Preliminary Economic , Environmental and Social Impact Assessment of the EADD Project in Kenya Using the Tradeoff Analysis

Report to the Trade-off Analysis for the Heifer Project using a Minimum Data Approach.

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Executive Summary

This report summarizes a preliminary impact assessment of the practices promoted by the East Africa Dairy Development Project (EADD), using baseline data collected by the International Livestock Research Institute. This analysis was designed as a proof-of-concept for use of the Environmental Matrix, developed by the BMGF, with the Tradeoff Analysis Model for Multi-Dimensional Impact Assessment (TOA-MD) developed by Antle and Valdivia (2010). The analysis demonstrates the feasibility of using the TOA-MD model to implement an integrated economic-environmental-social impact assessment at low cost, using available baseline data supplemented with other available data.

This preliminary analysis highlights some of the complex economic, environmental and social tradeoffs and synergies that are likely to be associated with dissemination of the EADD practices at farm, sub-regional and regional scales. This information should facilitate project design to enhance synergies and mitigate adverse tradeoffs, and should also be useful for program design and priority-setting within the BMGF. This analysis also shows the value of considering all relevant dimensions of a project, in an integrated manner, from the beginning of a project. Taking an integrated approach from the outset is likely to improve the likelihood that projects will achieve positive objectives while mitigating possible unintended adverse outcomes, and do so at lower cost than a piece-meal approach.

Key findings of the EADD analysis are (see Summary Table below):

- *The TOA-MD analysis predicts a 76% adoption rate of EADD practices, defined as an increase in the average herd size of adopters by 1 cross breed cow, and the adoption of improved management practices.* The project PAR set a goal of 68% of the target population having at least one cross-breed cow by the end of 10 years. The 76% adoption rate assumes that the program's marketing development is effective, and that resource availability and other constraints do not limit adoption.
- *At the predicted adoption level of 76%, the adopting farms are likely to exceed the EADD income goal of doubling dairy income, and reduce poverty by about 8% among adopters (using a $1/person/day poverty line).* The analysis indicates that

by targeting small farms, this program would reduce inequality in the income distribution across small and large farms.

- *The EADD package of practices is predicted to result in gains in water use efficiency and methane emissions efficiency at the farm level, but to increase total water use and methane emissions.* While the EADD practices represent a win-win in economic and environmental efficiency, further attention to impacts on total water use and greenhouse gas emissions is needed as the project is scaled up to full implementation. A more complete analysis also could incorporate possible positive impacts on soil carbon that could offset the methane emissions, although this effect would likely be small. Other possible resource impacts not considered in this preliminary analysis, such as impacts on soil erosion and nutrients, also should be addressed in a more complete analysis. The baseline data were not adequate to address those impacts in this analysis.
- *Adoption of EADD practices is likely to increase household assets owned by both men and women, but the share of assets controlled by women is predicted to decline by about 9%, based on observed behavior in the population.* This finding indicates that development of strategies to mitigate possible adverse gender effects of the technology is warranted.
- *The analysis predicts that adoption of EADD practices is likely to increase all farm household members' milk consumption, including an increase in infant milk consumption of about 55% among EADD adopters.*
- *Incorporation of the Environmental Matrix and the TOA-MD data template into project design has the potential to provide integrated impact assessment of projects at lower cost, by focusing baseline data collection and follow-up data collection on the key indicators identified for each project.*

Summary Table: Indicators for Preliminary Impact Assessment of EADD in Kenya

		Adoption Rate			
		Low (34%)		Predicted (76%)	
	Base	Population	Adopters	Population	Adopters
Economic Indicators					
Ave. farm income ($/year)	583.94	34.78%	76.18%	46.28%	56.42%
Poverty rate (%) (Pov.line $1/day/person)	85.96	-4.76%	-12.70%	-6.72%	-8.45%
Poverty rate (%) (Pov.line $2/day/person)	97.82	-1.59%	-4.18%	-1.90%	-2.78%
Environmental Indicators					
Ave. water use efficiency (M3/kg milk)	9.85	-9.38%	-14.62%	-19.27%	-21.53%
Ave. total water use per farm (M3/year)	5756.86	22.21%	51.55%	29.77%	31.23%
Ave. CH4 efficiency (L/kg milk)	0.14	-18.08%	-43.21%	-26.72%	-31.56%
Ave. total CH4 emissions per farm (L/year)	142.38	4.33%	46.64%	21.52%	33.74%
Social Indicators					
Women's asset share (%)	0.31	-5.58%	-10.53%	-7.55%	-9.68%
Ave. infant milk consumption (L/day)	0.45	31.38%	69.05%	45.00%	55.56%

Note: Population = small dairy farm population of adopters and non-adopters.

