Assessing the potential impact of the consortium for improved agriculture-based livelihoods in Central Africa (CIALCA): Spatial targeting of research activities

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Assessing the potential impact of the consortium for improved agriculture-based livelihoods in Central Africa (CIALCA): Spatial targeting of research activities

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1 Introduction

1.1 Consortium for improved agriculture-based livelihoods in Central Africa

In 2005, the Directorate General for Development Cooperation (DGDC - Belgium) approved three proposals for projects working with the national agricultural research systems of Rwanda, Burundi, and the Democratic Republic of the Congo (DRC) and in similar geographic regions. The three projects are led by IITA, Bioversity-INIBAP, and TSBF-CIAT, focussing on banana-based systems in the first two cases and on sustainable natural resource management and marketing, coupled with resilient legume germplasm in the third project.

In order to exploit these similarities in project objectives, structure and sites, the three CGIAR institutes and their NARS partners proposed to operate as a consortium. Using the different capacities of the participating institutes, the consortium aims to enhance research synergies, while avoiding needless duplication of research activities. The setup of the Consortium for Improved Agriculture-based Livelihoods in Central Africa (CIALCA) was endorsed by the Director-Generals of INERA, ISAR, ISABU, IRAZ[1] in Kigali, on 15-16 September 2005.

[1] l'Institut de l'Environnement et de Recherches Agricoles (INERA- DRC), Institut des Sciences Agronomiques du Rwanda (ISAR), l'Institut des Sciences Agronomiques du Burundi (ISABU), Institut de Recherche Agronomique et Zootechnique (IRAZ – regional mandate based in Burundi

1.2 CIALCA mandate areas

CIALCA has chosen to work in ten geographical areas in Burundi, DRC and Rwanda. These ten 'Mandate Areas' (Figure 1) have been chosen to represent the diversity in agro-ecological characteristics, in demographic profile and in access to markets that are encountered in the three countries (Table 1). The mandate areas chosen also reflect the areas where bananas and legumes are an integral part of the farming system (Figure 1).

