9.8	88
12	5	CL17	33	33	Ethiopia	Ambo	5	9.05	37.82	2083	12.49	17.0	695	12.3	99
13	7	CL51	10510	10510	Colombia	Rionegro	4	6.18	-75.43	2156	12.23	17.1	825	9.8	92
5	9	CL22	30	30	Zimbabwe	Makoholi	11	-19.83	30.78	1111	13.12	22.5	489	11.2	146
5	9	CL22	13	13	Botswana	Pandamatenga	12	-18.55	25.65	1097	13.05	23.8	523	12.3	144
5	9	CL22	10207	10207	Bolivia	Iboperanda	11	-19.87	-63.77	1066	13.12	24.1	487	12.4	138
5	9	CL22	10224	10224	Bolivia	Algarrobal	11	-21.45	-63.65	777	13.22	24.7	539	12.5	139
5	9	CL22	72608	72608	Zimbabwe	Chisumbanji	12	-20.80	32.23	412	13.19	25.4	379	11.6	145
5	9	CL22	32	32	Zimbabwe	Save-Valley	12	-20.35	32.33	446	13.16	25.4	326	11.9	142
5	9	CL22	29	29	Zimbabwe	Chiredzi	12	-21.02	31.58	433	13.20	25.5	424	11.9	150
6	2	CL15	10203	10203	Bolivia	Santa Cruz	10	-17.70	-63.13	350	12.69	26.0	564	10.7	152
6	2	CL15	80404	80404	India	Hyderabad	7	17.33	78.50	521	12.71	26.1	541	9.1	195
5	9	CL22	72607	72607	Zimbabwe	Mzarabani	12	-16.37	31.02	429	12.92	26.5	584	11.1	139
5	9	CL22	71004	71004	Malawi	Ngabu	12	-16.47	34.92	108	12.92	27.5	584	11.3	141
5	9	CL22	20764	20764	Mexico	Culiacan, Sin.	7	24.80	-107.40	48	13.06	29.0	560	12.0	143
10	15	CL31	80403	80403	India	Ludhiana	7	30.90	75.80	241	13.38	29.5	513	11.9	275
4	8	CL42	72501	72501	Zambia	Mount-Makulu	11	-15.53	28.25	1281	12.86	22.0	687	10.1	129
4	8	CL42	71001	71001	Malawi	Chitedze	12	-13.98	33.63	1097	12.78	22.1	724	9.6	119
4	8	CL42	72406	72406	Zaire	Kaniamesh	11	-11.73	27.42	1295	12.64	22.1	952	11.5	110
5	9	CL22	20798	20798	Mexico	S. M. Cuyutlan,	6	20.50	-103.50	1616	13.17	22.3	754	12.6	121
4	8	CL42	25	25	Zambia	Kabwe	11	-14.45	28.47	1200	12.80	22.4	780	10.2	124
4	8	CL42	20506	20506	Guatemala	San Jeronimo	5	15.08	-90.23	1420	12.83	22.4	1081	10.2	114
4	8	CL42	10302	10302	Brazil	Sete Lagoas	10	-19.47	-44.25	823	12.76	22.5	954	11.1	115
4	8	CL42	72503	72503	Zambia	Golden Valley	11	-14.17	28.37	1170	12.78	22.5	818	10.3	123
4	8	CL42	20612	20612	Honduras	Catacamas	5	14.91	-85.90	819	12.82	22.8	687	8.9	120
5	9	CL22	20794	20794	Mexico	Tlajomulco, Jal	6	20.47	-103.77	1513	13.17	22.8	742	13.0	121
5	9	CL22	21101	21101	Mexico	Zapopan, Jal.	6	20.70	-103.38	1566	13.19	22.9	743	12.8	123
4	8	CL42	71005	71005	Malawi	Bvumbwe	11	-15.92	35.07	889	12.88	23.1	788	9.3	128
5	9	CL22	10317	10317	Brazil	Jardinopolis	10	-20.98	-47.80	709	12.82	23.3	834	11.4	128
5	9	CL22	71201	71201	Mozambique	Sussundenga	11	-19.33	33.22	787	13.09	23.5	739	11.5	139
4	8	CL42	20507	20507	Guatemala	Jutiapa	5	14.25	-89.92	948	12.78	23.7	1032	9.7	125
5	9	CL22	27	27	Zambia	Masabuka	11	-15.85	27.75	1000	12.88	23.7	658	10.6	135
4	8	CL42	20501	20501	Guatemala	Cuyuta	5	14.25	-90.00	950	12.78	23.9	1040	9.6	125
4	8	CL42	71006	71006	Malawi	Chitala	12	-13.13	34.07	733	12.73	24.1	948	8.9	125
5	9	CL22	11303	11303	Venezuela	San Joaquin	6	10.26	-67.78	580	12.57	24.1	602	10.6	123
5	9	CL22	21143	21143	Mexico	Ameca, Jal.	6	20.55	-104.05	1244	13.18	24.5	702	13.5	123
3	6	CL23	80422	80422	India	Arabhavi	6	16.20	74.90	531	12.91	24.6	1053	7.1	160
5	9	CL22	10322	10322	Brazil	Capinopolis	10	-18.68	-49.57	579	12.73	24.6	816	12.0	131
3	6	CL23	20311	20311	Costa Rica	Turrialba	5	9.88	-83.65	595	12.53	24.7	1225	10.7	106
5	9	CL22	91602	91602	Philippines	U.P. Los Baños	5	14.17	121.25	52	12.77	24.9	949	12.0	163