1. Introduction

This report presents results of a preliminary impact assessment of the East Africa Dairy Development Project (EADD) carried out in November-December 2010. This undertaking has several purposes:

- The *primary* objective was to demonstrate the potential for the Tradeoff Analysis Model for Multi-Dimensional Impact Assessment (TOA-MD) to be used by technology development projects, in conjunction with the Environmental Matrix developed by the BMGF Agricultural Policy team, to carry out impact assessments of projects as they are being evaluated for funding, or during project implementation.
- A *secondary* objective was to demonstrate the potential for TOA-MD to be used to provide more comprehensive impact assessments, including gender, health and nutrition.
- A *third* objective was to provide a substantive assessment of potential EADD impacts to complement other evaluations being carried out for EADD.

2. Background

The Agricultural Policy and Statistics group of the Bill and Melinda Gates Foundation is developing procedures to evaluate the potential environmental impacts of projects funded by the Foundation. This activity, known as the "Environmental Matrix" project, identified several Foundation-funded projects that could be used to test the procedures being developed. One of these projects is the East Africa Dairy Development Project. Application of the Environmental Matrix indicated a number of possible environmental issues that could be associated with the EADD project:

(1) water quality effects of effluents from the milk chilling plant
(2) water quality effects of cattle dung and urine disposal
(3) effects of livestock intensification on vegetative cover and soil erosion
(4) effects on soil nutrients and soil C
(5) water consumption by livestock including water requirement for fodder production
(6) effects on greenhouse gas emissions.

We emphasize that the main goal of the analysis reported here is to illustrate the use of TOA-MD to carry out a preliminary impact assessment. The original EADD project design focused on economic and social impact assessment, so data needed to do an environmental assessment were not collected. Thus, the analysis presented here is based on data similar to what would be available in the planning stages or early in the implementation of a typical project. However, as we discuss in the Conclusions, if a more comprehensive impact assessment strategy had been adopted at the beginning of the project, better data for environmental assessment could have been acquired at low additional cost.

Given the limited time resources dedicated to this illustrative analysis (two weeks of time in-country in Kenya for Valdivia to obtain and organize data, and two weeks additional time for analysis by Antle and Valdivia), we selected impacts on water consumption and methane emissions from livestock to illustrate the TOA-MD analysis. We note that with the exception of the first impact listed above (the impacts associated with operation of chilling plants), all of the other farm-related impacts could be addressed with TOA-MD analysis with a modest increase in the time and resources needed to collect additional data and implement analysis.

In addition to environmental impacts, the TOA-MD approach is capable of analyzing any quantifiable economic or social impacts associated with technology adoption, as well as impacts associated with environmental change such as climate change. Economic impacts such as average farm income and the poverty rate can be quantified, and are presented in this analysis. In addition, we utilized available data to estimate the impact of improved dairy production on two other types of indicators: nutrition, measured as milk consumption by infants, children and adults; and gender, measured as men's and women's ownership of household assets. The asset ownership index was constructed using the weighting suggested by the BMGF document, "Agricultural Development Outcome Indicators" (Draft for Initiative review, 2010).

In summary, in this analysis the indicators are based on the following outcomes:

- water consumption by livestock
- livestock methane emissions
- farm household income
- milk consumption by infants, children and adults
- men's and women's asset ownership.