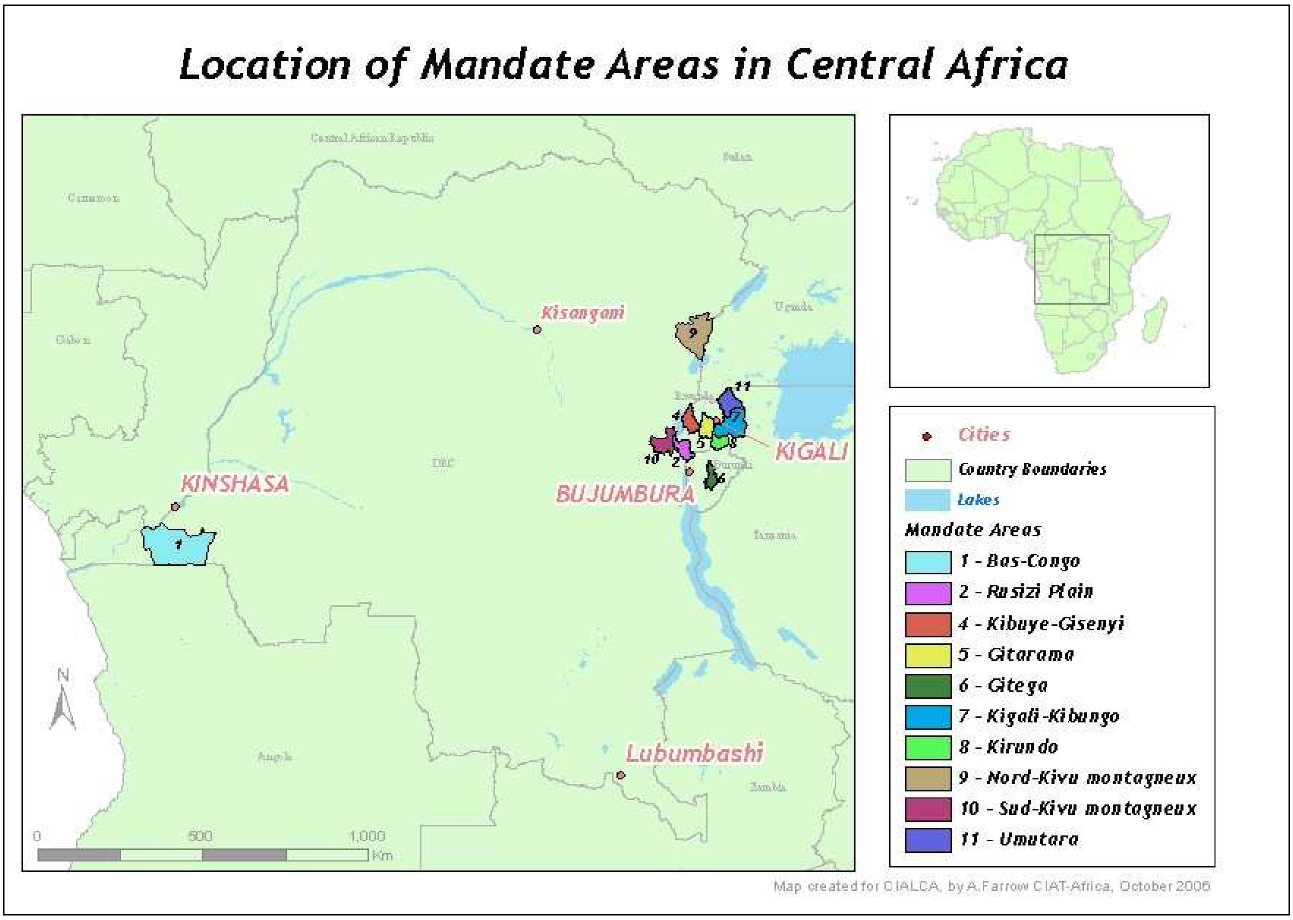


Figure 1. Mandate areas in Central Africa

Table 1. Characteristics of the 10 mandate areas

Name	**Country**	**Approximate Political Boundaries**	**Biophysical characteristics**	**Description/reason for interest**	**Main markets**
Bas-Congo	DRC	Cataractes, Lukaya district	Lowlands	Lowlands, close to Kinshasa	Kinshasa, Mbanza-Ngungu
Ruzizi plain	Burundi / Rwanda	Cibitoke province/district	Ruzizi plain	Banana good access to Bujumbura, lowlands (800m)	Bujumbura
Gisenyi-Kibuye	Rwanda	Gisenyi, kibuye provinces	Highlands, high ppt, relatively young soils	Bananas, beans with good growth potential	Kigali, Gisenyi, Goma, Ruhengeri, Kibuye
Gitarama	Rwanda	Gitarama province	Granite plateau, poor soils	High population density good market access, poor soils on granitic plateau	Kigali, Gitarama, Ruhango
Gitega	Burundi	Gitega province	Poor acidic soils, central plateau,	Banana, representative of central area, high population density, with input use common	Gitega, Bujumbura
Kigali-Kibungu	Rwanda	Kigali, kibungu provinces	900-1200mm, 900 – 1700m mid-altitude, old weathered soils on schist	Bananas, beans, potentially good access to Kigali	Kigali
Kirundo	Burundi	Kirundo province	900-1200mm, 900 – 1700m mid-altitude, old weathered soils on schist	Banana area, similar to Kibungu, international NGOs are there	Kirundo, potentially to Kigali
Kivu montagneux*	DRC	Ngweshe, Kabare, Masisi, Butembo, Kamanyola (territoires)	Highlands	Banana-bean area, high population, high rainfall, potential good access to urban centres	Beni, Butembo, Kasindi, Kampala, Bukavu, Goma, Kigali, Cyangugu, Gisenyi
Umutara	Rwanda	Umutara province	800-1000mm with drought stress, potentially good NRM base	Recently settled, potentially good access to Kigali	Kigali