5	9	CL22	20725	20725	Mexico	Xalisco, Nay.	6	21.43	-104.80	987	13.23	25.0	1094	12.1	124
5	9	CL22	72504	72504	Zambia	Kaoma	12	-15.77	27.92	668	12.88	25.1	618	10.3	134
4	8	CL42	20606	20606	Honduras	Omonita	5	14.40	-87.67	560	12.79	25.2	990	9.9	132
5	9	CL22	20401	20401	El Salvador	San Andres	5	13.80	-89.42	452	12.75	25.9	1083	10.9	135
3	6	CL23	20304	20304	Costa Rica	Los Diamantes	5	10.22	-83.77	245	12.55	26.0	1400	9.9	111
3	6	CL23	20102	20102	Belize	Central Farm	6	17.00	-89.00	353	12.96	26.0	1520	7.3	120
5	9	CL22	71208	71208	Mozambique	Nampula	12	-15.10	39.28	329	12.84	26.3	831	11.5	142
6	2	CL15	90403	90403	China	Nanning	4	22.60	108.17	115	12.89	26.3	680	6.9	168
5	9	CL22	20712	20712	Mexico	Tlaltizapan	6	18.68	-99.13	945	13.06	26.5	819	13.5	119
6	2	CL15	61401	61401	Burkina Faso	Farako-Ba	5	11.10	-4.33	466	12.60	26.7	744	10.5	149
3	6	CL23	61302	61302	Guinea-Bissau	Cenmac	6	12.35	-14.55	23	12.69	26.8	1265	8.6	128
6	2	CL15	91609	91609	Philippines	Ilagan	4	16.50	121.15	278	12.63	27.0	612	9.1	205
6	2	CL15	80417	80417	India	Jalna	6	19.85	75.88	485	13.13	27.0	602	9.5	208
3	6	CL23	20716	20716	Mexico	Veracruz	6	19.15	-96.12	3	13.09	27.4	968	9.9	124
3	6	CL23	20502	20502	Guatemala	La Maquina	6	14.30	-91.57	55	12.80	27.4	1642	10.2	121
6	2	CL15	20805	20805	Nicaragua	Santa Rosa	5	12.13	-86.18	77	12.66	27.4	617	9.2	146
6	2	CL15	91513	91513	Vietnam	Doc Trong Farm	5	11.13	108.38	173	12.60	27.4	622	7.6	163
2	4	CL28	20615	20615	Honduras	La Ceiba	6	15.75	-86.87	22	12.88	27.5	648	7.5	121
3	6	CL23	20710	20710	Mexico	Poza Rica	6	20.53	-97.43	87	13.18	27.5	999	10.7	129
3	6	CL23	20518	20518	Guatemala	Polochic	5	15.31	-89.75	40	12.84	28.2	1326	9.6	134
6	2	CL15	90302	90302	Cambodia	Banteay-dek	5	12.00	105.00	15	12.65	28.3	680	8.2	180
6	2	CL15	80209	80209	Bangladesh	Rangpur	4	25.73	89.23	32	13.03	28.3	1324	9.8	213
6	2	CL15	91406	91406	Thailand	Nakhon Sawan R.	6	15.35	100.50	83	12.86	28.4	705	9.3	193
3	6	CL23	20717	20717	Mexico	Nayarit (INIFAP)	6	21.51	-105.20	7	13.24	28.6	1300	10.1	138

Newnr	Meclas	MEname	Classification following 1991 latitude	altitude	tmean	Cluster Diagnostic	Cluster Characteristic
157		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
158		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
159		True Subtropical lowland wet	subtropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
160		True Subtropical lowland wet	subtropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
161		True Subtropical lowland wet	subtropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
162		True Subtropical lowland wet	tropical	lowland	tropical	vhTmean-lTdif-aP-aDl	Tropical Lowland very hot
163	5b	Subtropical midaltitude mesic	subtropical	troptrans	htroptrans	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
164		Subtropical midaltitude mesic	tropical	highland	htroptrans	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
165		Subtropical midaltitude mesic	subtropical	highland	htroptrans	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
166		Subtropical midaltitude mesic	tropical	midaltitude	htroptrans	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
167		Subtropical midaltitude mesic	subtropical	highland	htroptrans	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