3. The TOA-MD Model

The TOA-MD model is a unique simulation tool that uses a statistical description of a *heterogeneous farm population* to simulate the proportion of farms that utilizes a baseline system (in this case, farms without improved dairy) and the proportion of farms that would adopt an alternative system (in this case, farms using the package of practices promoted by EADD) within defined *strata* of the population. The TOA-MD model predicts an adoption rate for each stratum of the population, using the assumption that farmers are economically rational and adopt practices that are expected to provide the highest economic return. Accordingly, this predicted adoption rate should be interpreted as the proportion of farms for which the EADD practices are *economically feasible*. If there are institutional or behavioral factors that constrain adoption – such as limited access to financial resources, or risk aversion – then this predicted adoption rate is likely to be an upper bound on the actual adoption rate that is observed. Further analysis may be required to incorporate the effects of such constraints. Based on the predicted rate of adoption, the TOA-MD model also simulates

economic, environmental and social *impact indicators* for the sub-population of adopting farms, the sub-population of non-adopters, and the entire population.

Further details about the TOA-MD model are available at http://tradeoffs.oregonstate.edu. This version of the TOA-MD model, designed for impact assessment, is based on an earlier version developed for analysis of ecosystem service supply, and has been validated against more complex impact assessment models (Antle and Valdivia 2006; Antle et al. 2010; Antle 2010).

One unique feature of the TOA-MD model is its capability to use statistical relationships between technology adoption and the environmental, economic and social outcomes, to simulate impacts of adoption. Impacts are defined as population means, or as the proportion of the population above or below a threshold, e.g., a poverty line or a nutritional requirement. Economic research shows that taking into account the inter-relationships between adoption and outcomes is critical to obtain accurate estimates of impact. This fact has important implications for data collection, discussed in the Conclusions of this report.

Another unique feature of the TOA-MD model is its parsimonious, generic structure, which means that it can be used to simulate virtually any farm system. One virtue of this model design is that, unlike many large, complex simulation models, it is easy to address the inherent uncertainty in impact assessments by using sensitivity analysis to explore how results change with the relatively small number of model parameters. The TOA-MD model is programmed in Excel, and is easy to learn and use. A self-guided course is available for new users, and the TOA-MD team offers periodic in-person training courses at Oregon State University.

In this analysis, the strata are the "hubs" or regions defined within the EADD project for development of improved production and marketing of milk, see Figure 1. Using the adoption rate combined with environmental and social data, the model simulates the impact of adoption on economic, environmental and social indicators of *adopters* and *non-adopters* in each strata. Impacts can be aggregated across the adopter and non-adopter groups by strata, and also can be aggregated across strata.

The model utilizes the following types of data:

- population means and variances of production, output price and cost of production, by crop and livestock activity
- population means and variances of environmental and social outcomes associated with each system
- correlations between system returns and environmental and social outcomes
- population means and variances of farm household characteristics (farm size, household size, off-farm income).

The data used in this analysis were obtained from several sources:

- baseline surveys carried out by the International Livestock Research Institute (ILRI) as part of the EADD project.
- supplemental technical data on water consumption were obtained from the literature with assistance of ILRI scientist Dr. Amare Haileselassie.
- technical data needed to run the LIFESIM livestock simulation model with assistance of CIP scientist Dr. Carlos Leon-Velarde.

4. Analysis Procedures

The results presented below are based on the following system definitions:

- *System 1* is the baseline system representing the populations of small farms, defined as farms averaging 1.6 hectares and that keep less than four cows in the farm (with an average herd size of 2 cows). The economic data characterizing this system were obtained by stratifying the baseline survey data.
- *System 2* represents farms that have adopted the package of practices promoted by the EADD project. This system is characterized as follows:
  - Farms utilize artificial insemination to improve breed quality and increase their herd size by one cross breed cow. Sensitivity analysis was used to assess the potential EADD impacts with different assumptions to represent farms in system 2. In addition to the specification of systems according the EADD plan (small farms increase herd size by 1 cross-breed cow), three other scenarios were constructed:
    - Scenario 1: Farms using system 2 increased their average herd size by two cross breed cows after 5 years.
    - Scenario 2: The average herd size is assumed to double after 5 years and be maintained at that size, with the mix of local breeds and cross breeds as in the current population.
    - Scenario 3: The average herd size is assumed to increase from 2 in the base system to 3 cows after 5 years. Note that, as in Scenario 2, adopting farms are increasing herd size with both local and cross breeds.
  - Farms adopt improved feeding practices, in terms of quantity and quality of feed through the use of crop residues (particularly maize) and concentrate feeds which have the potential of increasing dairy production.
  - Productivity and cost of production were estimated using sub-samples of the baseline data representing the populations described in each scenario (data used in the model are summarized in Table 1).