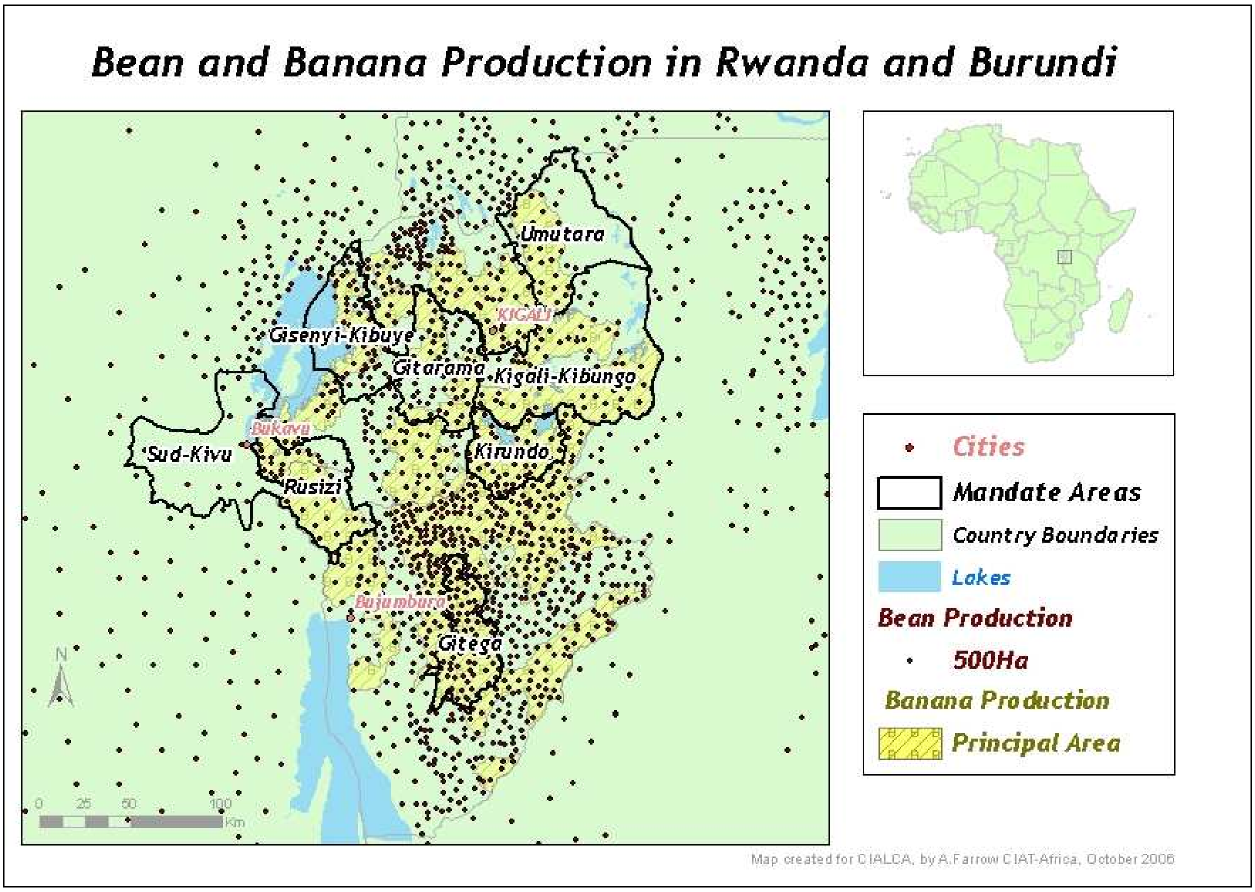


Figure 2. Bean and Banana production in Rwanda and Burundi (data unavailable for banana production in DRC)

1.3 Representativity and scaling-out

A number of locations have been chosen as candidates for action sites. At each location a participatory rural assessment (PRA) was carried out to determine the important characteristics of the communities, such as the major farming systems, their engagement with markets, and to gauge the presence and strength of local organisations. As part of the characterization of mandate areas we have also analyzed the representativity of each PRA site within the mandate site as a whole in terms of the major variables described above. In addition an exploratory scaling-out exercise has been carried out for each PRA site in order to judge potential diffusion areas and beneficiaries of the technologies developed by the CIALCA projects.

2 Methods and Materials

2.1 Data

Each mandate area was characterized in terms of certain key variables, these included the agro-climatology of the area, the population density of the area, and the access to markets. Population density was provided by the Global Rural Urban mapping project (GRUMP 2005) datasets for

Africa. This dataset was chosen to ensure consistency across the three countries. GRUMP is inferior to some publicly-available data for Rwanda (the GRUMP data are older and the spatial resolution is poorer) but it is the only reliable source of data for DRC.