168		Subtropical midaltitude mesic	subtropical	midaltitude	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
169		Subtropical midaltitude mesic	subtropical	highland	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
170		Subtropical midaltitude mesic	subtropical	midaltitude	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
171		Subtropical midaltitude mesic	tropical	troptrans	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
172		Subtropical midaltitude mesic	subtropical	lowland	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
173		Subtropical midaltitude mesic	subtropical	troptrans	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
174		Subtropical midaltitude mesic	subtropical	troptrans	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
175		Subtropical midaltitude mesic	subtropical	troptrans	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
176		Subtropical midaltitude mesic	tropical	midaltitude	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
177	5c	Subtropical midaltitude wet	tropical	troptrans	htroptrans	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
178		Subtropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
179		Subtropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
180		Subtropical midaltitude wet	subtropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
181		Subtropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
182		Subtropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
183		Subtropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
184		Subtropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
185		Subtropical midaltitude wet	tropical	midaltitude	st/ma	aTmean-aTdif-hP-haDl	NONEQ Tropics wet
186	6b	Subtropical highland mesic	subtropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
187		Subtropical highland mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
188		Subtropical highland mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
189		Subtropical highland mesic	subtropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
190		Subtropical highland mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
191		Subtropical highland mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
192		Subtropical highland mesic	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
193		Subtropical highland mesic	tropical	highland	htroptrans	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
194		Subtropical highland mesic	subtropical	midaltitude	htroptrans	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
195	6c	Subtropical highland wet	tropical	highland	trophighland	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands
196	8a	Subtropical winter warm dry	subtropical	lowland	htroptrans	alTmean-htdif-vlP-vlDl	Subtropical winter, short Day, rainfall limited
197		Subtropical winter warm dry	subtropical	lowland	htroptrans	alTmean-htdif-vlP-vlDl	Subtropical winter, short Day, rainfall limited
198		Subtropical winter warm dry	subtropical	lowland	htroptrans	alTmean-htdif-vlP-vlDl	Subtropical winter, short Day, rainfall limited
199		Subtropical winter warm dry	subtropical	lowland	st/ma	alTmean-htdif-vlP-vlDl	Subtropical winter, short Day, rainfall limited