  In addition, the following assumptions were made:

- Farms participate in milk marketing so that they are able to sell their increased production, net of household consumption, at observed market prices in their region.
- For the economic analysis of adoption, costs and returns are annualized over a ten-year period. During the first five years, milk production increases from the level of the baseline system to the level associated with the larger and more productive herd.
- Other economic characteristics of the farms remain the same, including off-farm income and returns to crop production. While it was recognized that some changes are likely in farms' crop production with adoption of EADD practices, e.g., a shift from crops to fodder production, the baseline data did not include information on crop management so this type of change could not be incorporated into the analysis. However, with some additional data on crop management, these changes could be incorporated easily.

5. Results

The TOA-MD model is capable of generating a large amount of detailed output. In the Summary Table (Executive Summary, above) we present results aggregated across regions for two adoption rates of the EADD system: the adoption rate predicted by the model; and an alternative, lower adoption rate which could be the result of constraints on the adoption of EADD practices. For these two adoption-rate scenarios, we present the following indicators:

- The baseline values of the indicators for the population of small farms that are potential adopters of the EADD system.
- Percentage changes in indicators for the *entire* population of small farms (i.e., averaged across adopters and non-adopters) relative to the baseline.
- Percentage changes in indicators for the *adopters* of the EADD system relative to the baseline.

5.1 Baseline Indicators for the Small-Farm Population

The Summary Table presented in the Executive Summary presents the baseline values of the indicators in the analysis. The environmental indicators are defined in two ways: as average methane emissions and water use per liter of milk produced, so a reduction in these indicators represents an increase in environment efficiency; and total water use and methane emissions per farm per year, averaged over farms.

The baseline data show that mean farm income is about $584, but varies substantially across the regions, reflecting differences in dairy productivity as well as other crop income. Using $1/day/person as the poverty line, the poverty rate across the seven regions is estimated to be about 86%, and ranges from about 54 to almost 100 percent

in the regions. In contrast, the average poverty rate using the poverty line of $2/day/person is estimated to be about 97% across all the regions, and ranging from 85 to 100% in the regions.

The survey data show that women's assets are generally half of men's. The asset index is based on the weighting of individual assets as suggested by the BMGF. Our analysis used both the level and the share of women's and men's assets in total household assets. The average baseline value of the index is about 9 for women and 20 for men. To put this index into perspective, a hand tool such as a hoe has a weight of 1 in this index, a radio has a weight of 2, and a motorcycle has a weight of 48. Due to small sample sizes for the baseline data, the region-by-region numbers were highly variable, but we think that the values for the entire population should be reliable.

Milk consumption tends to be highest for infants, but this pattern does vary across regions. Again, the small sample sizes appear to be causing the large differences in these indicators across regions, so we think it is prudent to focus on the results aggregated across regions.

5.2 Predicted Adoption Rates

The TOA-MD model predicts the rate of adoption of the EADD practices within the population of small farms that are targeted for the EADD interventions. As noted above, this predicted adoption rate is based on the expected economic benefits and costs of adoption. It should be interpreted as the likely rate of adoption that would occur after the EADD practices have been effectively disseminated. This analysis does not take into consideration possible constraints on adoption, such as financing or market access, so the adoption rate predicted by the TOA-MD model could be interpreted as an upper bound on the likely rate that would occur.

The Summary Table shows that the predicted adoption rate among the entire target population of small farms is about 76 percent. This adoption rate represents about 49,000 small farms in these seven regions.

The TOA-MD model is designed to simulate the effects of alternative adoption rates. For example, in the Summary Table presented in the Executive Summary, we presented the impacts associated with a 34% adoption rate as well as the predicted 76% adoption rate. This table shows that the aggregate impacts change accordingly. Note, however, that the impacts on the adopter sub-population do not vary in direct proportion to the adoption rate. In fact, the statistical relationship between the adoption rate and the impacts on the adopter and non-adopter sub-populations is complex, and involves the correlations between the spatial patterns of adoption and the associated outcomes.