Different markets were chosen for characterizing the mandate areas (Table 1); these were based on local knowledge of current trade flows as well as for the identification of potentially new markets. Accessibility was then calculated to all of these markets. The access is modelled in a geographical information system (GIS) using a set of rules and data, which results in a value in minutes to a pre-determined market (Farrow and Nelson 2001). The model takes into account road location and quality as well as barriers such as international borders and constraints to movement, like slope. The values generated were validated by the project team coordinators in Rwanda, Burundi and DRC. Each market was modelled individually, assuming a transport mode of medium-sized trucks able to carry agricultural goods (both input and output) in bulk[2]. This links with CIALCA's research on collective action for marketing outputs and bargaining power for the purchase of inputs.

Due to lack of digital soils data, the characterisation of the agro-climatology was limited to the annual precipitation (Hijmans *et al.* 2005) and a calculation of the length of growing season (Thornton *et al.* 2006). An indication of the soils can be derived by the underlying geology. For Rwanda geological maps are available in scanned format (Selvaradjou *et al*. 2005) and can be used for those mandate areas located in that country. No data were available for Burundi or DRC.

The results of characterising the mandate areas were combined to form development domains similar to those used for priority setting by the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA). The agro-ecological potential layer was the same as that used by IFPRI-ASARECA. Slight modifications were made to the ASARECA development domains, especially in the choice of markets and in the threshold values used.

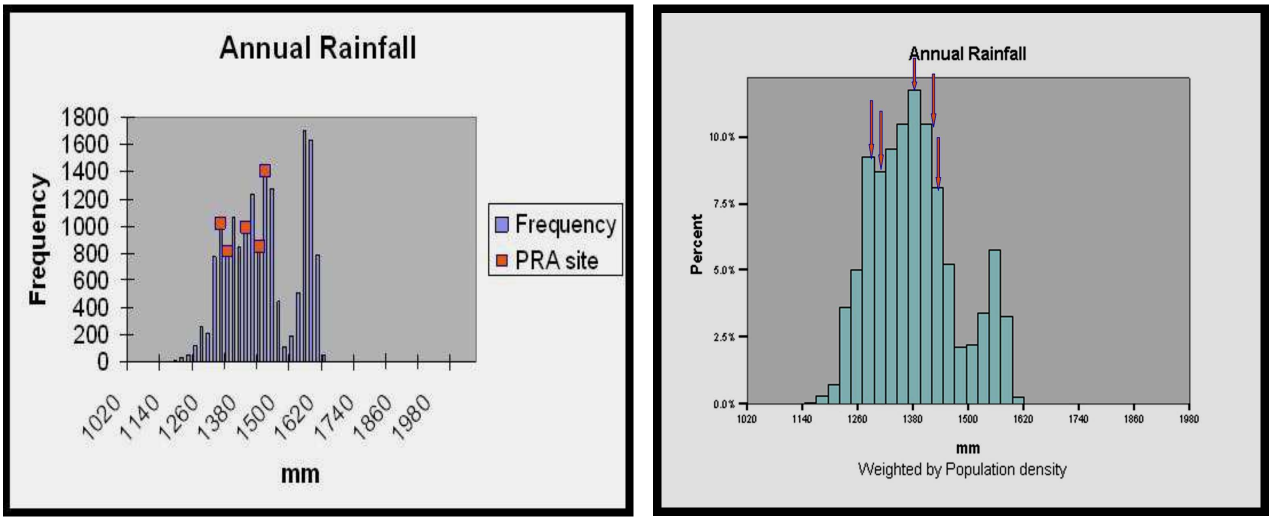
2.2 Assessing representativity of PRA sites

While it will be the results from the PRA that decide which sites will be chosen as the locations for interventions[3], it was deemed important by CIALCA that the PRA sites themselves are broadly representative of the mandate area. This has slightly different connotations in each mandate area but in general the researchers were keen to avoid outliers in terms of the major biophysical and socioeconomic variables used to characterise the mandate areas. A sampling framework is traditionally devised to ensure representativity and to enable inferences to be drawn about the population at large. However given the small number of intervention sites, our analysis of representativity is visual and intuitive rather than statistically rigorous.