200		Subtropical winter warm dry	subtropical	lowland	st/ma	alTmean-htdif-vlP-vlDl	Subtropical winter, short Day, rainfall limited
201		Subtropical winter warm dry	subtropical	lowland	st/ma	alTmean-htdif-vlP-vlDl	Subtropical winter, short Day, rainfall limited
202	9a	Subtropical winter cold dry	subtropical	midaltitude	trophighland	alTmean-htdif-vlP-vlDl	Subtropical winter, short Day, rainfall limited
203	10a	Temperate-HighlatST hot dry	temperate	lowland	tropical	hTmean-lTdif-vlP-hDL	Dry subtropical-temperate
204		Temperate-HighlatST hot dry	temperate	lowland	tropical	hTmean-lTdif-vlP-hDL	Dry subtropical-temperate
205		Temperate-HighlatST hot dry	temperate	lowland	tropical	hTmean-lTdif-vlP-hDL	Dry subtropical-temperate
206		Temperate-HighlatST hot dry	subtropical	lowland	tropical	hTmean-lTdif-vlP-hDL	Dry subtropical-temperate
207	10b	Temperate-HighlatST hot mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
208		Temperate-HighlatST hot mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
209		Temperate-HighlatST hot mesic	subtropical	lowland	tropical	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
210		Temperate-HighlatST hot mesic	temperate	lowland	tropical	vhTmean-aTdif-lP-hDL	Dry temperate lowlands
211		Temperate-HighlatST hot mesic	temperate	lowland	tropical	vhTmean-aTdif-lP-hDL	Dry temperate lowlands
212		Temperate-HighlatST hot mesic	temperate	lowland	tropical	vhTmean-aTdif-lP-hDL	Dry temperate lowlands
213	10c	Temperate-HighlatST hot wet	subtropical	midaltitude	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
214		Temperate-HighlatST hot wet	subtropical	midaltitude	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
215		Temperate-HighlatST hot wet	subtropical	lowland	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
216		Temperate-HighlatST hot wet	subtropical	lowland	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
217		Temperate-HighlatST hot wet	subtropical	lowland	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
218		Temperate-HighlatST hot wet	subtropical	lowland	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
219		Temperate-HighlatST hot wet	subtropical	lowland	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
220		Temperate-HighlatST hot wet	subtropical	lowland	tropical	ahTmean-lTdfi-hP-vhDL	Subtropical wet
221	10d	Temperate-HighlatST hot extreme wet	subtropical	midaltitude	tropical	hTmean-lTdif-vvhP-hDL	Subtropical extreme wet
222	11b	Temperate-HighlatST warm mesic	subtropical	troptrans	htroptrans	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
223		Temperate-HighlatST warm mesic	subtropical	midaltitude	st/ma	variousTmean-ahTdif-ahP-ahDl	Subtropical, long day
224		Temperate-HighlatST warm mesic	subtropical	midaltitude	st/ma	aTmean-htdif-alP-hDl	Subtropical highlands, long day, warm dry
225	11c	Temperate-HighlatST warm wet	subtropical	highland	htroptrans	ahTmean-lTdfi-hP-vhDL	Subtropical wet
226		Temperate-HighlatST warm wet	subtropical	troptrans	st/ma	ahTmean-lTdfi-hP-vhDL	Subtropical wet
227		Temperate-HighlatST warm wet	subtropical	midaltitude	st/ma	ahTmean-lTdfi-hP-vhDL	Subtropical wet