5.3 Environmental Impacts

The average water use efficiency and the average methane (CH4) efficiency indicate how much water is used and the amount of methane emissions per unit of milk produced. These indicators show that, on average, the environmental efficiency of adopting farms will increase by about 22% for water consumption by livestock and about 32% for methane emissions (Summary Table). Averaged over all farms in these regions, the improvements increase efficiency of the entire population of small farms by about 20% and 27%, respectively.

Although environmental efficiency increases, the Summary Table in the Executive Summary shows that total water use and total methane emissions increase, by about 31% and 34%, respectively, for adopting farms. This finding indicates that as the project is scaled up to full implementation, further analysis may be warranted to ensure that water availability does not constrain adoption or result in adverse external impacts on other water users. Likewise, further attention to greenhouse gas emissions appears warranted.

Other environmental impacts that should be addressed in a more complete analysis include potential impacts of fodder production and grazing on soil erosion, soil nutrients and soil carbon. These impacts could be positive or negative, depending on land use and management of grazing and crop production. With suitable management, for example, synergies could be exploited between dairy intensification, nutrient cycling, soil management, and soil carbon sequestration.

5.4 Economic Impacts

The analysis shows that mean farm income in the adopting population will increase by about 56%. Taking into account that on average about 37% of farm income is generated by dairy production, this implies that dairy income is likely to increase by at least 100%, meeting the goal of doubling dairy income. This number is higher in some regions but lower in others, following the pattern of adoption discussed above. The poverty rate, using the $1/day/person poverty line, is predicted to decline by about 8.5% for adopting farms, and by about 6.7% for all small farms. Using the $2/day/person poverty line, poverty rate is predicted to decline by about 2.8% for adopters and by about 1.9% across the regions(Summary Table).

5.5 Women's and Men's Asset Ownership

The asset ownership index indicates that overall, both women's and men's asset ownership is likely to increase as incomes rise with adoption of EADD practices. Among adopters, men's assets are predicted to almost double on average, while women's assets increase about 70%, so men's assets increase relative to women's (i.e. the share of women's assets is predicted to decline, see Summary Table). This finding is based on the observed patterns of behavior in the baseline data, so effective intervention by the

EADD project to increase women's participation could alter this outcome. Follow-up data collection later in the project should be undertaken to evaluate actual outcomes.

5.6 Nutrition

The analysis indicates that milk consumption would increase among adopting households by 55% for infants, 14% for children, and 35% for adults. The relatively large increase for adults is due in part to very low levels of consumption observed for adults in some regions, which increase substantially with adoption. We also caution that sample sizes for some of the regions are small, making the regional results possibly unreliable.

5.7 Sensitivity Analysis

The results summarized in Table 2 show that Scenario 1, increasing herd size with two cross breed cows on average, is predicted to result in a 77% adoption rate, almost the same as the rate predicted under the analysis assuming herds would be increased by 1 cross breed cow on average. Although the adoption rates for these two analyses are similar, the economic impacts are larger: increasing herds by 2 cross breed cows raises farm income by 65% and the poverty rate decreases by 11% (or by 3% using the $2/day/person). The environmental indicators in Scenario 1 follow the same pattern as the case of adding one cross breed cow. Scenarios 2 and 3 show lower adoption rates (55% and 49% respectively) and smaller economic impacts. Farm income increases by 33% in Scenario 2 and 23% in Scenario 3. Environmental impacts with Scenarios 2 and 3 also show an increase in water use similar to Scenario 1, but total methane emissions are much larger. Women's asset share for Scenarios 2 and 3 increase by about 3% and 5% respectively, in contrast to the other cases where it declines. This difference is explained by the differences in the adoption rate and the correlations between income and asset ownership. At the lower adoption rate, the model shows that adopters are farms with higher incomes on average and among these farms women's asset shares tend to be larger. Scenarios 2 and 3 show that milk consumption for infants would increase between 30% and 34%.