[2] Where no roads or tracks are mapped, the model uses values for walking.

[3] Half of the PRA sites in each mandate area will be chosen as action sites depending on a number of factors including the strength of community organisations, and current engagement with markets.

We compare the values of the characteristics at the location of the village where the PRA was undertaken with the values of the mandate areas as a whole. All of the PRA sites are plotted on the histogram of observations. A histogram can be produced for each variable where each observation refers to a 1km^2 cell. The interpretation of the annotated histogram is improved[4] when the variable is weighted according to the population density as shown below (Figure 3).



(a) (b)

Figure 3. Histograms of annual rainfall in Bas-Congo mandate area; (a) unweighted, and; (b) weighted by population density

2.3 *Scaling-out as a guide to potential impact*

The interventions that will be carried out as part of the CIALCA projects in the action sites will be analyzed and the best practices will be scaled-up via development partners and the national agricultural research and extension systems. Another aspect of "going to scale" is the horizontal replication across the three countries and beyond (Cook and Fujisaka 2004). The potential areas of this scaling-out are determined in part by the interventions themselves, which are constrained by various external factors, notably the edapho-climatic conditions, the receptiveness of the livelihood systems and access to input and output markets.

We have used two methods of assessing the potential for the scaling-out of interventions in the action sites. The first and most fully developed is the use of the Homologue software (CIAT 2004) to search for environments similar to those encountered in each mandate area. The second method has resulted in the creation of development domains based on key variables related to agricultural livelihoods (e.g., Pender *et al.* 2004).

[4] The PRA site should be representative of the population of the mandate area rather than the area *per se*.

2.3.1 Homologue

Homologue produces raster grids of the probability of encountering an environment similar to the input location. For each mandate area we chose the position of each PRA as the input location. These individual grids were then merged to form a probability cloud, whose values varied between 1 (100% chance of encountering a similar edapho-climatic environment) and 0.

The probability 'cloud' was then used to give the population in the probability band between 50% and 100%. No account was taken of the actual diffusion mechanism, that is whether the diffusion was a natural process or was aided by NARS and NGOs.

2.3.2 ASARECA Development Domains

For scaling-out purposes we have decided to use the development domains developed for ASARECA (2005). These domains have been created using many more markets than those used in the characterization of the CIALCA mandate areas. The domains have been produced for eastern and central Africa, so the results are only comparable for a selection of countries. Each PRA in the mandate area is located in a particular domain, and each domain has a total population in eastern Africa. Therefore for each mandate area the scaling-out population is the total population of all the domains represented by the PRA sites.

3 Results

3.1 Assessing representativity of PRA sites

The PRA sites in Bas-Congo represent well the mandate area in all of the variables although they tend to be located in the lower and drier parts of the region. Differences between the weighted and un-weighted distributions are obvious for elevations above 800m and for annual rainfall totals above 1500mm. These sparsely-populated, higher and wetter areas in Madimba *territoire* tend to have poorer access to Kinshasa and to Mbanza-Ngungu. All except two of the PRA sites are within 8 hours of the capital Kinshasa. In Gitarama the single PRA site is broadly representative of the mandate area although a location a little higher and wetter would have been more typical. More importantly the PRA site is located on the granitic plateau that characterises the south-central part of the Mandate area and for which reason the mandate area was chosen.

The focus of research in the Gitega mandate area is banana-based systems; as such, the higher elevation parts of the district were not sampled. The differences between the weighted and un-weighted histograms are small in this mandate are due to the lack of variability in the distribution of the (high) rural population. Also in Burundi, the PRA sites in Kirundo represent the mandate area well. The sites offer sufficient variation to capture differences in key biophysical and demographic variables, although the driest areas were not captured.

In the Kibuye-Gisenyi mandate area the two PRA sites are in the lower and drier locations close to Lake Kivu; this is where the urban population is located and where market access is good. Nevertheless the PRA sites do not represent well the whole mandate area as a whole, this is perhaps because the emphasis in this mandate area is bananas, which are not well suited to the higher areas of the mandate area. In terms of geology the PRA sites are located on the granitic/volcanic-derived soils in the north and on schist-derived soils in the south, representing well the mandate area. In contrast the PRA sites in Kigali-Kibungo represent the mandate area well. Despite similar altitudes they are well spread in each of the other variables and are located on the granite-derived soils in Bugasera and on schist-derived soils in Kibungo, representing well the range of the underlying geology in the mandate area.