228	11d	Temperate-HighlatST warm extreme wet	subtropical	midaltitude	st/ma	hTmean-lTdif-vvhP-hDL	Subtropical extreme wet
229	12a	Temperate-HighlatST cold dry	temperate	midaltitude	highlandtemp	vlTmean-htdif-alP-ahDl	Subtropical, cold highlands

Tree	CLUSTER	CLUSNAME	CID	newid	Country	Location	PLANT	LAT	LONG	Z	DL	TMEAN	TOTP	TDIF	ETP
6	2	CL15	91407	91407	Thailand	Phraphutthabat	6	14.73	100.60	6	12.82	28.6	742	9.1	190
6	2	CL15	91414	91414	Thailand	Khonkaen	6	16.43	102.83	162	12.92	28.8	795	8.5	195
6	2	CL15	91501	91501	Vietnam	Song Boi	6	20.48	105.78	55	13.17	29.0	1219	6.9	183
6	2	CL15	80201	80201	Bangladesh	Joydebpur	4	24.00	90.42	8	12.95	29.2	912	7.9	198
6	2	CL15	80202	80202	Bangladesh	Ishurdi	4	24.12	89.08	31	12.95	29.5	775	9.9	225
6	2	CL15	91401	91401	Thailand	Suwan	6	14.08	101.00	13	12.79	29.9	602	8.8	203
15	11	CL19	18	18	Lesotho	Leribe	10	-28.88	28.05	1699	13.19	18.4	411	13.5	151
14	10	CL25	21162	21162	Mexico	Cuautitlan	6	19.68	-99.18	2246	13.12	18.8	552	12.9	107
14	10	CL25	21150	21150	Mexico	Calera, Zac	7	22.90	-102.65	2213	12.97	19.1	276	13.3	114
5	9	CL22	7	7	Angola	Humpata	11	-15.03	13.43	1468	12.83	19.8	448	12.1	127
14	10	CL25	20763	20763	Mexico	Gomez Farias, C	7	29.33	-107.75	2136	13.29	19.9	358	15.4	123
14	10	CL25	71404	71404	RSA	Viljienskroon	1	-27.17	26.92	1347	13.15	20.6	317	14.8	140
14	10	CL25	21138	21138	Mexico	Pabellon Ags	6	22.18	-102.30	1952	13.28	20.7	387	14.2	129
5	9	CL22	31	31	Zimbabwe	Matopos	11	-20.38	28.50	1457	13.15	21.0	458	11.6	147
5	9	CL22	10208	10208	Bolivia	Mairana	11	-18.12	-63.95	1600	13.01	21.3	417	11.3	132
5	9	CL22	72001	72001	Swaziland	Malkerns	10	-26.55	31.15	763	13.08	21.7	490	11.6	148
14	10	CL25	20708	20708	Mexico	Celaya (INIFAP)	6	20.52	-100.82	1765	13.18	21.7	501	13.8	129
14	10	CL25	21117	21117	Mexico	Queretaro	6	20.52	-100.67	1777	13.18	21.7	465	13.7	129
14	10	CL25	21124	21124	Mexico	Irapuato	6	20.73	-101.32	1785	13.19	21.7	570	13.8	128
5	9	CL22	72604	72604	Zimbabwe	Kadoma	11	-18.32	30.90	1309	13.03	21.8	585	11.3	136
4	8	CL42	20604	20604	Honduras	La Esperanza	5	14.25	-88.20	1821	12.78	18.9	1225	11.0	113
4	8	CL42	72602	72602	Zimbabwe	Harare	11	-17.80	31.05	1489	12.99	20.7	646	10.5	129
4	8	CL42	72601	72601	Zimbabwe	Rattray-Arnold	11	-17.67	31.17	1452	12.99	20.8	683	10.5	128
4	8	CL42	28	28	Zimbabwe	Chipinge	11	-20.20	32.62	1102	13.14	21.0	751	9.6	132
4	8	CL42	71203	71203	Mozambique	Lichinga	11	-13.30	35.23	1305	12.73	21.1	815	9.9	124
4	8	CL42	21	21	Malawi	Bembeke	12	-14.17	34.43	1170	12.79	21.5	802	8.8	117
4	8	CL42	26	26	Zambia	Kasama	11	-10.22	31.13	1363	12.56	21.6	918	9.9	113
4	8	CL42	72609	72609	Zimbabwe	Glendale	11	-17.08	31.03	1250	12.95	21.7	682	10.5	131
4	8	CL42	72502	72502	Zambia	Mansa	11	-11.10	28.85	1267	12.61	21.8	842	10.3	112
15	11	CL19	20	20	Lesotho	Mokotlong	10	-29.28	29.08	2359	13.21	13.9	395	13.9	126
15	11	CL19	21130	21130	Mexico	Metepec	5	19.30	-99.63	2650	13.08	14.4	572	13.3	107
15	11	CL19	20715	20715	Mexico	Toluca, Mex.	5	19.28	-99.65	2657	13.07	14.4	576	13.2	106
15	11	CL19	70801	70801	Lesotho	Thaba-Tseka	10	-29.50	28.62	2218	13.22	14.9	363	13.6	134
15	11	CL19	10206	10206	Bolivia	Cochabamba	12	-17.43	-66.17	2895	12.98	15.6	485	12.8	115
15	11	CL19	10205	10205	Bolivia	Parirumani	12	-17.35	-66.32	2819	12.98	16.1	500	12.9	116