6. Conclusions

This preliminary analysis demonstrates how the TOA-MD could be used in conjunction with the Environmental Matrix and similar tools for evaluation of social impacts. Using these tools, it is possible to implement an integrated assessment of economic, environmental and social impacts at low cost relative to methods that rely on case-specific, complex bio-economic simulation models. Cost is reduced in two ways. First, by using a generic model that can be applied to virtually any system, the time and resources needed to design a new model for each case are largely eliminated. Second, by identifying in advance the indicators that need to be quantified, any data collection

activities can be focused on the relevant information, thus eliminating the cost and respondent burden caused by the "kitchen sink" approach to survey design.

The TOA-MD approach shows that correlations between economic, environmental and social data are often needed to obtain accurate estimates of impact on adopting farms. This fact has important implications for the design of impact assessments. In particular, by recognizing this need in advance, the cost of collecting data often can be substantially reduced, and data quality can be improved. For example, in the case of the EADD study, the size of the survey questionnaires could have been reduced, while at the same time improving the quality of the information for economic and environmental analysis, by focusing on the specific data needed to implement the TOA-MD analysis. In the baseline data, milk production data could only be inferred indirectly from data collected on sales and consumption; data on crop management were not collected, presumably because an environmental assessment was not part of the original design. Better information on these key variables could have been obtained in the baseline surveys at relatively low additional cost. These data would have facilitated analysis of the adoption of EADD practices, as well as analysis of environmental impacts associated with likely changes in crop management such as a shift from crops to fodder production.

This preliminary analysis shows that there are complex economic, environmental and social tradeoffs and synergies that are likely to be associated with EADD practices at farm, sub-regional and regional scales. An important question for the BMGF to address is how to use this kind of information in the grant-making cycle, as well as more broadly for priority setting and resource allocation decisions. Experience suggests that integrating impact assessment into project design, management and evaluation will improve project performance.

Acknowledgments

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Table 1. Summary of Economic Data Used in the Analysis

	Base (System 1)			System 2			Sensitivity analysis for system 2					
							Scenario 1		Scenario 2		Scenario3	
Strata	Livestock (milk) Returns ($/farm/year)	Variable cost ($/farm/year)	Standard deviation of net returns	Livestock (milk) Returns ($/farm/year)	Variable cost ($/farm/year)	Standard deviation of net returns	Livestock (milk) Returns ($/farm/year)	Variable cost ($/farm/year)	Livestock (milk) Returns ($/farm/year)	Variable cost ($/farm/year)	Livestock (milk) Returns ($/farm/year)	Variable cost ($/farm/year)
Kabiyet	275.51	98.56	168.72	827.79	243.40	143.32	1053.40	329.67	775.85	185.95	471.85	173.82
Kandara	294.63	69.29	216.93	931.60	252.36	221.26	1256.78	330.47	501.07	152.87	344.14	119.10
Kaptumo	214.75	82.50	348.75	817.50	242.02	229.36	1135.34	314.12	326.41	114.64	399.44	114.64
Metkei	145.13	75.89	459.06	2403.62	181.24	260.19	3177.76	237.87	621.87	159.42	781.58	159.42
Siaya	415.45	77.97	167.10	1321.62	180.22	828.74	1858.05	241.67	854.55	118.77	872.98	118.77
Siongiroi	376.49	224.00	218.38	1154.16	546.35	312.75	1563.81	749.39	1550.21	537.73	996.53	578.89
Soy	186.60	84.36	401.99	1197.87	231.44	246.99	1755.34	361.67	1098.73	124.38	576.96	173.88

* variable cost does not include family labor

Table 2. Sensitivity Analysis. Predicted Adoption Rates of EADD Practices, Base Values of Impact Indicators, and Percent Changes from the Base at Predicted Adoption Rates (Impacts Averaged over All Small Farms in EADD Kenya Hubs).