The PRA sites in the Rusizi plain and Nord-Kivu montagneux mandate area represent well the mandate areas in all of the variables, although in the latter case they tend to be located in the lower and drier parts of the region, which is not surprising given the mountainous terrain. The PRA sites in sud-kivu montagneux represent well the mandate area, especially when the western portion of the area (which is included for administrative rather than biophysical reasons) is ignored. Finally in Umutara the four PRA sites represent well the granite-derived soils in the north and the schist-derived soils in the west and south, representing well the mandate area. There is perhaps a gap in the coverage for the lower elevations, which are areas with longer growing seasons and higher precipitation. These areas are, however, almost mutually exclusive with the lower elevations in the east of the mandate area associated with lower rainfall and shorter growing seasons.

We have shown that access to markets in Burundi and Rwanda appears to be more widespread than in DRC, due to the number and quality of the feeder roads in these two small countries. The quality of the digital data is also probably a factor with very good datasets available for both Burundi and Rwanda.

3.2 Potential impact of CIALCA interventions

The population has been derived for those areas in Africa, which exhibit biophysical conditions similar to those encountered in each of the CIALCA mandate areas (Table 2). The population in this table could be considered the potential population that could be positively impacted by the interventions proposed in the three CIALCA projects. The results show that the Bas-Congo mandate area and the Gitega mandate areas have homologue environments with large populations; in the latter case this includes almost half of Burundi as well as the higher density areas of eastern DRC. Despite the fact that there are eight PRA sites in the Sud-Kivu montagneux mandate area, the population in similar environments is quite small.

Table 2. Population (000,000's) in homologue environments for each CIALCA mandate area.

Name	Bas-Congo	Rusizi	Gisenyi	Gitega	Gitarama	Kigali	Kirundo	Nord-Kivu	Sud-Kivu	Umutara
Algeria	0	0	0	0	0	0	0	0	0	0
Angola	1.5	0	0	1.7	0	0	0	0	0	0
Burundi	0.7	1.2	0.1	5.0	1.1	0.9	2.1	0	0.3	0.2
Cameroon	0	0	0	0	0	0	0	0.3	0	0
CAR	0	0	0	0	0	0	0	0	0	0
Comoros	0	0	0	0	0	0	0	0	0	0
Congo	1.8	0	0	0	0	0	0	0	0	0
DRC	13.0	1.2	3.0	1.3	0.1	0	1.3	6.9	1.6	0
Ethiopia	0	0.7	0	5.2	0.7	1.5	0.9	0.3	0.3	0.3
Gabon	0.2	0	0	0	0	0	0	0	0	0
Ghana	0.5	0	0	0	0	0	0	0	0	0
Ivory	0.1	0	0	0	0	0	0	0	0	0
Kenya	0	0.1	0.4	0	0	0	0	2.3	0	0.1
Madagascar	0	5.1	0.3	0.4	0	0	0	0.1	1.4	0
Malawi	0	0.1	0	0.3	0	0	0	0	0	0
Mozambique	0	0.5	0	0.3	0	0	0	0.1	0	0
Nigeria	5.8	0	0	0	0	0	0	0	0	0
Zimbabwe	0	0.1	0	2.7	0	0	0	0	0	0
Rwanda	0	2.7	2.9	1.2	4.6	3.6	4.7	3.4	0.7	2.5
South Africa	0	0.6	0	4.4	0.6	1.2	1.2	0	0	0.2
Sudan	0	0	0	0	0	0	0	0	0	0
Swaziland	0	0.1	0	0.6	0	0.1	0.1	0	0	0
Tanzania	1.4	0.9	0.7	1.2	1.2	1.7	1.8	0.5	0	0.8
Togo	0.1	0	0	0	0	0	0	0	0	0
Uganda	0	0.2	0.5	0	0.1	0.2	0.2	3.6	0	0.2
Zambia	0	0	0	0.2	0	0	0	0	0	0
Total	25.0	13.5	8.0	24.5	8.4	9.2	12.2	17.5	4.2	4.2

An alternative strategy for gauging the potential population who might benefit from the technologies tested in the CIALCA projects is to analyze the development domains in which each PRA site is located, and extrapolate to the population of the same domains in the countries of eastern and southern Africa. The result of this extrapolation (Table 3) gives a far larger potential population than the results of the analysis of homologue environments. This is most evident in the Sud-Kivu Montagneux mandate area, which in this case has the largest potential scaling-out population.