15	11	CL19	21144	21144	Mexico	Amecameca, Mex.	5	19.13	-98.77	2491	13.07	16.2	518	13.5	109
15	11	CL19	20713	20713	Mexico	El Batan	5	19.52	-98.87	2267	13.09	17.4	492	14.3	115
15	11	CL19	22	22	RSA	Greytown	10	-29.02	30.60	1314	13.19	17.5	473	12.1	130
15	11	CL19	20504	20504	Guatemala	Quetzaltenango	5	14.87	-91.52	2388	12.81	14.2	679	11.8	104
11	3	CL20	80420	-16	India	Bahraich	12	27.72	81.60	130	10.35	18.6	66	15.8	168
11	3	CL20	80209	-15	Bangladesh	Rangpur	11	25.73	89.23	32	10.50	19.7	34	14.3	160
11	3	CL20	20709	20709	Mexico	Los Mochis, Sin	11	25.77	-109.00	10	10.50	19.9	43	17.3	94
11	3	CL20	20711	20711	Mexico	Cd. Obregon	10	26.67	-109.42	2	10.92	20.6	82	16.5	102
11	3	CL20	80202	-14	Bangladesh	Ishurdi	11	24.12	89.08	31	10.61	20.8	50	14.1	168
11	3	CL20	80201	-13	Bangladesh	Joydebpur	11	24.00	90.42	8	10.62	21.3	55	12.6	160
11	3	CL20	11	11	Botswana	Good-Hope	6	-25.48	25.47	1231	10.50	13.8	26	18.1	104
9	14	CL16	50403	50403	Egypt	Sakha	6	31.12	30.95	7	13.91	25.7	0	13.3	177
9	14	CL16	50404	50404	Egypt	Nubaria	6	31.00	30.50	8	13.90	25.8	0	11.9	173
9	14	CL16	50402	50402	Egypt	Gemmeiza	6	30.72	31.12	9	13.88	26.0	0	13.6	178
9	14	CL16	50401	50401	Egypt	Sids	6	28.93	30.98	29	13.74	27.2	0	14.2	188
5	9	CL22	71202	71202	Mozambique	Umbeluzzi	11	-26.58	32.38	23	13.56	24.7	371	10.7	148
5	9	CL22	72005	72005	Swaziland	Big-Bend	11	-26.78	31.92	109	13.57	25.0	351	11.6	149
5	9	CL22	71209	71209	Mozambique	Chokwe	12	-24.53	33.00	33	13.43	26.6	411	12.5	151
10	15	CL31	80705	80705	Pakistan	Islamabad	6	33.50	72.75	521	14.10	29.2	414	13.1	300
10	15	CL31	80701	80701	Pakistan	Pirsabak	6	34.00	72.83	474	14.14	30.2	446	12.1	323
10	15	CL31	80702	80702	Pakistan	Yousafwala	6	31.00	74.00	176	13.90	32.2	266	11.4	313
7	12	CL18	35	35	Nepal	Pakhribas	6	27.08	87.33	1148	13.61	24.4	696	6.8	210
7	12	CL18	38	38	Nepal	Dailekh	6	28.85	81.72	1237	13.74	25.6	1302	6.5	213
7	12	CL18	80413	80413	India	Jorhat	6	26.77	94.27	123	13.59	28.0	1685	7.1	190
7	12	CL18	80608	80608	Nepal	Surkhet	6	28.60	81.60	617	13.72	28.3	1531	7.6	238
7	12	CL18	80601	80601	Nepal	Rampur	6	27.62	84.42	185	13.65	28.9	1576	8.6	228
7	12	CL18	80405	80405	India	Pantnagar	6	29.00	79.45	204	13.75	29.1	993	8.8	230
7	12	CL18	80407	80407	India	Dholi	6	25.98	86.25	34	13.53	29.6	1050	7.6	208
7	12	CL18	80420	80420	India	Bahraich	6	27.72	81.60	130	13.66	30.1	1012	8.5	230
8	13	CL35	36	36	Nepal	Pokhara	5	28.22	84.00	944	13.66	24.7	2765	8.8	215
14	10	CL25	19	19	Lesotho	Maseru	11	-29.28	27.50	1635	13.75	19.9	384	13.7	156
5	9	CL22	10102	10102	Argentina	Leales	12	-25.83	-65.25	1219	13.52	21.1	475	11.9	137
14	10	CL25	71401	71401	RSA	Potchefstroom	12	-26.67	27.07	1354	13.58	22.0	385	14.0	160
7	12	CL18	90402	90402	China	Kunming	6	25.12	102.72	1957	13.48	19.4	703	8.8	183
7	12	CL18	34	34	Nepal	Kabre-Dolakha	5	27.68	86.07	1733	13.62	20.8	1625	6.8	193
7	12	CL18	90406	90406	China	Gui-Yang	6	26.48	106.65	1153	13.57	23.2	631	9.0	203
8	13	CL35	37	37	Nepal	Lumle Reg. Agric. Res. C	5	28.30	83.80	1492	13.66	22.8	3745	5.1	190
15	11	CL19	10402	10402	Chile	La Platina	10	-33.57	-70.63	1037	13.43	15.4	44	15.9	137

Appendix H. **Zonal maps of maize mega-environments made using trigger season planting.**
Source of climate data: Latin America, Africa: Corbett and O'Brien, 1997; Asia: Jones 1998.