		Scenario 1	Scenario 2	Scenario 3
	Predicted Adoption rate:	**77%**	**55%**	**49%**
Economic Indicators	***Base***			
Ave. farm income ($/year)	583.94	64.69%	32.70%	22.53%
Poverty rate (%) (Pov.line $1/day/person)	85.96	-11.30%	-6.01%	-4.02%
Poverty rate (%) (Pov.line $2/day/person)	97.82	-3.13%	-1.12%	-0.91%
Environmental Indicators				
Ave. water use efficiency (M3/kg milk)	9.85	-12.42%	-15.16%	-15.78%
Ave. total water use per farm (M3/year)	5756.86	27.50%	21.34%	23.84%
Ave. CH4 efficiency (L/kg milk)	0.14	-25.65%	-22.88%	-20.14%
Ave. total CH4 emissions per farm (L/year)	142.38	21.51%	47.99%	54.04%
Social Indicators				
Women's asset share (%)	0.31	-8.33%	2.86%	4.61%
Ave. infant milk consumption (L/day)	0.45	45.43%	29.78%	34.29%

Scenario 1: System 2: adding 2 cross breed cows with EADD-recommended management.
Scenario 2: System 2: doubling the average herd size (cows), use of improved feeding management.
Scenario 3: System 2: small farms with an average herd size (cows) of 3 local and cross-breed cows.

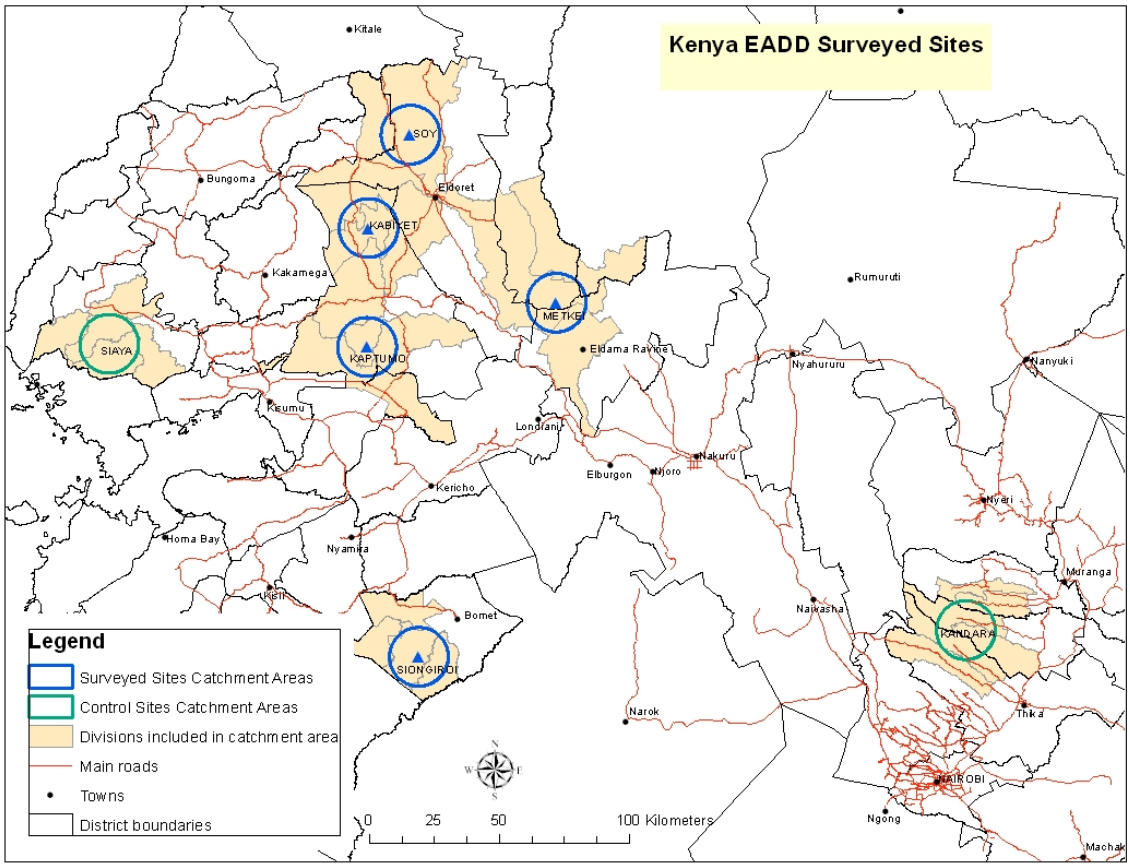

Figure 1. Map of EADD survey sites in Kenya.