Table 3. Population (000,000's) in development domains of the PRA sites in each mandate area.

Name	Bas-Congo	Rusizi	Gisenyi	Gitega	Gitarama	Kigali	Kirundo	Nord-Kivu	Sud-Kivu	Umutara
Burundi	3.7	2.2	5.1	4.8	1.8	4.1	0.0	0.2	2.3	0.5
Ethiopia	25.8	25.1	15.5	33.1	2.5	35.1	15.5	12.5	27.8	14.9
Kenya	11.9	10.9	16.4	15.1	6.2	16.5	16.4	4.9	12.9	2.7
Madagascar	8.9	12.0	3.2	2.7	1.7	10.7	3.2	5.2	14.2	8.7
Rwanda	2.5	4.8	7.0	3.1	4.6	3.2	7.0	0.1	4.9	0.2
Sudan	10.7	22.9	7.6	2.3	5.9	14.3	7.6	15.0	29.8	12.0
Tanzania	15.9	14.1	7.2	9.5	0.9	21.3	7.2	10.5	21.0	14.1
Uganda	14.0	5.9	13.2	15.8	2.3	15.7	13.2	1.9	7.3	4.3
Zaire	31.6	37.9	12.6	11.9	6.2	37.7	12.6	12.1	43.3	29.3
Eritrea	0.7	2.8	1.3	0.3	1.0	1.0	1.3	2.4	3.8	0.7
Total	125.7	138.6	89.0	98.7	33.0	159.6	83.9	64.8	167.4	87.4

4 Conclusions and Discussion

The case of Umutara highlights the difficulty of assuring representativity in multivariate space, especially when limited to at most eight sites across areas of up to 20,000 km^2. One solution is to reduce the dimensions of this multivariate space by classifying and merging the variables to create domains that reflect the objectives or research questions tackled by the project, program or organization. The CIALCA mandate areas have been assessed in terms of the development domains, which are based on access to markets, agro ecological potential and population density. The markets used in the creation of these domains are specific to the particular mandate areas. This makes it difficult to use the same development domains for scaling-out purposes and a more general set of domains, such as those used by ASARECA was necessary.

The analysis of spatially-variable characteristics has been used in combination with the participatory rural assessments which were carried out in each mandate area. A criticism of the methodology used by CIALCA could be that the characterisation should precede the choice of sites for the PRAs. There are, however, practical reasons why this approach was chosen, not least because the characterization consumes time, which is itself a limited resource in research projects like CIALCA. Nevertheless the characterization process has confirmed the soundness of the sites chosen for PRAs and ultimately for action sites and interventions.

The assessment of areas for the scaling-out of interventions might normally be confined to an *ex ante* economic analysis. We feel that a combination of economic impact assessment and spatial analysis can deliver a realistic range of impacts. Both the strategies of assessing the potential scaling-out populations have flaws. The use of homologue environments ignores the socio-economic conditions that ensure the success of the intervention, while the development domains are too broad for anything other than policy recommendations. Neither of these considers the precise mechanisms for scaling-out and neither considers the effects of distance, for instance some homologue environments occur in southern Africa). The scaling-out assessments undertaken in this study can also be improved by the consideration of the welfare or nutritional levels of the potential beneficiaries (see, for example, the section *Strategic approaches to targeting technology generation: Assessing the coincidence of poverty and drought-prone crop production* by Hyman *et al.* in this Report).

A response to this evaluation would be the further development of the CaNaSTA (Crop Niche Selection in Tropical Agriculture) tool (O'Brien, 2004) for a range of technologies allied with research on socio-ecological niches (Ojiem 2006) and impact pathways (Douthwaite *et al.* 2003).

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