Corresponding environmental variables

Mega-environment	Daylength	Mean temperature	Precipitation
1a	11-12.5	>=24	<200
1b	11-12.5	>=24	>=200<600
1c	11-12.5	>=24	>=600<2000
1d	11-12.5	>=24	>=2000
2a	11-12.5	>18-<24	<200
2b	11-12.5	>18-<24	>=200<600
2c	11-12.5	>18-<24	>=600<2000
2d	11-12.5	>18-<24	>=2000
3a	11-12.5	<=18	<200
3b	11-12.5	<=18	>=200<600
3c	11-12.5	<=18	>=600<2000
3d	11-12.5	<=18	>=2000
4a	1 12.5-13.4	>=24	<200
4b	1 12.5-13.4	>=24	>=200<600
4c	1 12.5-13.4	>=24	>=600<2000
4d	1 12.5-13.4	>=24	>=2000
5a	1 12.5-13.4	>18-<24	<200
5b	1 12.5-13.4	>18-<24	>=200<600
5c	1 12.5-13.4	>18-<24	>=600<2000
5d	1 12.5-13.4	>18-<24	>=2000
6a	1 12.5-13.4	<=18	<200
6b	1 12.5-13.4	<=18	>=200<600
6c	1 12.5-13.4	<=18	>=600<2000
6d	1 12.5-13.4	<=18	>=2000
7a	<=11	>=24	<200
7b	<=11	>=24	>=200<600
7c	<=11	>=24	>=600<2000
7d	<=11	>=24	>=2000
8a	<=11	>18-<24	<200
8b	<=11	>18-<24	>=200<600
8c	<=11	>18-<24	>=600<2000
8d	<=11	>18-<24	>=2000
9a	<=11	<=18	<200
9b	<=11	<=18	>=200<600
9c	<=11	<=18	>=600<2000
9d	<=11	<=18	>=2000
10a	>=13.4	>=24	<200
10b	>=13.4	>=24	>=200<600
10c	>=13.4	>=24	>=600<2000
10d	>=13.4	>=24	>=2000
11a	>=13.4	>18-<24	<200
11b	>=13.4	>18-<24	>=200<600
11c	>=13.4	>18-<24	>=600<2000
11d	>=13.4	>18-<24	>=2000
12a	>=13.4	<=18	<200
12b	>=13.4	<=18	>=200<600
12c	>=13.4	<=18	>=600<2000
12d	>=13.4	<=18	>=2000

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Abstract: This publication presents a GIS-based approach for revising the definitions of global maize production environments, called "mega-environments" (MEs), used by CIMMYT and its partners. A cluster analysis was performed on climate data, representing a four-month growing season, for key maize producing locations. Assuming rainfed production, the onset of the growing season was determined based on the month when the ratio of precipitation over potential evapotranspiration exceeds 0.5. Diagnostic criteria for mapping MEs were based on cluster analysis results and expert knowledge. The resulting maps can be used to select appropriate target environments for maize germplasm and trials, as well as in priority setting and site selection for global maize breeding programs.

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